ISASI FORUM

"Air Safety Through Investigation"

APRIL–JUNE 2009

Causation: What Is It, and Does It Really Matter?
(Page 4)
Do Cultural Characteristics Affect Investigations?
(Page 9)
Investigating Unmanned Aircraft System Accidents
(Page 15)
What Can Experience Learn from Inexperience?
(Page 20)

Contents

Features

Departments

About the Cover

A student investigating a simulated accident on the airfield at Cranfield University as part of the aircraft accident investigation course. (See *What Can Experience Learn from Inexperience,* page 20.) Photo: Graham Braithwaite, Cranfield University.

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"Air Safety Through Investigation"

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AIR SAFETY INVESTIGATORS
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'The Safest Period Ever?'

By Frank Del Gandio, ISASI President

Aviation officials in much of the world have become fond of making statements like "This is the safest period ever in aviation." Indeed, that has been an accurate statement throughout aviation history. Yet we have always understood, at least in principle, that such rhetoric can become so ingrained in us that we can become complacent about safety, believing somehow that constant improvement is a function of natural law.

However, occasional spikes in major accidents also have been part of aviation history, and they can rudely remind us that natural law does not dictate a constantly safer system. We are in the midst of such a spike in accidents right now. Once again, major accidents, which remain among the most basic measures of safety, have reminded us that safety requires continued effort to understand new risks as they are introduced into the system and, at the same time, constant reinforcement of lessons learned from past accidents.

As of this writing, airlines in the United States alone have incurred seven hull losses in the past 9 months. The first three, from May 25, 2008, through July 8, 2008, involved U.S. cargo operators: a Kalitta Airlines B-747-100 crashed in Brussels after a rejected takeoff (minor injuries); a USA Jet DC-9-32 crashed on approach to Plan de Guadelupe International Airport in Mexico (one of two pilots died); and, just 2 days later, on July 8, Kalitta Airlines stalled and crashed while trying to return to Bogota, Colombia, after losing power in two of four engines (no onboard fatalities but two fatalities on the ground).

Though these three accidents occurred just within 7 weeks, they did not generate broadly based concern. Several factors might explain the relative calm that continued to prevail. First, all three were cargo flights involving two relatively small operators. Second, they resulted in "only" three fatalities and just one onboard fatality. Third, all three occurred abroad and simply did not generate much attention.

This began to change on Dec. 20, 2008, when a Continental Airlines crew lost control of a B-737-500 on takeoff roll at Denver in a strong crosswind and ran off the side of the runway at high speed. A fire broke out on the right side and destroyed the aircraft. However, all 115 occupants escaped with a total of just five injuries. Five weeks later, on Jan. 15, 2009, a US Airways crew ditched an A320-200 in the Hudson River after multiple bird strikes on climbout from JFK in New York. All 155 occupants were rescued. Those accidents received lots of attention but mostly for their positive outcomes. This was especially true of the ditching in the Hudson and its subsequent portrayal as a human drama.

Yet, the Denver and Hudson River accidents had good outcomes. Though both aircraft were destroyed, all 270 occupants survived, with just six serious injuries. In important ways, they were success stories because they illustrated the major improvements in survivability achieved over the past 20-25 years. However, these two accidents began to raise some doubts about the wisdom of continuing our "safest ever" rhetoric.

On January 27, just 12 days after the US Airways accident, an ATR 42 operated by Empire Airlines on a cargo flight for FedEx crashed and burned short of the threshold during an ILS approach to Lubbock, Tex., in night icing conditions. Once again, there were no fatalities. A total of four cargo hull losses and two passenger hull losses in just 8 months had produced a total of "only" three fatalities, two of which were ground fatalities and might be explained as random misfortune, but the "best ever" rhetoric was looking still more suspect.

Finally, on February 12, a Dash 8-400 operated by Colgan Air as Continental Connection crashed on approach to Buffalo, N.Y., in night icing conditions; all 49 occupants and 1 person on the ground died. This accident has ended any complacency inadvertently encouraged by persistent references to "the safest period ever."

> **"This is the safest period ever in aviation." …Yet we have always understood, at least in principle, that such rhetoric can become so ingrained in us that we can become complacent about safety, believing somehow that constant improvement is a function of natural law.**

The really bad news is that the United States has not been alone in this recent spike. In the same 9 months, fatal accidents have included the following. (Note that the list includes only fatal accidents; several cargo accidents and non-fatal hull losses could be added.)

- February 2009: THY, B-737-800 at Amsterdam, nine fatalities.
- February 2009: Manaus Aerotaxi in the Amazon, Embraer Bandierante, 24 fatalities and four serious (Yes, 28 occupants in a Bandeirante).
- October 2008: Yeti Airlines, DHC-6 at Lukla, Nepal, 18 fatalities.
- September 2008: Aeroflot-Nord, B-737-500 at Perm, Russia, 88 fatalities.
- August 2008: Spanair, MD-82 at Madrid, 154 fatalities.
- June 2008: Sudan Airways, A310-300 at Khartoum, 36 fatalities.
- May 2008: TACA, A320-233 at Tegucigalpa, six fatalities.

None of the 14 accidents noted here were related to previ-

(continued on page 30)

CAUS

WHAT IS IT, AND DOES IT REALLY

By Michael B. Walker (MO4093)
Senior Transport Safety Investigator, Australian Transport Safety Bureau

(This article was adapted, with permission, from the author's paper entitled Causation: What Is It, and Does It Really Matter? *presented at the ISASI 2008 seminar held in Nova Scotia, Canada, Sept. 8-11, 2008, which carried the theme "Investigation: The Art and the Science." The full presentation, including cited references to support the points made, is on the ISASI website at www.isasi.org.—Editor)*

The definition of "cause" in fields such as law has been a matter of significant debate and disagreement. However, there is a widely held view that what is determined as being a cause of a particular event depends on the purpose of the inquiry or investigation. A variety of legally based investigations may follow an accident or incident. These include regulatory or administrative investigations whose purpose is to determine whether any requirements have been breached or to assess the suitability of an individual or organization for ongoing operations.

For such legally based investigations, determining if the individual's or organization's actions played a causal role in the occurrence is not relevant. The legal proceedings of interest here are civil proceedings that arise from an accident. The purpose of such proceedings is the allocation of responsibility for the accident, or at least for the damage or loss resulting from the accident. This purpose is directly achieved when the proceeding's findings state who or what is responsible.

Contrastingly, the purpose of a safety investigation, as outlined by ICAO and others, is to enhance safety (or prevent accidents), not to apportion blame or liability. Safety investigations do not directly achieve their purpose, but information obtained from investigations can be used to enhance safety in many ways, such as

- identifying safety issues that could adversely affect the safety of future operations, and encouraging or facilitating safety action by relevant organizations to address these issues through recommendations or other forms of communication. This is generally the most effective way investigations can enhance safety.
- providing information about the circumstances of the occurrence, and the factors involved in the development of the occurrence, to the transportation industry. Communicating such information provides valuable learning opportunities.
- providing information for an occurrence database that can then be combined with information from other occurrences and used proactively for research and trend analysis purposes and any necessary safety recommendations.

The role of causation in investigations

In legal proceedings, determining causation is essential for achieving the purpose of allocating responsibility. An individual or organization cannot be held legally responsible for an accident unless their conduct has been shown to be a cause.

In safety investigations, determining causation is obviously relevant but not essential for the purpose of enhancing safety. To explain this point, let's look at the Australian Transport Safety Bureau (ATSB) concept of "safety factors."

The ATSB defines a safety factor as an event or condition that increases safety risk. As shown in Figure 1, a safety factor can be categorized in terms of whether it contributed to the development of the occurrence (or was a "contributing safety factor," using ATSB terminology). A safety issue is an organizational or systemic condition that can be reasonably regarded as having the potential to adversely affect the safety of future operations (e.g., problems with procedures, training, safety management processes, and regulatory surveillance). In contrast, a safety indicator is any other type of safety factor (e.g., technical failures, individual actions, or local conditions such as workload) that may indicate the existence of a safety issue.

Each safety factor identified by an investigation fits into one of the boxes in

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ATION MATTER?

The author examines several aspects of legal proceedings and safety investigations to make the point that because legal proceedings and safety investigations have different purposes, they should have different approaches to causation.

Figure 1. Legal proceedings are interested in contributing or causal factors. However, for safety enhancement purposes, importance should reflect the degree of safety risk for future operations. Therefore, the most important safety factors are the safety issues associated with the most risk, and not all of these will be identified during an occurrence investigation as being contributing safety factors.

Accordingly, safety investigations should ideally focus on identifying safety issues, regardless of whether they were contributory or not. However, to purely do this is not possible for a variety of reasons:

• Investigation organizations have various requirements in legislation and standards to determine causes or contributing factors (e.g., ICAO Annex 13).

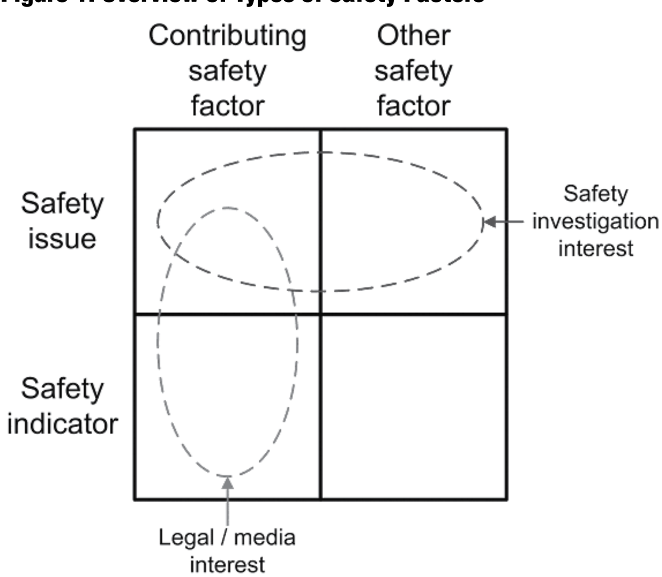
• The public and other stakeholders expect safety investigation reports to identify and discuss the factors involved in the development of an occurrence.

• Some organizations will unfortunately appreciate the importance of a particular safety issue only if it can be shown to have actually been involved in the development of an occurrence.

• The concept of contribution provides a central organizing principle for an investigation. With regard to this last point, safety investigations are not broad audits or examinations of an organization or safety system with unlimited resources. Although any safety factors that are identified during an investigation should be raised in an investigation report, regardless of whether they contributed or not, the search for potential safety factors needs to be pragmatically focused in areas that are related to the circumstances of the occurrence, and the contributing safety factors that have already been identified. In other words, to be efficient and timely, safety investigations should not stray too far from the paths of contribution when searching for potential safety factors.

In summary, for pragmatic reasons causation does matter for safety investigations. However, the primary interest of safety investigations should be identifying safety issues, and causation should be viewed as a means to achieve this rather than as the end point itself.

Figure 1: Overview of Types of Safety Factors



Terminology

Legal proceedings are concerned with determining the "cause" or "causes." In the safety investigation field, organizations use a variety of terms to describe the factors involved in the development of an occurrence. These terms are commonly based on "cause" (e.g., cause, causal factor, direct cause, probable cause, proximate cause, root cause, contributing cause, descriptive cause, explanatory cause), though other terms are also used (e.g., contributing factor, significant factor).

It is relatively common for an organization to use multiple terms. Some organizations use some terms to describe factors that have a closer or higher degree of relationship to the occurrence (e.g., direct cause, proximate cause) whereas other terms are used for factors that have a lower degree of relationship (e.g., contributing factor). Differentiating groups of factors in this way have the significant potential to lead to perceptions that the factors in the closer group are more important or associated with more responsibility for the occurrence than the other factors. As these closer group factors will generally involve technical failures and individual actions rather than safety issues, such perceptions interfere with the purpose of safety enhancement.

Sometimes organizations differentiate terms on the basis of their potential for preventing recurrence (e.g., direct cause versus root cause). This approach emphasizes the importance of addressing the underlying factors. However, it also limits the focus of attention to factors involved in the development of the occurrence, and it does not clearly deal with important safety issues that may be identified but that did not contribute.

Given these observations, there are advantages in just using one term to describe the factors involved in the development of an occurrence. There are also advantages in using a term such as "contributing factor" instead of one based on "cause." Firstly, the term "cause" is commonly used in legal proceedings and therefore is commonly associated with the allocation of responsibility. The use of a different term can help minimize misinterpretation of a safety investigation's findings as being synonymous with those of legal proceedings.

Secondly, when organizations use "contributing factors" or some analogous term together with "causes" or some similar term, the contributing factors are generally described as having a lower degree of relationship to the actual occurrence than the causes. This means that the term "contributing factor" is more inclusive and can therefore provide a richer picture of the factors involved in the occurrence.

For these reasons, the ATSB has chosen to use the term "contributing safety factor." The word "safety" was added to emphasize the safety focus of its investigations.

Definitions

Many legal theorists have proposed that the determination of causes in legal proceedings should be separated from the policy and judgmental aspects of determining which of the causes (if any) should be held to be legally responsible or liable. The latter part of the inquiry involves concepts such as "remoteness" and whether any intervening acts (after the cause of interest) break the "chain of causation," as well as the notion of the extent to which the damage was foreseeable.

However, this distinction between determining causes (without policy judgments) and then determining responsibility (using policy judgments) has often not been reflected in practice, with much confusion in the use of causal language. Many also hold the view that policy and judgment issues are necessary for the determination of causation as well as the determination of responsibility. Part of this view appears to be associated with the lack of agreement on the appropriate test to determine causes.

Many different tests or approaches have been proposed and used for legal proceedings. The most common approach is the use of the "but-for" test, which states that an event or condition (usually an individual's or organization's conduct) is a cause of the damage of interest (for example, injury, death, or other loss) if, but for the act or condition, the damage would not have occurred. In other words, if the cause had not occurred, the accident (or the damage) would not have occurred.

The but-for test (also known as the counterfactual conditional) is widely acknowledged to be simple and works well in most situations. There are some limitations with the test, such as "overdetermination," although these problems are more salient when using the test for legal purposes and are less critical to other fields such as science. Various solutions have been proposed to overcome the limitations, though none appear to solve all the problems and none have been widely agreed upon in the legal field. Consequently, the but-for test is often supplemented by the use of "commonsense" and policy judgments when determining causes in legal proceedings, and the concepts of causation and responsibility are very closely related in such proceedings.

In the safety investigation field, ICAO Annex 13 defines "causes" as "actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident." Such statements describe what types of things causes can be but provide minimal indication of their meaning. Some organizations have adopted the Annex 13 definition, whereas some others appear to have no clear definition. Nonetheless, the but-for test has gained widespread acceptance in the safety field as a means of defining cause-related terms.

The term "contributing factor" is often used without any definition. When it is defined, the definitions can vary widely. For example, it has been described as something that increases the likelihood of an accident, or something that may have contributed to an occurrence. It has also been defined in terms of the but-for test.

The but-for test, also known as the counterfactual conditional, is therefore a common part of legal proceedings and safety investigations. It is also widely used in other fields. Accordingly, the ATSB used the test as the basis for its definition of a "contributing safety factor." More specifically, it defined a contributing safety factor to an occurrence as a safety factor that, if it had not occurred or existed at the relevant time, then either

- the occurrence would probably not have occurred or
- adverse consequences associated with the occurrence would probably not have occurred or have been as serious or
- another contributing safety factor would probably not have occurred or existed.

However, there are two important aspects of the ATSB definition that are different from how the but-for test is generally used. These include the linking approach and the standard of proof included in the definition.

Linking approaches

In seeking an answer to the question "What does the proposed cause or contributing factor link to?" there are two basic approaches: the relative-to-occurrence approach and the link-by-link approach (see Figure 2).

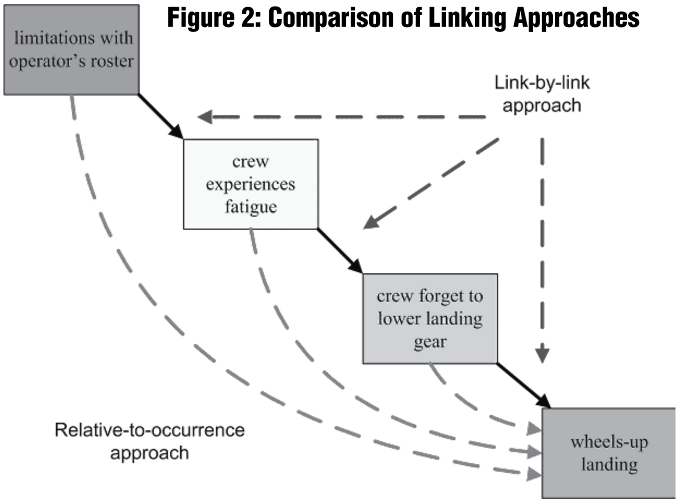
In the relative-to-occurrence approach, the subject is the occurrence itself: If the safety factor did not happen, then the occurrence would not have happened. This is the approach used in legal proceedings, with the subject being the accident or the damage resulting from the accident. It is also often used in safety investigations, with the subject being the occurrence, or in some cases also the severity of the consequences arising from the occurrence.

In the link-by-link approach, judgments about contribution are made about the strength of links between factors, rather than made in terms of the overall relationship between each potential factor and the occurrence itself. The ATSB definition incorporates a link-by-link approach. Others have also advocated a link-by-link approach for safety investigations, and the International Maritime Organization has also recently adopted a similar definition to the ATSB, using the term "causal factor."

Comparing approaches

The relative-to-occurrence approach has merit when the purpose is to determine responsibility for an occurrence. However, there is a significant dilemma associated with the approach that fundamentally con-

Figure 2: Comparison of Linking Approaches



strains its potential for enhancing safety; the most effective findings for safety enhancement (safety issues) are the most difficult to justify. As discussed above, for pragmatic reasons an investigation cannot stray too far from the paths of contribution when searching for potential factors. The more remote the safety investigation proceeds away from the occurrence when identifying potential factors, the more difficult it becomes to meet the relevant standard of proof for contribution or causation. As safety issues are generally quite remote from the occurrence, they are generally going to be less likely to be looked for or found to be contributing or causal.

In contrast, by making judgments about each link separately, the link-by-link approach has more scope to proceed more remotely from the occurrence. The approach therefore has the potential to identify more safety issues (whether ultimately with sufficient evidence to be termed contributing or not), as well as providing more learning opportunities by providing a richer picture of the factors involved.

There are other advantages associated with a link-by-link approach compared to relative-to-occurrence approach. A link-by-link approach can lead to simpler judgments about contribution and better enable a safety investigation to be more open and intellectually rigorous. In addition, a relative-to-occurrence approach is used in legal proceedings, and the findings of safety investigations conducted using this approach can therefore be readily interpreted in terms of a legal perspective. Thus, this association with legal proceedings has the potential for some parties to respond to safety investigation findings with future liability and compensation consequences in mind.

Still, there are also potential problems with a link-by-link approach. Firstly, there may be a greater tendency to proceed too remotely from the occurrence and identify factors that cannot be practicably addressed by any organization. This problem can be minimized with a clear definition of a "stop rule" and consideration of the concept of practicability when identifying potential factors.

A second problem is that findings about safety issues produced using a link-by-link approach can be misinterpreted by some parties as being based on a relative-to-occurrence approach. As a result, some of the findings about contributing and causal factors may be perceived by these parties to be weak or poorly supported. Such misinterpretation can interfere with an understanding of the importance of addressing the safety issues in order to reduce the risk of future accidents.

The potential for misinterpretation of the link-by-link approach can be minimized by clearly defining the types of findings and the approach being used by the investigation, and by emphasizing that findings produced with the link-by-link approach should not be directly compared to findings produced by a relative-to-occurrence approach. Misinterpretation can also be minimized by considering the standard of proof that is used for the links.

Standard of proof

In the legal system, the term "standard of proof" is used to refer to the degree of certainty with which a contested fact (such as determination of a cause) must be established in order to be accepted or proven. Different standards of proof are applied depending on the implications associated with an erroneous decision for the parties involved.

In civil proceedings, the standard of proof is termed "proof beyond the balance of probabilities" in some countries or "preponderance of the evidence" in the U.S. This is a lower standard than that used in criminal proceedings (beyond reasonable doubt), with the general view being that the risk of an erroneous decision should be the same for both parties in civil proceedings, although only one party will have the "burden of proof."

The civil standard is generally interpreted to mean that the matter of interest has to be found to have "more likely than not" occurred. However, the standard is not that straightforward. There is a general view that it is unreasonable to take the same approach to making findings for more serious matters as it is for relatively minor matters. As a result, decision-makers may vary the standard of proof required, or vary the standard of evidence (or quantity or quality of evidence) they will accept before determining that the standard of proof has been met. Many aspects of these determinations are not well specified.

As far as the ATSB is aware, most organizations that conduct safety investigations do not clearly specify the standard of proof (or standard of evidence) they use when making findings regarding contributing or causal factors. In selecting an appropriate standard for its purposes, the ATSB was aware that the use of a high or conservative standard (such as "beyond reasonable doubt," "almost certain," or similar) would produce few contributing safety factors in most investigations, particularly in terms of safety issues. The ATSB was also aware that the use of a relatively low standard (such as "balance of probabilities"), combined with a link-by-link approach, could produce more contributing safety factors that would be perceived by many parties as having a relatively weak role in the overall development of an occurrence.

To achieve an appropriate compromise, the ATSB definition of contributing safety factor was aligned with a standard of "probable" or "likely." Initially this was defined as meaning a likelihood of 75% or more, based on a conservative interpretation of research into what different parties considered different verbal probability expressions to mean. However, this was changed to a likelihood of more than 66% (or a two-in-three chance) following the high-profile usage of that definition by the Intergovernmental Panel on Climate Change in early 2007.

Compared with legal proceedings using a relative-to-occurrence approach and a balance of probabilities standard, the ATSB approach will use a higher standard of proof for factors relatively close in proximity to the occurrence (that is, more than 66% versus more than 50%). But as an ATSB safety investigation proceeds to identify contributing safety factors more remote from the occurrence, the degree of relationship of the factors to the occurrence itself will generally decrease using the ATSB approach.

For example, consider the situation outlined in Figure 2. If the link between the roster problems and fatigue was assessed as being at least a 67% likelihood, and the link between fatigue and the crew's action was assessed as being at least a 67% likelihood, then the resulting likelihood of a relationship between the roster and the crew's action could be as low as 45%. The more links in the chain, then the lower the likelihood could be between the first (highest-level) factor and the occurrence.

The reduction in the likelihood between a higher-level factor and the occurrence itself over multiple links may not be substantial in practice. In many situations, the likelihood level for each link will be higher than the minimum required level of more than 66%. Nevertheless, for contributing safety factors that are safety issues, the balance of probabilities standard for a direct relationship to the occurrence itself may not be met. As a result, all that can be said in such situations is that, if the contributing safety factor had not existed, then the occurrence "**may**" not have occurred.

Level of guidance

Making decisions about what events and conditions should be found to be contributing or causal factors can be difficult. To assist in making these judgments, investigators need more than clear definitions. However, for both legal proceedings and safety investigations, the means of examining the evidence and making determinations is usually not formally defined and relies extensively on the expertise of the decision-maker.

This does not mean to imply that some investigation approaches do not conduct a detailed, thorough, or high-quality examination of the available evidence when determining contributing or causal factors. However, to improve the consistency and rigor of the decision-making, a more systematic approach is warranted: There needs to be more science and less art.

To address this need, the ATSB analysis framework includes several elements to assist in the determination of findings. These elements include

- a structured and defined process for identifying potential safety factors.
- a process for testing a potential safety factor in terms of its existence, influence, and importance.
- a tool known as an "evidence table" for conducting a structured examination of the available evidence when doing the tests.
- lists of criteria to consider when evaluating items of evidence, evaluating sets of evidence, and making judgments on existence, influence, and importance.
- general guidance on critical reasoning principles.

The ATSB experience

The ATSB has been using its new terminology (including "contributing safety factor"') in investigations reports since 2006. The most high profile example was the ATSB investigation into the fatal Metro 23 accident near Lockhart River on May 7, 2005. In a recent coronial inquest into this accident, aspects of its definitions were queried by one party and the coroner. These queries related to the standard-of-proof aspect rather than the definition itself, and they have been discussed and addressed in detail in the ATSB Aviation Research and Analysis Report AR-2007-053.

However, during the investigation and inquest, it was apparent that there was some misinterpretation of the ATSB findings and its use of the link-by-link approach. For example, the civil aviation safety authority (CASA) chief executive officer made a news media statement that he did not accept that CASA "caused the errors on the flight deck that resulted in the accident," and that although there was "room for improvement" in CASA's oversight processes, these problems could not be linked "directly" to the failures that occurred on the flight deck.

However, the ATSB report did not state that CASA directly contributed to the crew's actions or the occurrence itself. The ATSB report concluded that limitations with the design of CASA's regulatory oversight processes contributed to CASA not being able to detect fundamental problems with the operator's safety management processes. Using a link-by-link approach, these safety management problems were in turn linked through various risk controls and local conditions with the crew's actions involved in the occurrence.

To minimize the potential for such misinterpretations in the future, future ATSB investigation reports will include clear statements to explain that ATSB investigations use a different methodology and will often produce different findings compared with legal proceedings or other types of investigation and that the use of the term "contributing safety factor" should not be considered as being equivalent to "causes" in a legal sense, or reflect what the findings of a legal proceedings would produce.

Conclusions

Causation is a complex concept; and to effectively address it, an investigation organization needs to consider many aspects. The ATSB has examined these aspects and developed an approach to causation that is tailored to the purpose of safety investigation.

Different organizations have different contexts, and not all aspects of the ATSB approach will be appropriate for other organizations. However, based on the ATSB experience, the following principles can be offered for those interested in reviewing or developing their own approach:

- Terms and definitions should be clearly distinguished from those used in legal proceedings.
- Contributing or causal factors should not be differentiated in terms of their degree of involvement with the occurrence.
- The importance of factors should be based on their future risk rather than degree of involvement with the occurrence.
- The definition of cause-related terms should have a broad scope for inclusion and readily permit investigators to identify potential safety issues that are remote from the occurrence.
- Terms and definitions need to be supported by a comprehensive investigation analysis framework to assist investigators in making judgments. ◆

(Editor's note: For a more detailed discussion about concepts such as causation and standard of proof, see Walker, M.B., & Bills, K.M. (2008). Analysis, Causality, and Proof in Safety Investigations. *ATSB Aviation Research and Analysis Report AR-2007-053. Canberra, Australia: Australian Transport Safety Bureau.)*

Do Cultural Characteristics Affect Investigations?

The challenge for safety is not to ignore cross-cultural issues influencing safety but to manage the potential risks they may present.

By Wen-Chin Li, Hong-Tsu Young, Thomas Wang, and Don Harris

(This article was adapted, with permission, from the authors' paper entitled Approaches to Accident Investigation by Investigators from Different Cultures *presented at the ISASI 2008 seminar held in Nova Scotia, Canada, Sept. 8-11, 2008, which carried the theme "Investigation: The Art and the Science." The full presentation, including cited references to support the points made, is on the ISASI website at www.isasi.org.—Editor)*

The collective nature of Chinese society is consistent with its broad, contextual view of the world and the Chinese belief that events are highly complex and determined by many factors. On the other hand, the individualistic nature of Western society is consistent with a focus on particular objects in isolation from their context and with Westerners' belief that they can know the rules governing objects and therefore can control that object's behavior. Westerners have a strong interest in categorization, which helps them know what rules to apply to objects, and formal logic plays a major role in problem solving.

The Chinese attend to objects within their broad context. The world seems more complex to the Chinese than to Westerners, and understanding events always requires consideration of many factors that operate in relation to one another in a complex manner. From the *I-Ching* (the ancient Chinese book of philosophy): "*For misery, happiness is leaning against it; for happiness, misery is hiding in it. Who knows whether it is misery or happiness? There is no certainty. The righteous suddenly becomes the vicious; the good suddenly becomes the bad.*" Chinese are less concerned with finding the truth than with finding a harmonious way to live in the world. In part, the Chinese failure to develop science can be attributed to a lack of curiosity, but the absence of a concept of nature would also have served to inhibit the development of science.

C. Kluckhohm proposed one well-known definition for culture: "Culture consists in patterned ways of thinking, feeling, and reacting, acquired and transmitted mainly by symbols constituting the distinctive achievements of human groups, including their embodiments in artifacts; the essential core of culture consists of traditional ideas and especially their attached values." If the majority of people in a society have the same way of doing things, it becomes a constituent component of that culture. According to A. Merritt and D. Maurino, a culture is formed by its environment and evolves in response to changes in that environment; therefore, culture and context are really inseparable.

Commercial aviation accident rates differ among global regions. Asia has a higher accident rate (5.1 and 8.0 accidents/million departures) than either America or Europe (1–1.5 accidents/million departures). The underlying causal factors also show differences between the regions. In Asia, failures in crew resource management (CRM) are the most frequent circumstantial factor in accidents. An analysis of accidents involving aircraft from Asia (Taiwan) by Li, Harris, and Yu using the Human Factors Analysis and Classification System found that poor CRM was related to subsequent errors in decision-making, perceptual errors, and violations in procedures. These subsequent error categories showed a thirty- to fortyfold increase in their likelihood of occurrence in the presence of poor CRM.

Regional differences in accident rates have a major impact on CRM implementation and crew performance. There is a difference in how CRM training is perceived across the world. In the U.S., CRM is normally seen as the primary vehicle to address human factors issues. Other countries perceive human factors and CRM as overlapping concepts, viewing them as close but distinct relatives.

However, cultural issues in aviation operations run deeper than simply issues in CRM. They pervade all aspects of operations (including standard operating procedures) and ultimately stem from issues in design. For example, Westerners tend to adopt a function-oriented model (where stimuli are grouped in terms of their purpose) connected to a task-oriented operating concept (where specific actions are performed to achieve well-defined results) resulting in a preference for a sequential approach to undertaking tasks (inherent in checklists and SOPs). The Asian preference is for an integrated, thematic approach (where stimuli are grouped in terms of common, generic interrelationships); hence a task-oriented operating concept contradicts their preferred method of working.

There are also fundamental differences in the mental models of people in these cultures. As mentioned previously, Westerners have a strong interest in categorization, which helps them know what rules to apply to the objects. In contrast, the Chinese believe in constantly changing circumstances; they pay attention to a wide range of events and search for relationships between things. The Chinese think you can't understand the part without understanding the whole. Westerners apply a logical and scientific approach and occupy a simpler, more deterministic world. Westerners focus on salient objects instead of the larger picture,

The Asian preference is for an integrated, thematic approach (where stimuli are grouped in terms of common, generic interrelationships); hence a task-oriented operating concept contradicts their preferred method of working.

and they think they can control events because they know the rules that govern the behavior of objects. The Chinese are disinclined to use precisely defined terms or categories in many areas but instead use expressive, metaphoric language, e.g., "painting a dragon and dotting its eyes" (means hit the point). From the *Tao Te Ching*, *"The heavy is the root of the light; the unmoved is the source of all movement; to shrink something, you need to expand it first; to weaken something, you need to strengthen it first; to abolish something, you need to flourish first."* The dialectical thought of the Chinese Yin-Yang principle is in some ways the opposite of Western-style logical thought. It seeks not to decontextualize but to see things in their appropriate contexts. Chinese believe that what seems to be true may be the opposite of what it seems to be. However, from a Western viewpoint, the Chinese seem to not only lack logic but to even deliberately apply principles of contradiction.

There is an interesting issue that results from these differences between cultures and regions. Culture is not just about the superficial, observable differences between counties, their food, their style of clothes, and even their languages. There are some fundamental cognitive differences in reasoning, organization of knowledge, structures of causal inference, and attention and perception between Eastern and Western cultures. These issues manifest themselves in the following manner. Westerners are likely to overlook the influence of the wider context on the behavior of objects and even of people. However, Asian cultures are more susceptible to "hindsight bias." Westerners

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HFACS Category		United Kingdom N=16		Taiwan N=16		Chi Square df = 1	
		Frequency	Percentage	Frequency	Percentage	Value	p
Level-4 Organizational Influences	Organizational process	15	93.8	11	68.8	3.29	<0.10
	Organizational climate	12	75.0	8	50.0	2.13	N/S
	Resource management	13	81.3	10	62.5	1.39	N/S
Level-3 Unsafe Supervision	Supervisory violation	12	75.0	12	75.0	0.00	N/S
	Failed to correct a known problem	10	62.5	13	81.3	1.39	N/S
	Planned inadequate operations	12	75.0	9	56.3	1.24	N/S
	Inadequate supervision	12	75.0	8	50.0	2.13	N/S
Level-2 Preconditions for Unsafe Acts	Technology environment	11	68.8	14	87.5	1.64	N/S
	Physical environment	5	31.3	5	31.3	0.00	N/S
	Personal readiness	5	31.3	8	50.0	1.16	N/S
	Crew resource management	15	93.8	15	93.8	0.00	N/S
	Physical/mental limitation	10	62.5	9	56.3	0.13	N/S
	Adverse physiological states	2	12.5	1	6.3	0.36	N/S
	Adverse mental states	15	93.8	6	37.5	11.22	<0.001
Level-1 Unsafe Acts of Operators	Violations	13	81.3	11	68.8	0.67	N/S
	Perceptual errors	5	31.3	11	68.8	4.50	<0.05
	Skilled-based errors	14	87.5	11	68.8	1.64	N/S
	Decision errors	15	93.8	15	93.8	0.00	N/S

Table 1. Frequency and Percentage Counts of Causal Factors Deemed as Being Present in the Ueberlingen Accident in the HFACS Framework Broken Down by Eastern and Western Investigators

are more likely to apply formal logic when reasoning about events, but Easterners are more willing to entertain apparently contradictory propositions.

Do differing cognitive styles matter?

The aim of this research on which this article is based was to establish if the different cognitive styles of European and Chinese accident investigators have an effect on the conclusions drawn when conducting an accident investigation.

Participants—The participants in the study were 16 Chinese (Taiwanese) accident investigators and 16 British accident investigators. As much as possible, the participants were matched for experience. They had a background as pilots, air traffic controllers, airline safety officers, and maintenance staff.

Data—The research data were based on the narrative descriptions from the Ueberlingen accident report (BFU: AX001-1-2/02) occurring on July 1, 2002.

Analytical tool—The Human Factors Analysis and Classification System (HFACS, Wiegmann and Shappell, 2003) was used as a basis upon which to classify the factors in the accident. HFACS is based upon Reason's (1990) model of human error in which active failures are associated with the performance of front-line operators in complex systems. Latent failures are characterized as inadequacies or mis-specifications that lie dormant within a system for a long time and are only triggered when combined with other factors to breach the system's defenses. The first (operational) level of HFACS classifies events under the general heading of "unsafe acts of operators." The second level of HFACS concerns "preconditions for unsafe acts." The third level is "unsafe supervision," and the fourth (and highest) organizational level of HFACS is "organizational influences."

Research design—All participants were trained for 2 hours by an aviation human factors specialist in the use of the HFACS. This was followed by a debriefing sessions, then a summary of the events in the Ueberlingen mid-air crash was presented. All the participants then received a blank form to code their HFACS data to classify the contributing factors underlying this accident. This study used the version of the HFACS framework described in Wiegmann and Shappell (2003). The presence (coded 1) or absence (coded 0) of accident factors falling within each HFACS category was assessed by the investigators. To avoid overrepresentation from any single accident, each HFACS category was counted a maximum of only once per accident. Thus, this count acted simply as an indicator of presence or absence of each of the 18 categories in the Ueberlingen accident.

Differences in the frequency of use of each HFACS category by Chinese and British investigators were examined using a chi-square (χ^2) test of association. Further analyses examining the association between the categories in higher and lower levels of the HFACS framework were also performed. As there is no identifiable dependent or independent variable in a χ^2 test of association, these analyses were supplemented with further analyses using Guttmann and Kruskal's tau (χ), which was used to calculate the proportional reduction in error (PRE).

Results and discussion

The results of frequencies and percentages of HFACS categories used by Chinese and British investigators when analyzing the Ueberlingen accident are shown in Table 1. In general, there were few significant differences in the frequency of use of the HFACS categories between British and Chinese accident investigators. The only significant differences were related to the frequency of use of the categories concerned with "adverse mental state" (HFACS Level-2) and "perceptual error" (Level-1). As has been noted previously, UK investigators were more likely to attribute "adverse mental state" as a psychological precursor to the accident, and the Taiwanese participants were more predisposed to attributing the accident to a "perceptual error." This may reflect reluctance on the part of Eastern participants to utilize the category of "adverse mental state" as it possibly has a degree of stigma attached to it. Chinese investigators may have opted to use the less blameworthy category of "perceptual error."

However, there are interesting findings with regard to the different patterns of causality between the different levels of the HFACS analyses between the Chinese investigators and British investigators. Using the analytical methodology described in W-C. Li and D. Harris's *Pilot Error and Its Relationship with Higher Organizational Levels: HFACS Analysis*

Data from Eastern Participants (Taiwan)	Pearson Chi-square test			Goodman & Kruskal Tau		Odds ratio
	Value	df	P	Value	p	Value
Organizational process * Inadequate Supervision	7.27	1	.002	.46	.009	NS
Organizational climate * Supervisory violation	5.33	1	.021	.33	.025	NS
Organizational climate * Planned inadequate operations	6.35	1	.012	.40	.015	21.00
Organizational climate * Inadequate Supervision	16.00	1	.000	1.00	.000	NS
Resource Management * Inadequate Supervision	9.60	1	.002	.60	.003	NS
Supervisory violation * Personal readiness	5.33	1	.021	.33	.025	NS
Planned inadequate operations * Personal readiness	6.40	1	.012	.40	.015	21.00
Inadequate Supervision * Physical environment	7.27	1	.007	.46	.009	NS
Inadequate Supervision * Personal readiness	9.00	1	.003	.56	.004	49.00
Inadequate Supervision * Physical/mental limitation	6.35	1	.012	.40	.015	21.00
Technology environment * Perceptual errors	5.03	1	.025	.31	.030	NS
Technology environment * Decision errors	7.74	1	.006	.47	.008	NS
Personal readiness * Perceptual errors	7.27	1	.007	.46	.009	NS
Physical/mental limitation * Skill-based errors	3.88	1	.049	.24	.050	10.667

Table 2. Chi-square Test of Association, Goodman and Kruskal's Tau and Odds Ratios Summarizing Significant Associations Between Categories of HFACS Framework for Chinese Investigators

Data from Western Participants (United Kingdom)	Pearson Chi-square test			Goodman & Kruskal Tau		Odds ratio
	Value	df	P	Value	p	Value
Planned inappropriate operations *Technology environment	4.75	1	.029	.30	.025	15.00
Personal readiness * Skill-based errors	5.03	1	.025	.31	.030	NC
Adverse physiological states * Perceptual errors	5.03	1	.025	.31	.030	NC
Adverse mental states * Decision errors	16.00	1	.000	1.00	.000	NC
Adverse mental states * Violations	4.62	1	.032	.29	.037	NC

NC: *Not computed due to a zero frequency in one cell of the contingency table*

Table 3. Chi-square Test of Association, Goodman and Kruskal's Tau and Odds Ratios Summarizing Significant Associations Between Categories of HFACS Framework for British Investigators

of 523 Accidents (2006) and Li, Harris, and Yu's *Routes to Failure: Analysis of 41 Civil Aviation Accidents from the Republic of China Using the Human Factors Analysis and Classification System* (2008) to analyze the relationships between HFACS categories, the data sets from the Chinese and British investigators were analyzed separately. The results of the Chi-square, Goodman and Kruskal's tau and odds ratios for the Chinese investigators, are given in Table 2; the results for the British investigators are given in Table 3. These results are also depicted graphically in Figures 1 and 2, respectively.

What is noticeable is that there are differences in the pattern of results described by Goodman and Kruskal's tau between the investigators from Britain and China. Goodman and Kruskal's tau has the advantage of being a directional statistic. In the analyses described in Tables 2 and 3 (and Figures 1 and 2), the lower-level categories in the HFACS were designated as being dependent upon prior actions in the categories at the immediately higher level in the framework, which is congruent with the theoretical assumptions underlying HFACS. The value for tau in these tables indicates the strength of the relationship, with the higher levels in the HFACS being deemed to influence (cause) changes at the lower organizational levels, thus going beyond what may be deemed a simple test of co-occurrence between categories, which is the basis of the simple χ^2 test of association.

There were 14 pairs of HFACS categories in adjacent organizational levels that had significant associations between causal factors in the Ueberlingen accident based on the analysis provided by Chinese investigators. Further examination of Goodman and Kruskal's tau showed five significant associations between categories at Level-4 and Level-3, five significant associations between categories at Level-3 and Level-2, and four significant associations between categories at Level-2 and Level-1 (see Figure 1). There are also five pairs of associations between categories that had a high odds ratio. These suggested that "poor operational practices" were more than 21 times more likely to occur when associated with poor higher levels of "organizational climate." For the Chinese investigators, the highest odds ratio was for "personal readiness," which was 49 times more likely to occur in the accident sequence when associated with "inadequate supervision" (see Table 2).

There were five pairs of HFACS categories in adjacent organizational levels that had significant associations between causal factors in the Ueberlingen accident based upon the data provided by British investigators. There were no significant associations of categories between HFACS Level-4 and Level-3, one significant association between categories at Level-3 and Level-2, and four significant associations between categories at Level-2 and Level-1 (see Figure 2). Furthermore, from the analyses performed by the British investigators, there was only one pair of association between categories that had a high odds ratio. This suggested that the problem of "technology environment" was more than 15 times more likely to occur when associated with "planned inadequate operations" (see Table 3).

This pattern of associations described diagrammatically in Figures 1 and 2 may reflect the different cognitive styles of Eastern and Western accident investigators, who are in turn products of their respective cultures. For Eastern investigators, many categories were associated with each other reflecting a predisposition for a holistic understanding of the events in their wider context.

However, the British (Western) accident investigators preferred patterns of explanation that ultimately lead directly to the accident event. Focus was on specific objects (categories). The decontextualization and object emphasis favored by

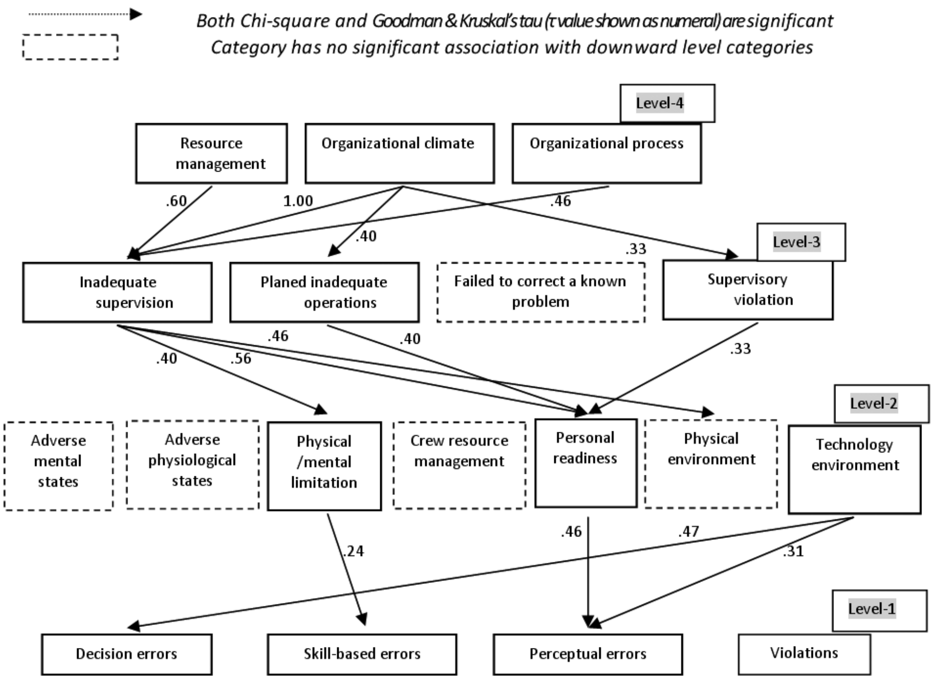

Figure 1. **Significant association of causal factors for the Ueberlingen accident at the four levels of the HFACS framework as categorized by Eastern (Taiwanese) aircraft accident investigators.**

Westerners and the integration and focus on many complex relationships by Easterners resulted in very different ways of making inferences about the accident, as was evident in the patterns of associations depicted in Figures 1 and 2. These may reflect the fundamental differences between Chinese and Western minds.

In terms of patterns of attention and perception, Eastern cultures attend more to the environment; people from Western cultures attend more to objects. In science and technology, Western truth stimulated analytic thinking, whereas Eastern virtue led to synthetic thinking. Through these different logics, Eastern and Western people followed different paths in developing government and in developing their respective science and technology. This analysis further demonstrates that people from different cultures differ in cognition in ways that result in different perceptions, judgments, and decisions concerning the factors at play in the sequence of events in an accident.

As a result, it is argued that Chinese investigators will be predisposed to approaching accident investigation in a holistic manner, attempting to understand the complex relationship of causal factors leading to an accident. The Chinese conviction about the fundamental relatedness of all things made it obvious to them that objects are altered by context. Trying to categorize objects with exactness would not have seemed to be of much help in comprehending events. The world was simply too complex for categories for understanding objects or controlling them. The Chinese might be right about the importance of the field to understanding the behavior of the object and they might be right about complexity, but their lack of interest in categories prevented them from discovering laws that really were capable of explaining classes of events.

As H. Nakamura in *Ways of Thinking of Eastern Peoples: India, China, Tibet, Japan* (2003) noted, the Chinese advances reflected a genius for practicality, not a penchant for scientific theory and investigation. The process of accident investigation is almost akin to a Western notion of art. British (Western) investigators are more predisposed to approaching accident investigation (and human behavior) using rules of logic. Accident investigation is almost a scientific process.

When Western engineers develop flight operation systems, training manuals, and standard operation procedures, they integrate their own vision of the world, which itself is heavily influenced by their cultural norms. They implicitly assume that all users around the world share their reasoning and values. H.A. Klein in *Cognition in Natural Settings: The Cultural Lens Model* (2004) observed that people from different nations differ in their cognition in ways that result in dissimilar perceptions, judgments, and decision-making. National culture provides a fundamental basis for a group member's behavior, social roles, and cognitive processes. A frequently used example is that Western copilots (British) from a low power distance culture are more likely to question the actions of their captains. However, copilots from Eastern (China) high power distance countries dare not to speak out when their opinions may contradict their captain.

According to G. Hofstede's classification of national culture, the working environments of Taiwan prefer tall organizational pyramids with centralized decision structures and have a large proportion of supervisory personnel. In these cultures, subordinates expect to be told what to do. However, members of these cultures frequently experience role ambiguity and overload. In general, group decisions are preferred but information is constrained and controlled by the hierarchy and there is resistance to change.

On the other hand, the working envi-

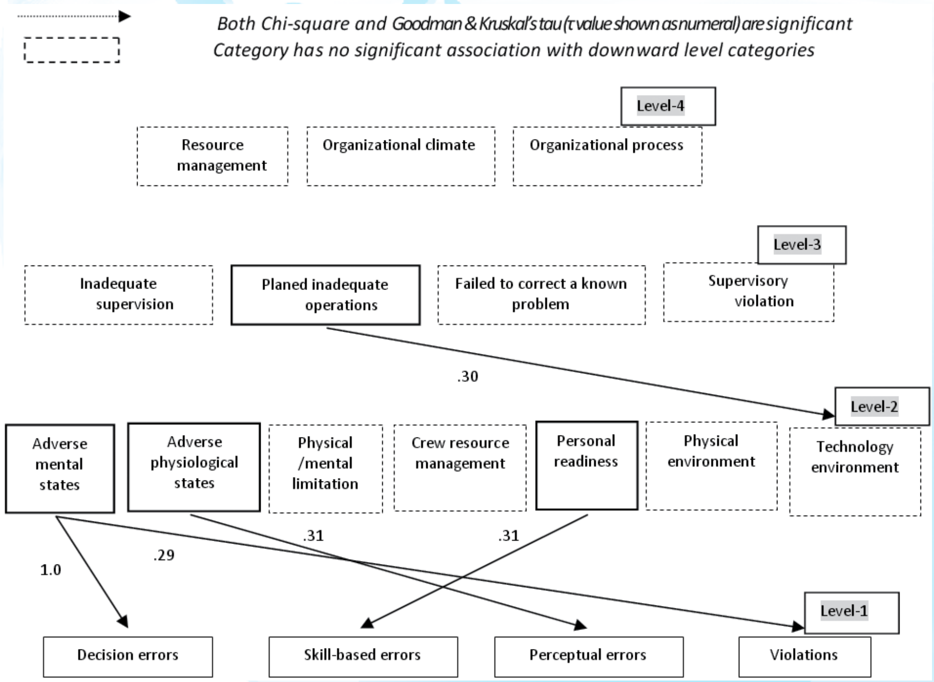

Figure 2. **Significant association of causal factors for the Ueberlingen accident at the HFACS framework as categorized by Western (British) aircraft accident investigators.**

ronment of the UK exhibits low power distance and is a culture high on individualism. Flat organizational structures are preferred with a relatively small proportion of supervisory personnel. Subordinates expect to be consulted. Self-orientation and identity is based on the individual, and individual decisions are regarded as being superior.

The design of the aircraft, the management procedures, and the nature of safety regulation all have a strong Western influence. So it is not too surprising that a Western country comes out better when using the HFACS to analyze the underlying causes of accidents. However, it could even be argued that the accident analysis system itself has an implicit cultural bias within it. The way Chinese investigators and British investigators attribute the causal factors at play in the same accident seems to be completely different. A simple frequency count of the categories used by accident investigators would seem to suggest that there is no difference between investigators from the two cultures. However, when the underlying causality between categories at different levels of HFACS is analyzed, a completely different pattern emerges between Eastern and Western investigators. It is difficult to say that either of these views is either right or wrong. You may only conclude that they are different. Global aviation is strongly influenced by Western mindsets; however, the challenge for safety is not to ignore these cross-cultural issues influencing safety but to manage the potential risks they may present. The ultimate purpose of accident investigation is to find the best approach for accident prevention strategies around the world. This may require local, culturally congruent solutions, not the universal solutions currently being pursued in many cases.

Conclusion

Separating the people from the problem assumes an individualist value set underlying the Western approach to investigation. In collectivist cultures, where relationships prevail over tasks, this is an almost impossible demand. Effective investigation of aviation accidents within different cultural contexts demands insight into the range of cultural values to be expected among partners from other countries, in addition to an awareness of the investigator's own culturally determined values. Effective international investigations also demand language and communication skills to guarantee that the messages sent to the other professional investigators from different cultures with different approaches to accident investigation will be understood in the way they were meant to be.

The global interaction between different cultures involves sharing the values of all partners. It is important to know more about the similarities and differences in culture-influenced accident investigation philosophies, e.g., when European and Asian culture collaborate together. The cognitive orientation and mechanisms of Eastern and Western cultures are sufficiently different that they may draw completely different inferences from the same set of data (as in this case), especially in the case where human factors are concerned. The best approach may be to try to understand the events in the accident from the viewpoint of the culture of the pilots/airline involved in the accident and not from the cultural viewpoint of the investigator. This way there might be a better chance that culturally congruent remedial actions can be proposed. However, by better understanding these cultural differences it seems highly likely that they can only serve to complement and enrich each other.

There is no one "objective" truth to any accident investigation. Whether we realize it or not, all conclusions (and the process by which we reach them) are deeply influenced by our culture. ◆

Investigating Unmanned Aircraft System Accidents

It doesn't matter whether you are a friend or a foe of unmanned aircraft systems. They are coming. The author provides basics of unmanned aircraft systems —what they are, how they work, and the hazards they pose—and how that basic knowledge can be applied to investigating UAS accidents.

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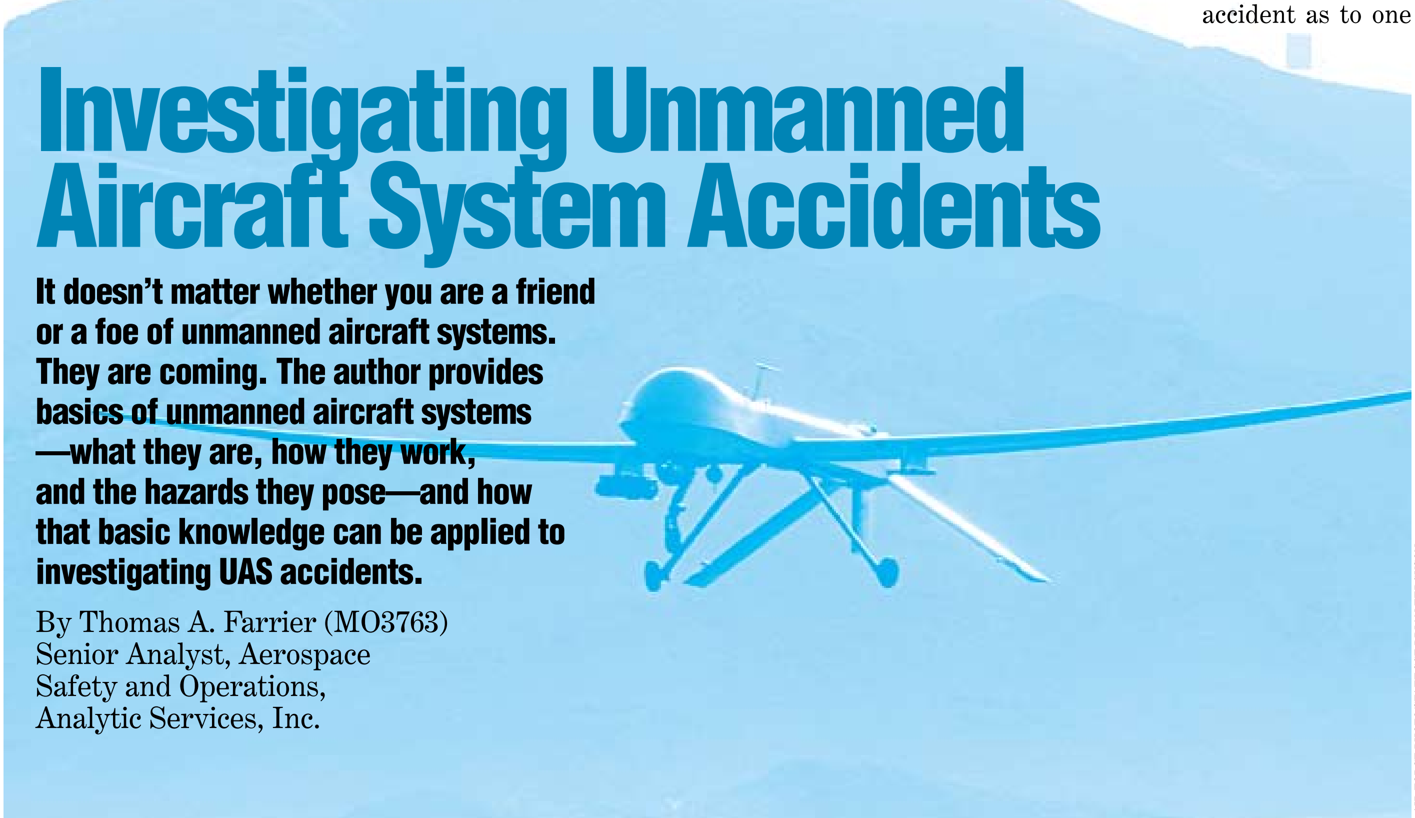

U.S. AIR FORCE PHOTO/STAFF SGT. BRIAN FERGUSON

(This article was adapted, with permission, from the author's paper entitled Investigating Unmanned Aircraft System Accidents *presented at the ISASI 2008 seminar held in Nova Scotia, Canada, Sept. 8-11, 2008, which carried the theme "Investigation: The Art and the Science." The full presentation, including cited references index, is on the ISASI website at www.isasi.org.—Editor)*

It doesn't matter whether you are a friend or a foe of unmanned aircraft systems. They are coming. Unmanned aircraft systems (UAS) of virtually every possible type will, at some point in the not-too-distant future, share most classes of airspace with occupied aircraft.

Many commercial concerns looking to build and sell unmanned aircraft systems have virtually no prior experience in the aerospace domain, but their desire to gain a foothold in an entirely new kind of market is leading them to innovate. Similarly, many governmental entities perceive great value in the kinds of capabilities that UAS provide, but are not pursuing their development in a consistent manner. These two factors suggest that many practices long held to be "industry standard" in the areas of aircraft manufacture and operations are going either unrecognized or disregarded in the quest to move forward in the UAS arena.

Meanwhile, regulators have been obliged to make many critical decisions regarding the safety of various technologies, operational concepts, and rule-driven requirements for unmanned aircraft almost exclusively on the basis of manned aircraft experience. None of the processes currently used to evaluate UAS risks and authorize UAS operations were designed with UAS in mind. The long-term correctness of regulatory strategies resulting from these processes will be judged, at least in part, on the nature of safety issues identified through UAS accident investigations. This means that, for the foreseeable future, every UAS investigation carries with it the potential to make a significant contribution to regulatory decision-making.

What is an unmanned aircraft system?

There is general agreement by both International Civil Aviation Organization and U.S. Federal Aviation Administration authorities that the flying part of an unmanned aircraft system meets the definition of an "aircraft" for regulatory purposes. However, beyond that top-level understanding, there is a near-total absence of regulatory language that can shed light on what a UAS is or is not.

The baseline definition of "aircraft" is a good place to start, especially if you're an air safety investigator. There's a substantial body of knowledge our profession has assembled and can draw upon that's as applicable (with a few caveats discussed below) to a UAS accident as to one

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involving a widebody passenger jet.

Next, consider the "unmanned" part of the current term of art. There are occasional attempts to render this term more gender-neutral through substitution of the word "uninhabited" as the "U" in UAS. Setting aside the imprecision of that word in the context of an aircraft (as well as it's being a bit more of a mouthful to say), there's some virtue in the general concept it expresses. For the foreseeable future, there will be no such thing as an occupied UAS, because there is unlikely to be a viable combination of a sufficiently refined business model (or military requirement) and a sufficiently reliable UAS to support passenger operations. So, let's stipulate that an "unmanned aircraft" is an aircraft with no one aboard.

Now comes the tricky part. Special Committee 203 (SC-203) of RTCA developed a working definition that addresses most of the above considerations, but is a bit vague when it comes to the "system" part of the naming convention. In DO-304, Guidance Material and Considerations for Unmanned Aircraft Systems (March 22, 2007), SC-203 defines a UAS as follows: *An unmanned aircraft system is an unmanned aircraft and its associated elements required to operate in the NAS. An unmanned aircraft (UA) is an aircraft operated without the possibility of direct human intervention from within or on the aircraft.* The word "system," as used in this document, includes all elements that make up a UAS.

As far as the last sentence is concerned, there's a lot of devil in this particular detail. Apart from the design differences that exist among the various types of aircraft meeting the broad definition of "UA," there are a host of possible ways that such aircraft can be controlled "without direct human intervention"—some resident on the airframe itself, and some requiring interactions between a UA and a pilot located elsewhere. However, the means by which an unmanned aircraft is controlled becomes a relatively small consideration when one acknowledges that a UAS is at once a stand-alone system and a part of a far larger, highly structured existing aviation system.

Unmanned aircraft system segments

SC-203 has done much to develop and elaborate on some fundamental concepts regarding general characteristics of UAS operations. One SC-203 concept that is readily applicable to understanding the hazards associated with UAS operations and by extension, the potential root causes of UAS accidents is what they term the "segments" of unmanned aircraft systems.

In the context of the U.S. national airspace system (NAS), or anywhere that a UAS might operate, segments consist of both stand-alone, discrete elements and the interactions among them. The following diagram was developed by SC-203 and included in DO-304 to visually depict the concept of unmanned aircraft system segments.

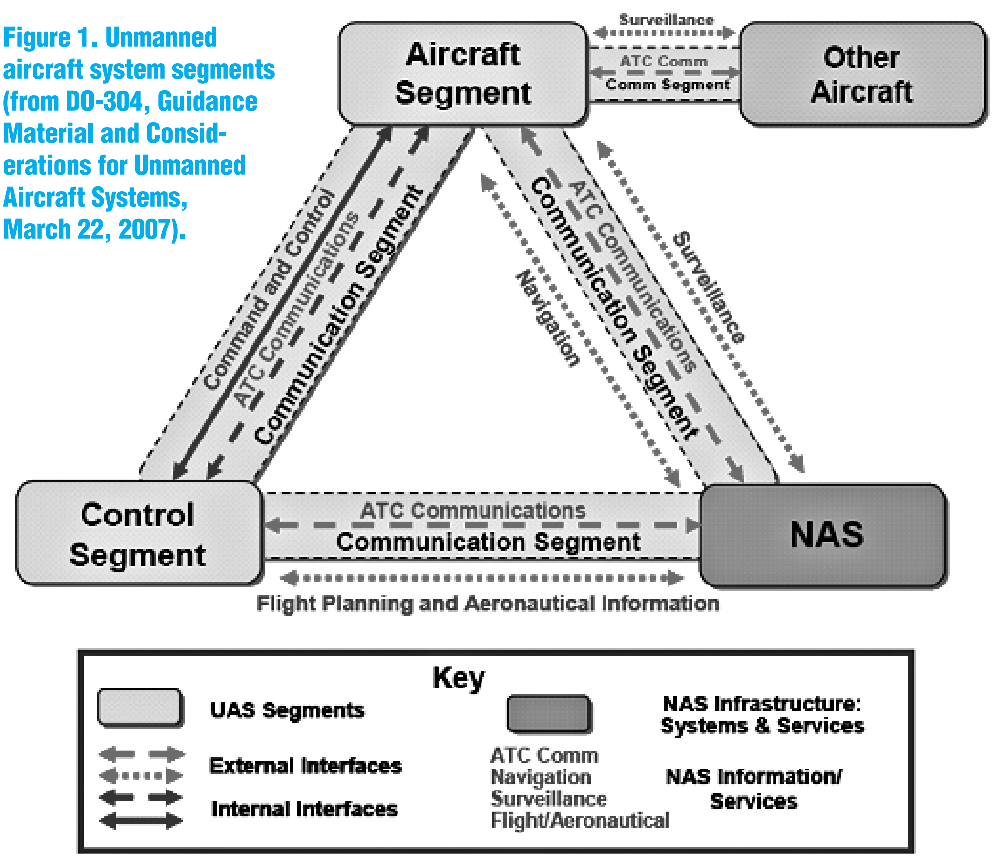
The aircraft segment consists of the UA plus as much (or as little) onboard hardware and software as it requires to conduct a flight from takeoff through landing. At the high end of capabilities, a UA's avionics suite may include a control system (receiving commands and providing aircraft performance and health feedback); a communications relay for beyond line-of-sight operations; navigation, traffic and terrain avoidance, and surveillance systems; and a flight management computer to support inflight stability and reduce pilot workload. At the opposite extreme, a low-tech, line-of-sight UA may have little more than the ability to receive pilot inputs and turn them into control surface movements.

The control segment consists of the pilot, as well as any non-UA-mounted equipment that supports launch and recovery, flight planning, and flight control and operations. The control segment may be no more than a pilot with a hand-held controller, with the UA taking off by being hand-launched, and landing via parachute or capture in a net. At the other end of the scale are ground control stations with comprehensive pilot displays and significant automation. Any observer or chase pilot required for safety purposes should be considered part of this segment. The inclusion of such an individual creates a "segment within a segment," since the observer must communicate directly with the UA pilot.

The communications segment is best understood as the link or links that connect the pilot to the aircraft, and the pilot to the controlling air traffic facility and other sources of aviation-related information. This segment also is intended to encompass any electronic interactions between the UA and other aircraft that enhance their mutual situational awareness.

Some readers may argue that other aircraft are part of the larger airspace system within which each UAS operates (i.e., the

Figure 1. Unmanned aircraft system segments (from DO-304, Guidance Material and Considerations for Unmanned Aircraft Systems, March 22, 2007).



NAS). However, the SC-203 separation of the two highlights the fact that controllers and other aircraft each perceive and react to a UAS through different means. This in turn invites safety personnel including air safety investigators to explore how those different paths could result in hazards to the manned aircraft, as will be discussed presently.

How UAS differ from manned aircraft

Unmanned aircraft fly using the same aerodynamic principles as their heavier- (or lighter-) than-air manned counterparts. A thorough investigation, using the same familiar techniques of gathering testimony and analyzing evidence, will lead to accurate and useful conclusions in most cases.

Now, the bad news. Unmanned aircraft systems can be different in any number of ways from manned aircraft. Most members of the aviation community key on UAS' inability to clear their own flight path. Small size, and in some cases deliberate design for minimum observability, can make it equally hard for other aircraft to acquire and avoid them as well.

To gain a deeper appreciation for the countless combinations of performance, capabilities, and physical attributes associated with unmanned aircraft across the size and complexity spectrum, the reader is invited to pick three systems of different sizes at random and compare them against one another based on the following:

- Vehicle length,
- Vehicle wingspan,
- Vehicle takeoff gross weight,
- Maximum rate of climb/descent,
- Service ceiling,
- Climb/cruise/dash/loiter/approach airspeeds,
- Line-of-sight/beyond-line-of-sight operations,
- Echelon of control (military only),
- Vehicle applications (surveillance, etc.),
- Type of ground control (line of sight, internal/external, distributed, etc.),
- Capability for autonomous flight (e.g., fully preprogrammed mission with minimum pilot intervention, autonomous during periods of control link loss, etc.), and
- Lost link behavior (e.g., return to origin, fly to predetermined or reprogrammable orbit point, initiate termination system, etc.).

Much of this data is publicly available, although not always in a form that lends itself to apples-to-apples comparison. However, the simple act of going through this exercise will do much to raise one's awareness of just how complicated the process of categorizing or classifying unmanned aircraft systems within a consistent regulatory structure is going to be.

The bottom line is that it is impossible to generalize about unmanned aircraft systems, either in terms of how they work or as a means of making judgments as to UAS attributes that may have been factors in a given accident. Until widely accepted standards of manufacture, certification and operation are adopted, every investigation must be approached with a clean piece of paper, a willingness to ask seemingly oversimplified questions, and a total lack of preconceptions.

Sources of potential accident risk in UAS

Most present-day unmanned aircraft systems are in the relatively early stages of development, and there is little in the way of standardization among the various components of different manufacturers' systems. This means that problems are continuously being identified in the following three main areas:

- Aircraft-specific reliability (structure, propulsion system, autopilot/flight management or control system, and onboard system interfaces),
- Control link stability and reliability (past performance, frequencies used, lost link behavior), and
- Human performance, especially with respect to how information flows between the control and aircraft segments, and how to ensure the timely and appropriate selection of whatever subset of that information needs to be presented to the pilot based on the UA's current phase of flight.

In the absence of existing regulations or design criteria specific to the above issues, the U.S. FAA has made three broad policy determinations as an interim measure to ensure essential access to the NAS by unmanned aircraft systems for the purposes of military readiness, research and development, and other activities of national-level interest:

- UAS operations outside regulatory special use airspace as defined in Title 14, Code of Federal Regulations (14 CFR), Part 73 may only be conducted under a Certificate of Waiver or Authorization (COA) issued in accordance with FAA Order 7210.3, *Facility Operation and Administration*, Chapter 18 ("Waivers, Authorizations, and Exemptions"), or pursuant to the FAA/DOD *Memorandum of Agreement for Operation of Unmanned Aircraft Systems in the National Airspace System*, Sept. 24, 2007.
- Certificate of Waiver or Authorization are issued only for UAS that meet the definition of "public aircraft" as provided in 14 CFR §1.1, and their operators are limited to public entities or contractors to those entities.
- Any operator other than those described above may not apply for COAs at this time, but is free to seek a Special Airworthiness Certificate Experimental Category if they wish to fly in the NAS.

The key to the above is that all of these policy-based controls must of necessity be interim measures. The growth of UAS activity in the United States soon will overwhelm the FAA's ability to manage individual UAS operator's activities. Therefore, the COA process owner, the FAA's Air Traffic Organization (ATO), has been developing a means of assessing UAS hazards as they affect other aircraft in, and controllers of, regulated airspace. Their approach is based on one of the main components of the FAA's Safety Management System: the Safety Risk Management (SRM) process.

Throughout 2007, the ATO had a team of experts evaluating the various hazards that could be reasonably expected to be encountered in the course of UAS operations in Class D airspace. This panel generated the list in Figure 2.

The three hazards underlined in Figure 2—sustained loss of control link and system failures resulting in degraded or total loss of control—were assessed as "initial high risks" by the panelist. While the specific assessments and the recommendations for reducing the residual risk are still undergoing formal review, the implications are clear: a lot can go wrong with a UAS in the confines of Class D airspace that can quickly lead to significant risk to persons and property in the air and on the ground.

Investigators are invited to consider the above list as a starting point for development of a list of generic issues that should be explored in the context of each UAS-related investigation. Determining how specific attributes of the various types of unmanned aircraft systems may be related to these hazards is discussed in the next section.

Planning and carrying out a UAS investigation

The simplest way to approach a UAS investigation is to treat it exactly as you would any other aircraft investigation: systematically, deliberately, and scaled appropriate to the loss sustained. However, the only way you can do that in real time is by preparing well in advance and building an understanding of the different aspects of unmanned aircraft systems and operations to which you will have to pay special attention.

There is one indisputable fact about unmanned aircraft system accidents: unless it has been a **very** bad day, an investigator pretty much always will have a live pilot to interview. Beyond that, virtually every accident investigation will be heavily dependent on the nature and specific capabilities of the involved vehicle and systems.

The following list of generally descriptive questions is intended to help drive the investigation of a UAS accident in productive directions with a minimum of wasted time:

Propulsion: What type of engine does the aircraft use and how is it powered, e.g., AVGAS, MOGAS, diesel, Jet-A/JP-8, special fuel, electric (solar or battery-powered), etc.? Is the powerplant certified for aviation use, was it built specifically for the unmanned aircraft, or was it adapted from an existing engine used for other purposes? Are there any unusual components that might pose hazards to investigators in the field following a crash (capacitors with high residual charges, fuel cells, etc.)?

Control: How does the pilot control the aircraft? Does the system incorporate a hand-held controller, a fully equipped ground control station, or both? What type of instrument layout is used by the pilot for control, navigation, communications, and mission execution? To what extent does the aircraft provide information to the pilot about its operating conditions and environment, such as turbulence, icing, vibration, overheat/fire, etc.? If the control link is lost, what is the aircraft designed to do, and how much time normally will elapse before it autonomously executes a course change or termination subroutine? Can lost link behavior be changed throughout the flight, or is it preprogrammed?

Operations: Is the aircraft designed for line-of-sight operations only, or is it intended to be operated beyond visual range? If the latter, how does the pilot maintain contact with the aircraft and with the ATC facility responsible for its area of operations? How does the pilot navigate? Does the navigation system afford the pilot the ability to change heading, altitude, and airspeed at will or as directed by air traffic control? Can the pilot identify and proceed to navigational fixes and waypoints upon request?

Collision Vulnerability: What does the aircraft look like? Is it a highly visible color, or designed to be difficult to visually detect? Does it incorporate position and/or anti-collision lights? On the size spectrum, is it closer in wingspan to a manned aircraft, or is it more model-like? Given that kinetic energy is expressed as $KE = \frac{1}{2} mv^2$, how fast is it designed to fly, and how much does it weigh?

Construction: What is the aircraft made of? Does it consist of aviation-grade components, or is it essentially off-the-shelf in manufacture? Is the aircraft made of materials that would tend to generate little or no primary radar return in normal operations? If so, does the aircraft incorporate a transponder?

Flight Systems: What avionics are used to support the UAS' operation? Are radios TSO-compliant? What frequencies are used for line-of-sight and beyond-line-of-sight control? Are there local sources of radio-magnetic frequency interference that could affect the communications segment? Does the aircraft have any ability to detect and react to conflicting traffic? What sources of electrical power are aboard the aircraft, and if they are interrupted or degraded, are there automatic protocols for load-shedding that help ensure its safe recovery?

Payload: What kind of payloads can the UA carry? Is any part of that payload potentially hazardous? Does the payload draw on aircraft power, or does it have its own power supply? Is the payload used to support flight operations, e.g., an optics ball aimed in the direction of flight? If so, how is its use coordinated with the needs of the pilot?

Flight Data: Does the UAS ground control station typically record flight performance and other relevant data during normal GCS operations? What parameters are captured, and in what format? What is the sampling rate? How long are such data retained? Are there recordings available that show a profile

Figure 2. Class D airspace UAS-related hazards.

• Loss of control or communications links

—Sustained loss of control link
—Sustained loss of data link
—Lost communications
- Between ATC and PIC
- Between PIC and OBS

• Other system issues

—UA system failures
- Degraded control
- Uncontrollable
- Engine malfunction

—Positionable ambiguity
—UAS latency not otherwise described (i.e., unforseen system failure mode associated with human/machine interface, etc.)
—Power failure in tower
—Crosstalk (command intended for UA on ground received and acted upon by UA in flight)

• Internal/external visual limitations

—ATC loses visual contact with UA
—Observer loses visual contact with UA
—Inability of UA to detect/respond to visual cues (e.g., hold short line, light gun signals, etc.)
—Other aircraft unable to see UA

• Outside interference or intrusion

—Wake turbulence on UA
—Unauthorized aircraft in Class D airspace
—UAS operations team human performance

• UAS operations team human performance

—Lack of standardization UAS-specific training or currency
- Pilot
- Observer
- Controller

—Unrecognized/unexpected meterological change similar to the one being flown at the time of the accident that can be compared with the accident sequence? Does loss of the control link also result in loss of downlinked performance and health data? Is there any onboard recording device that can fill gaps in the data stream? Are the recorded data compatible with any flight visualization software?

The questions above, used in combination with an investigator's preferred practices and checklists, should support a thorough, well-documented investigation of most UAS-related accidents and incidents, as well as yielding useful factual information upon which to develop credible recommendations (see below).

One final consideration. For any investigation involving a reasonably sophisticated UAS, it would be prudent to have a software engineer as a part of the investigation, either as a member or in a consulting capacity. Some off-the-shelf approaches to controlling and stabilizing unmanned aircraft involve taking existing sets of control laws in one computer language, applying those laws to control link inputs that arrive in a different format, and then translating the resulting commands to the flight control actuators in yet another operating language. If the UAS is self-stabilizing and/or has the ability to carry out complex lost link behavior, that means that all of those onboard communications will be two-way to enable self-correction and response to onboard navigation inputs.

The sheer complexity of many such arrangements makes finding software defects a daunting task for anyone lacking specific subject matter knowledge. Proprietary conversion or control protocols, as well as the inclusion of control command encryption in a system, make it virtually essential to bring an independent expert into the investigation from the outset.

Making useful recommendations

For at least the next decade, as efforts to normalize UAS activity and integrate it into civil airspace move ahead, air safety investigators must help identify the mitigations that work, and the ones that don't.

In developing UAS-related accident recommendations, it is important to examine each accident sequence in the context of how the UAS operation was being carried out. For example:

Was the UAS conforming in all respects to the flight rules applicable to manned aircraft operations at the accident location? If not, what regulations (if any) were waived for the UAS, and did those waivers have any bearing on the occurrence? Was the UAS activity being performed at the time of the accident suitable to the airspace and altitude at which it was conducted? Was the activity consistent with the design and performance of the UAS itself?

Would a manned aircraft operating under the same conditions have been equally likely to have been involved in an accident, or did some property or characteristic of the UAS start or sustain the accident sequence?

Unmanned aircraft systems will, sooner or later, become a significant sector of the overall aviation community.... If they do not accept their responsibility to others in the shared environment of aviation operations, they should not be permitted access to it.

Then, the investigator must fully document the exact configuration and capabilities of the involved UAS; understand each hazard resulting from the combination of UAS and flight activity under consideration; and assess the scope, quality, reliability, and proper implementation of each mitigation asserted as having been in place with the intent of interrupting an accident sequence before a worst-case outcome could occur. This should allow a gap analysis between what was being done, and what was not done, to prevent the accident.

Finally, the quality of pilot/operator decision-making will need to be subjected to close scrutiny in considering whether any recommendations need to be made toward limiting the opportunity for bad practices or bad choices to adversely affect the public at large. This set of issues has not required conscious addressal for many years. The present-day framework of regulations governing aviation has significantly evolved over time, and organizations like the Air Line Pilots Association and others have successfully pressed their case for "one level of safety" to great effect in most types of commercial operations. However, for now, unmanned aircraft systems are operating loosely under general aviation-type rules, which may not be suitable for two fundamental reasons.

First, unlike any other class and category of aircraft, the pilot of an unmanned aircraft is never at risk of physical harm. Pilots make decisions about their flights based on a variety of inputs, but many inflight judgments carry with them the implication of serious, possibly mortal injury should they prove incorrect. As such, aviation regulations are written somewhat from the same point of view as traffic rules; once taught the meaning and purpose of a double yellow line, drivers understand they have a vested interest in not crossing one on a blind hill.

Second, unlike most manned aircraft, the simplicity and relatively low cost of a bottom-end UAS carries with it the possibility of an unmanned aircraft being looked upon as being expendable. In a growing number of cases, the most valuable part of an unmanned aircraft is its payload, usually followed by its engine. If an operator of a UAS will not suffer serious financial harm from casual or negligent operation of it, and if there is little likelihood of a destroyed aircraft being traced back to them, there is less incentive for them to be responsible participants in the aviation system. The latter possibility begs an obvious question: how useful or relevant are investigations of accidents where at least one of the involved assets is considered disposable? As has been noted throughout this paper, there are no easy answers to issues like this, but answer them we must.

Unmanned aircraft systems will, sooner or later, become a significant sector of the overall aviation community. That means that they also will be involved in accidents, and as equal partners in aviation safety, their operators and pilots will have to learn from those accidents. If they do not accept their responsibility to others in the shared environment of aviation operations, they should not be permitted access to it.

UAS investigations in the coming years will need to take into consideration both regulatory and technical issues. There are strong commercial incentives driving interest in placing unmanned aircraft systems in urban areas, in the heart of the most congested airspace, and in the same environment used by current operators of a whole range of light aircraft and helicopters. Air safety investigators must be objective judges of the extent to which both administrative and technological protections will be needed to keep these current users safe today and tomorrow, while providing for appropriate, evolutionary growth of the UAS sector. ◆

What Can Experience Learn

The transition from operator to investigator is not always an easy one. The challenges facing new investigators asking the question, what can we learn

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(This article was adapted, with permission, from the author's paper entitled What Can We Learn? *presented at the ISASI 2008 seminar held in Nova Scotia, Canada, Sept. 8-11, 2008, which carried the theme "Investigation: The Art and the Science." The full presentation, including cited references, to support the points made is on the ISASI website at www.isasi.org.—Editor)*

"For the things we have to learn before we can do them, we learn by doing them."
—*Aristotle*

Each year, dozens of new investigators begin their training in aircraft accident investigation. Before them lay numerous traps and pitfalls to frustrate their transition from their first specialism as a pilot, engineer, air traffic controller, human factors specialist, etc., to that of "specialist generalist" investigator. The temptation to "revert to type," especially when facing an unfamiliar situation and with the heavy weight of expectations, is a real challenge. Yet as major accidents become less frequent, the firsthand experience of long-serving investigators is becoming limited and, as such, some of the same traps lie in wait, only arguably with more significant consequences. Higher fidelity simulation and continued self-assessment are two ways to assist even experienced aircraft accident investigators to continue to take a scientific approach to their art.

While new investigators are recruited primarily for their experience, there are also certain personality traits that allow them to adopt a fair investigative approach. Because old habits die hard, one of the key challenges is making the transition from their original specialism to that of an investigator.

However, there is some debate as to whether an investigator must remain a specialist or will, in fact, become a generalist (former AAIB Chief Ken Smart argues the correct description is a "specialist generalist"). What seems clear is that many of the habits or biases of the original specialism can pervade the new role. A few examples include the following:

Let me through, I'm an accident investigator! Former AAIB Principal Inspector Eddie Trimble always reminded new investigators that the first thing to do at an accident site was to place their hands firmly in their pockets and think before doing anything else. The temptation to avoid such sage advice is considerable, even for experienced safety professionals. This is partly understandable as emergency services are likely to be actively involved before investigators turn up on site. Influenced by the heavy weight of expectations, the perceived pressure for the investigator to be seen doing something straight away is significant. Numerous simulations have demonstrated this behavior, with examples including investigators walking on the wreckage trail, matching up fracture surfaces, and ignoring basic personal protective equipment needs. Experience is a partial fix for this, but the investigation community should be aware that the natural temptation for anyone on site is to "get on with it," which may have an effect on the preservation of evidence or the safety of the individual.

Even when it is appropriate to get on with the site phase, there remains the temptation to focus on certain aspects and miss perishable, or more important, evidence. Faced with a scene of chaos, it is a normal reaction to start to tunnel or focus in on a small number of cues as a coping mechanism. Believing that the investigation authority has unlimited powers to keep the site unaltered for as long as it wishes forgets the need for cooperation, which lies at the heart of successful investigation. Generally, the art of diplomacy should happen, regardless of what the documented procedures say.

The temptation to revert

It is easy to pick on the regulator when discussing no-blame investigation, but such criticism is sometimes warranted. However, many readers will have at least heard of the stereotypical regulator who cites regulations and tends to assume those who have failed to follow them are violators who should be punished. The temptation for investigators to become the identifiers of failure, the spotters of error, is great, especially when nervous and inexperienced.

While identifying what went wrong is an important step, it can be all too tempting to stop at the first "eureka moment." Indeed in one example (during simulation), it was a non-contributory paperwork error that became the focus of a regulator/investigator. Having found a problem, the individual then proceeded to aggressively interview an engineer who had actually acted appropriately. The discussion became increasingly heated and the engineer became uncooperative, leading the investigator to conclude he had definitely found the problem. Upon debrief, it was established that the error was minor—the sort of inconsequential error that any system is designed to tolerate—and in no way connected to the accident. The engineer explained that he had taken great

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from Inexperience?

author reflects on some of the from their experience?

exception to the accusatory style and had responded accordingly.

As S.W. Dekker in *The Field Guide to Human Error Investigations* (2002) reminds us, "The point of an investigation is not to find out where people went wrong, it is to understand why their assessments and actions made sense at the time." Further, armed with an understanding of why systems fail, the role of the investigator is to comprehend how failures occur, taking into consideration the redundancies, margins, processes, and procedures that are designed to allow a system to function.

For pilots in particular, the world is often ordered in terms of standard operating procedures and checklists. An early frustration for some investigators is to be told that accident investigation is not generally checklist based. Processes need to be adaptable to the specifics of a particular accident and, more importantly, the investigator needs to be able to think creatively. While memory aids can be helpful, a checklist-based approach to the investigation task is rarely able to cope with the complexities of a particular accident. Still, the new investigator can quickly revert to type. Similar challenges present themselves for air traffic controllers, engineers, and so on—often because it has become part of their culture, and as such is carried over to the new environment.

Hindsight bias is often cited as a threat to impartial investigation, but it remains a particular challenge for new investigators. Comparing what was done with what the investigator believes he or she would have done in a similar situation is a trap. Investigators rarely face the same set of cues/inputs at the same time or while feeling the same way that those involved in accidents did. Simply put, if it seems that someone has done something stupid, the challenge is to question whether the interpretation is correct—sometimes it will be, but far less often than some may think. Where a pilot makes an error that the investigator does not believe he or she personally would make, this does not necessarily equate with bad airmanship. The investigator must establish the context of any human act before being tempted to pass judgment.

First time on site

The experience of being on site for the first time is a vivid memory for most investigators, and some are better prepared for it than others. N. Faith observes in *Black Box: Why Air Safety Is No Accident* (1996) that "No rehearsal, no amount of experience or careful preparation…can ever prepare an investigator for what he finds on site." Faith goes on to cite former NTSB investigator Greg Feith who describes his experience: "The actual arrival at an accident site is probably the most traumatic thing anyone could ever experience."

How do we best prepare new investigators for this experience, and what can we learn from their reactions? For example, simulations at Cranfield have more recently used theatrical blood as a prop during simulation, with strong effect. Several investigators were noticeably shocked even though they were fully aware they were involved in a simulation. Similarly, the use of emotional witnesses or those with challenging attitudes and experience has highlighted the difficulty in moving from classroom theory to application.

When investigators are deployed into their new role, they do not always experience what they were expecting. For example, one (marine) investigator had not expected to deal directly with dead bodies, assuming that as crashworthiness was not a major issue in his industry the deceased would have been removed prior to his arrival on scene. His first investigation proved otherwise. As the accident vessel was winched onto the dock, all other services looked to him to be first on board, something he found very traumatic.

Other challenges have come about because society's expectations of what the investigation should deliver have grown. For example, liaising with those affected by an accident such as survivors, friends, and relatives has added an increased load to the already multitasking investigator. Not everyone expects to play this role, and some new investigators have found this to be an unexpected problem. In one instance, a rail accident investigator found the concept of not using names in an accident report to be a logical approach during training. However, on participating in an investigation where two young girls had been hit by a train while rushing across a crossing, the investigator felt it was going to be very difficult to explain to the parents that their daughters would not be named in the final report.

This event also highlights the fact that the type of experience gained in the field is primarily dictated by accidents that occur. Although common skills pervade many different types of accident, the general improvement in aviation safety provides a particular challenge. Simply put, many investigators have minimal opportunity to practice their skills before needing to tackle a major investigation. In China, for

EXPECTATIONS: "Of all the insiders in the aviation business, the air-crash investigators are the airline passengers' best allies. Their job is to attempt to prevent the things we fear most"—*Weir, 1999*

Avoiding traps and pitfalls is a worthwhile goal, but what else stands in the way of the new investigator? It is experience, not in their original specialism but in their new one, the much-harder-to-define role of accident investigator. This experience is hard won and, it is argued, becoming harder for some to gain.

example, where the aviation industry is growing rapidly, there is minimal general aviation, so investigators find they are more likely to be involved with events involving high-capacity regular public transport aircraft than, say, their British equivalents.

The improvement in safety is a good thing, but perhaps it is time that we considered more carefully the use of simulation in ab initio and recurrent training to help investigators build their experience. Even relatively small scale simulations can illustrate the sorts of things that will happen on site, such as the challenge of everything happening at once. However, simulations are presently limited by the size of event that can be staged and the duration for which it can run. How substantial a simulation would it take to be able to deliver the sort of experience that the AAIB, the NTSB, Boeing, and Rolls-Royce investigators received during the B-777 accident investigation at Heathrow?

Avoiding traps and pitfalls is a worthwhile goal, but what else stands in the way of the new investigator? It is experience, not in their original specialism but in their new one, the much-harder-to-define role of accident investigator. This experience is hard won and, it is argued, becoming harder for some to gain.

The trusted investigator

Accident investigation, as defined by ICAO Annex 13, is dependent on trust. Such trust takes many forms: whether it be trust that evidence collected by the investigation will not be used to allocate blame; trust that confidentiality or dignity will be respected; or more fundamentally, trust that the investigation will be accurate and correct. In terms of the expectation of the industry and society at large, G. Bibel remarks in *Beyond the Black Box: The Forensics of Airplane Crashes* (2008), "We trust that an investigation will pinpoint the cause(s) of the accident and deliver lessons that will protect us in the future." Indeed, part of society's valuation of safety, according to others, is the "absence of unsolved crashes." Ultimately, it is the trust that the air transport industry is able to understand and learn from its failures.

Where does the trust in accident investigation actually come from? While within the industry it is partly based on the way in which investigations are conducted, for the general population it seems more to do with the way in which investigators are apparently able to make sense from chaos.

HOW CAN WE GIVE NEW INVESTIGATORS EXPERIENCE OF THIS?

A. Weir in *The Tombstone Imperative: The Truth About Air Safety* (1999) describes investigators as follows: "Of all the insiders in the aviation business, the air-crash investigators are the airline passenger's best allies. Their job is to attempt to prevent the things we fear the most." While in *Investigating Human Error: Incidents, Accidents, and Complex Systems* (2002), B. Strauch quotes Reason observing, "Like the rest of the modern world, I owe an enormous debt to the skills of professional accident investigators. As a traveler and a consumer, I am extremely grateful for what they have done to make complex technologies significantly safer."

During training, it is the building of trust and credibility that many new investigators identify as their priority. So how is this priority best achieved? This is one aspect where the science is arguably rather easier than the art. Understanding the legislation, the theory of interviewing, different modes of failure, and so on seems more achievable than understanding how to combine these multiple inputs and deliver an answer that is accurate and will actually help to make the industry safer. The art lies in exhibiting the difficult to quantify the concept that is "investigative judgment."

Scientist or/and artist?

A scientist may be described as "a person who is studying or has expert knowledge of one or more of the natural or physical sciences." Scientists maintain their skill levels through practice and through maintaining their knowledge of the research literature. By doing the job, the scientists can maintain their currency, but such a vast topic cannot be covered by one scientist and is therefore dependent on being able to cite and link to the work of others.

An artist may be described as "a person skilled at a particular task or occupation, for example, a surgeon who is an artist with the scalpel." More commonly, the term artist is used to describe "a per-former, such as a singer, actor, or dancer." It is arguable that for many artists, their talent lies way beyond their training. This notwithstanding, even great artists need practice to become, and remain, successful. Expectations of their ability can place considerable pressure upon them, and few artists remain at the top of their game throughout their career.

So which best describes the accident investigator?

Investigation, like scientific research, requires disinterest, impartiality, and a desire to reach the truth, whether it fits your previous model, first guess, last 6 months' work, or not. However, like art, accident investigation also requires creativity, understanding, passion, commitment, and emotion. New recruits cite traits from both categories as being important qualities of an investigator, yet it is rare for all of the best traits to exist in just one category. It is clear that neither the pure scientist nor the pure artist will succeed, and for many this means the need to blend together two quite different approaches.

Perhaps, just as the "specialist generalist" describes the investigator, so does the description of "artistic scientist" (or "scientific artist" for that matter). The investigation of events within a complex socio-technical system such as aviation depends on a mixture of deductive and inductive logic. The former, where particular instances are explained in terms of a general law, depends upon absolute confidence in the data. Is it more likely then that an investigator would be dependent on inductive logic, where a particular instance is used to infer the presence of a general law. In other words, inductive logic depends on the investigator making inductive "leaps" on the basis of the weight of available evidence. Such evidence may be of variable form and quality, e.g., physical evidence, witness statements, digital data, and so on. As the Australian Transport Safety Bureau (ATSB) analysis review (2008) reported, "Safety investigations require analysis of complex sets of data and situations where the available data can be vague, incomplete, and misleading."

Similar to the work of social scientists, investigators look for convergence of evidence while also maintaining vigilance for their own biases. This is often a difficult transition for investigators to make, especially if they are used to precision and order in their prior aviation career. Witness evidence is a particular case in point where "expert" witnesses may seem more compelling than those who perhaps look or sound less credible. Similarly, it is known that unlikely explanations are much harder to accept than likely ones, even when the strength of evidence may actually be the same. Learning this skill is perhaps the hardest of all, especially when even experienced investigators struggle to articulate their own approach.

Myriad analysis tools abound, but the majority of them are suitable only for certain elements of the overall analysis. For example, fault trees may be a logical way of dealing with component or physical system failures but will struggle to handle less tangible factors such as the influence of, say, culture or training.

Even where investigation approaches have been defined, such as the Canadian Integrated Investigation Process or indeed some of the applications of Reason's organizational accident model, they tend to provide a framework rather than the rigid methodology that some persons expect. There is certainly scope for improvement, even among the leaders in this area. The Queensland state coroner complimented the ATSB's work to refine the way in which it approaches accident investigation: "The Bureau is to be commended for attempting to adopt a scientific approach to what has been, in many instances, treated as an art form." However, this did not stop the coroner from then voicing concerns over the standard of proof that was considered to be acceptable.

Maintaining competency

While gaining enough experience to start investigating is one task, how to nurture and preserve some of the skills is another problem. In short: How do investigators maintain their competency in what they do? There is a distinction between being competent (being able to demonstrate abilities upon recruitment) and maintaining competency throughout an investigator's career (maintaining currency in their skills). As mentioned above, the nature of investigation is such that it is often the accidents themselves or the position of the investigator on the call-out list that will determine what skills are exercised at any one time.

Writing more than 20 years ago about the impossibility of guaranteeing personal experience of a particular aircraft type for each investigator, former UK AIB Chief Bill Tench observed, "What you can and must do, however, is ensure that all the investigators are expert in every sense in the techniques of investigation and au fait with all aspects of operating modern aircraft…, but they must also have access to reliable and impartial specialists in the type of aircraft concerned." Unfortunately, some of the specialists are heading toward retirement, or have recently retired. For example, those investigators who were involved in the two major aircraft accidents at Lockerbie (1988) and Kegworth (1989) are dwindling in number within the UK AAIB.

What can experienced investigators learn? Firstly, they should acknowledge that with the reduction in large-scale aircraft accidents, a greater number of inexperienced investigators will find themselves having to deal with large accidents. This is against the backdrop of society's expectations that they will find the answer, the news media's expectation that it will be found now, and the legal industry's expectation that whatever the investigators come up with can still be challenged!

Many of the traps remain a hazard for even the experienced investigators, and for them the consequences may be greater.

Regardless of background and experience, it is important to remember that investigation is as much a way of thinking, an approach, as it is specific knowledge or experience and for that reason all involved can contribute to the process and its outcomes; or as Ron Schleede, former NTSB chief investigator put it, “It takes all kinds of people to make it click.”

Even if the lead investigation agency is able to send suitably experienced staff, many of those other agencies that may also have an interest will be starting with minimal experience. For example, how many modern airlines have staff with direct experience of dealing with an aircraft accident?

Even for the experienced air safety investigators, how often do they challenge themselves as to whether they are doing the right thing? Although the very nature of accident investigation requires constant challenge of the meaning of evidence, perhaps the overall approach taken to evidence collection, analysis, or recommendation-making is something that needs periodic review? There are a plethora of analysis methods, with their relative strengths and weaknesses that are applied to varying standards by different investigators.

The new investigator also has a contribution to make to this process, as often the inexperienced ask some of the most searching questions in part because they haven't yet learned not to. At times, underlying a question of “why is it done that way?” might be the question “because wouldn't this way be better?” These questions can be an opportunity to constantly reassess and revalidate existing techniques that are always open to improvement.

While recognizing that there are some exceptions, such as the Transportation Safety Board of Canada (TSB) and the ATSB, even they would admit that we still have a long way to go in terms of developing reliable analysis processes. While theories such as Reason's organizational accident model are generally widely accepted and even cited by ICAO, really good investigations into these areas are still comparatively rare. Similarly, recommendations remain an area where experienced investigators can do well to listen to the perspectives of new investigators, fresh in from the industry. As R.H. Wood and R.W. Sweginnis noted in *Aircraft Accident Investigation*, good investigators “listen to other investigators. They don't necessarily believe them, but they do listen to them.”

Perspective: “The point of all investigation is not to find out where people went wrong, it is to understand why their assessments and actions went wrong.”—Dekker, 2002

How can we better educate investigators?

While a lack of experience with large accidents will lead to new challenges being faced by all involved when such an event happens, many of these challenges can be anticipated. However, how many of us have detailed, tested plans in place to respond to, say, an A380 or B-787 catastrophe?

There is an argument to be made that the “void” created by the lack of large accidents (be it real or virtual) should not be entirely filled by smaller investigations. Time and space in an investigator's workload should also be made for training, simulation, skill review, etc. This could range from full-blown response, investigation, and analysis simulations to much shorter “what if?” tabletop sessions.

In addition, since the majority of training for most investigators will be “on the job,” it befalls the more experienced investigator to take some responsibility for educating others. It is here that continual monitoring of one's own practices can lead to gains for both parties. Reassessing procedures (what and why?) not only leads to improvement of those procedures but also helps to remind the more experienced of when they were new. The worst teachers are those who cannot remember what it is like not to know or understand, and often those same people are the worst at learning new things or updating existing thinking.

There is also a large role to be played by training organizations, whether it be in ab initio training or in more advanced continuing development. Carefully developed simulations can provide a high level of fidelity, thereby allowing investigators a “safe” environment in which to practice and develop skills that they may otherwise not have had a chance to acquire. Increasingly, these simulations incorporate not only the technical aspects of the field investigations (the science), but also the less tangible aspects such as analysis, critical thinking, group dynamics, etc.,—the art. The parallel with flightdeck simulation is clear with original simulations focusing on technical skills, and later refinements adding non-technical skills such as crew resource management (CRM) and threat and error management (TEM).

The difficulty, and also part of the attraction, of investigation is the variety of disciplines, approaches, knowledge, and personalities required to carry out a successful investigation. Myriad qualities are required with those of both artist and scientist featuring strongly. Hence, the types of people involved are also myriad. However, regardless of background and experience, it is important to remember that investigation is as much a way of thinking, an approach, as it is specific knowledge or experience and for that reason all involved can contribute to the process and its outcomes; or as Ron Schleede, former NTSB chief investigator put it, “It takes all kinds of people to make it click.” ◆

ISASI 2009 Registration Opens

ISASI 2009, the Society's 40th annual international seminar on air accident investigation, is now open for registration according to Jayme Nichols, seminar chairperson and vice-president of the United States Southeastern Regional Chapter (US-SERC), which is hosting the event to be held in Orlando, Fla., September 14-18.

The seminar program registration fee (in U.S. dollars) by August 10 is member, $525; student member, $200; non-member, $570. If registration is made after August 10, the fees are $570, $225, and $610, respectively. Day pass fee for any of the 3 days is $200 by August 10 and $225 after that date. The member fee for the September 14 tutorials is $125 by August 10 if you wish to attend both tutorials, or $65 if you wish to attend one, and $150 after that date; student member, $65 and $100. The companion fee is $300 by August 10 and $350 after that date. Registration cancellations made before July 10 will incur a $10 fee. Cancellations between July 27 and August 10 will incur a $75 fee. There will be no refund of fees for cancellations after August 10.

The Southeast Regional Chapter has established a detailed and easy-to-manage website accessible through the ISASI website, www.isasi.org. All areas of delegate interest are easily identified and accessed on the site. A seminar registration form may be found on the website and it may be submitted electronically. A copy of the seminar registration form is also printed on page 27. Either registration form may be downloaded or clipped out and mailed to ISASI Seminar Registration, P.O. Box 2710, San Pedro, CA 90731 USA.

The seminar will be held at the Coronado Springs Resort. The ISASI delegate room rate is US$144 for either a single or double and is subject to taxes. The special rate is valid to August 24 and is available from September 11-21. No provisions exist for special rates on upgrade rooms. Disney's Coronado Springs Resort is an American Southwest-themed Disney moderate resort hotel set on Lago Dorado—a glimmering 22-acre lake—that invokes the spirit and romance of Spanish-colonial Mexico. Delegates should deal directly with the Coronado Springs Resort regarding their accommodations. The hotel registration form is available through a link accessed through the ISASI 2009 seminar website (www.isasi.org).

Due to the current financial state, the 1st Annual Kapustin Memorial Golf Tournament has been cancelled. In its place, there will be a golf scramble held on the same morning at Disney's Magnolia Course. Bring your golf clubs (or rent on site) and enjoy a round of golf with colleagues from around the world! Price information will be posted on the seminar's website.

Program plan

The seminar program will follow the established format of past seminars, with 1 day devoted to two tutorial workshops and 3 days of technical paper presentations in plenary session. National society and working group meetings will also be scheduled. ISASI 2009 carries the theme "Accident Prevention Beyond Investigation."

Program chairperson Jayme Nichols says, "The Seminar Committee was looking for papers that would deal with the hard and soft aspects of investigation—in particular, new ideas that will lead us to improved investigation whether it is techniques, management, process, technology, factual analysis, high tech or low tech. The subject matter could be as broad as the imagination or expertise of the presenter. The Technical Committee wanted to reach beyond the normal papers and explore new ideas. We were also very interested in hearing from full-time investigators or agencies that have recent experience with new techniques or processes and their experience in applying them. Some 'soft side' subjects we were interested in were subjects ranging from dealing with the news media to relatives to interview techniques."

The Committee has received more than 30 proposals for papers from a number of qualified speakers on a wide range of subjects. About 25 of these proposals will be presented in Orlando following a thorough assessment by the ISASI 2009 Papers Selection Committee, which reflects the international aspect of ISASI.

The 1-day tutorial sessions will include two workshops. The first will center on media relations in air safety investigations and the second will deal with the criminalization of events in aviation safety. The tutorials will each be 4 hours long, which will allow attendees the opportunity to attend both tutorials.

Social programs

In keeping with ISASI tradition, the seminar social program will start with a welcome reception on Monday evening, September 14. This is an ice-breaker social, providing an opportunity to meet with old and new friends. On Tuesday evening a special dinner is planned that will allow attendees to experience some "pirate" fun at a dinner show in Orlando.

REMINDER

ISASI annual dues were due in January. For those membes who may not yet have made the payment, please contact Ann Schull at isasi@erols.com or call 703-430-9688 to make payment arrangements. If payment is not received, the affected member will be placed in an inactive status.

Wednesday evening will be a free night, permitting attendees to explore the many fine restaurants found in Orlando. The Awards Banquet, at which ISASI's Jerome F. Lederer Award presentation is made, will be held on Thursday evening at the Coronado Springs Resort. The usual post-seminar optional tour on Friday is a trip to Kennedy Space Center.

Companion's Program

The Companion's Program is being organized by Melody Coleman, and full details are available on the ISASI 2009 website.

Orlando fast facts

Time zone—Orlando is on Eastern Daylight Time, which is 4 hours later than Greenwich Mean Time. Daylight Saving Time will be in effect at the time of the seminar.

Climate and weather—Average daily temperatures during the seminar period will be 71-92° F (21.6-33.3° C); fall from 72-90° F (22.2-32.2° C). Weather forecasts are given in Fahrenheit measurements. For approximate temperature conversion—Fahrenheit to Celsius: subtract 30 and divide by 2. Celsius to Fahrenheit: multiply by 2 and add 30. ◆

Jerome F. Lederer Award Nominations Deadline Nears

The nomination deadline for persons to be considered for ISASI's coveted Jerome F. Lederer Award is May 31. Selection will be made by the ISASI Awards Committee, which is chaired by Gale Braden. Presentation of the Award is made at the Society's annual international conference on air accident investigation. This year ISASI 2009 will be held in Orlando, Fla., a stone's throw away from the Walt Disney Theme Parks.

The Lederer Award recognizes outstanding contributions to technical excellence in accident investigation. The criteria for the Award are as follows: Any member of the Society may submit a nomination, and the nominee may be anyone in the world. The Award may be given to a group of people or an organization, as well as an individual, and the nominee does not have to be a Society member. The Award may recognize 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."

Nomination letters for the Lederer Award must be limited to a single page. Nominations should be mailed or e-mailed to the ISASI office or directly to the Award Committee chairman, Gale Braden, 13805 Edmond Gardens Drive, Edmond, OK 73013, USA; e-mail address, galebraden@cox.net. ◆

ISASI Reachout Workshops Kick Off Early in 2009

(Adapted from Reachout reports by Caj Frostell)

The ISASI Reachout program continues its strong forward motion with two workshops early in 2009. The Reachout objective remains the delivery of relevant and proactive aviation safety support to states and organizations in need, wherever possible. Given the existing case of survival among ISASI's traditional corporate supporters, recent planning activity has moved from the tactical to strategic mode.

For example, exploratory work has been considered and discussed, in conjunction with the European Society, with a view to delivering support to those states in need within the African continent. This objective will be discussed during the European SASI seminar in Hamburg in April. Similarly, consultation has commenced to deliver support to South Pacific states.

In the meantime, Reachout has completed workshops in Abu Dhabi, United Arab Emirates, and Kathmandu, Nepal, as noted below.

Etihad Airways in Abu Dhabi, United Arab Emirates (UAE), hosted the 33th ISASI Reachout Workshop from January 25-28. Etihad Airways Vice-President of Safety, Security, and Quality Mohamed Abubaker Al Farea and Capt. John Downey, head of corporate safety, opened the Workshop, whose subject was aircraft accident and incident investigation.

The carrier became an ISASI corporate member in 2008, but had not been in a position to receive its corporate membership plaque at ISASI 2008 in September 2008 in Halifax, Nova Scotia, Canada. Caj Frostell, ISASI international councillor and Reachout instructor, on behalf of ISASI President Frank Del Gandio, presented the plaque to Vice-President Mohamed Abubaker Al Farea.

Program presentations made by Frostell and Nick Stross included several interactive case studies, such as a Boeing 737 accident near Athens, Greece, involving non-pressurization; a video of a Boeing 737 investigation in Panama; an Airbus A340 landing overrun in Toronto; a DC-10 rejected takeoff in Vancouver; an Airbus A330 landing in the Azores; and several incident investigations. Subjects of instruction included

- international requirements for accident investigation as contained in ICAO Annex 13,
- national legislation and regulations,
- planning, organization, and readiness for a major investigation,
- the role of an airline in a major accident investigation,
- accident site procedures and management,

40th Annual International Society of Air Safety Investigators Seminar

Sept. 14-18, 2009, Disney Coronado Springs Resort, Orlando, Florida USA

Delegate Registration Form and Fee Summary (US$)

Yes, please register me for the 40th Annual International Society of Air Safety Investigators Seminar!
You can register by e-mailing, mailing, or faxing this completed form (see below). Please complete one form for the primary individual attending. Exhibitors and companions have a separate registration form. Note: Please print all information on this form. This form may be reproduced as necessary. Cancellations made before July 10, 2009, will incur a $10 fee. Cancellations between July 27, 2009, and Aug. 10, 2009, will incur a $75 fee. There will be no refund of fees if cancelled after Aug. 10, 2009. However, substitutions are permitted at any time. Make sure to include the fees for any optional programs in the total amount being paid.

Please Complete All Areas as Appropriate **Is this Your First Seminar?** ❑ Yes ❑ No

ISASI Member? ❑ Yes ❑ No If yes, please complete the member information below:

Member number ________________ Society, chapter, or region: ________________

❑ Mr. ❑ Ms. ❑ Mrs. ❑ Dr. ❑ Other (If "other," please specify) ________________

First name ________________ Middle initial ______ Last name ________________

Company or organization ________________ Position, title, or job ________________

Address (line 1) ________________

Address (line 2) ________________

City ________________ State or province ________________ Country ________________

ZIP or postal code ________________ Telephone number ________________ Fax number ________________

E-mail address ________________

Special meals request (All requests will be honored if possible): ________________

Name and company as you want it on the badge: ________________

Registration type	Before August 10	After August 10
❑ ISASI member	US$525	US$570
❑ ISASI student member	US$200	US$225
❑ Not an ISASI member	US$570	US$610
Delegate nominated by sponsor (free)		

The above registration includes the reception (Monday), fun night (Tuesday), and banquet (Thursday). Please check below if *not* attending:
❑ Reception ❑ Fun night ❑ Banquet

❑ Day pass only (per day)	US$200	US$250

Check day(s): ❑ Tuesday ❑ Wednesday ❑ Thursday
❑ Welcome reception (Monday) (US$100)
❑ Tuesday fun night (US$100) ❑ Banquet only (US$100)

Optional programs	Before August 10	After August 10
❑ **Tutorial** (Monday, Sept. 14)	US$65	US$125
❑ **Tutorial** (student member)	US$65	US$75

Please select tutorials desired:
❑ Tutorial #1 (4 hours)—Media Relations in Air Safety Investigations
❑ Tutorial #2 (4 hours)—Crimininalization of Events in Air Safety Investigations

	Before August 10	After August 10
❑ **Companion's Program** (per person)	US$300	US$550

Note: Please fillout the companion registration for each companion.
# of Companion's Program _____
❑ **Tour of the Kennedy Space Center**, Friday, September 19. US$100 each
taking the Kennedy tour _____

Billing information

❑ **Charge my credit card:** ❑ AmEx ❑ VISA ❑ MasterCard Name on card ________________

Card number ________________ Expiration date ________________ Card code ________________

❑ **Send by mail:** ❑ Payment by check ❑ Company purchase order P.O. # ________________

TOTAL IN US$ ________________
Note: Credit card name must be listed on the card. Card billing address must match address listed above in registration. The card code is a four-digit number on the front of an American Express card or a three-digit number on the back of a VISA or MasterCard.

Mail to: ISASI Seminar Registration
P.O. Box 2710, San Pedro, CA 90731 USA

TEL: +1 (800) 545-3766, ext. 104 (U.S. and Canada)
TEL: +1 (310) 517-8844, ext. 104

FAX to: +1 (310) 540-0532
E-mail to: sharon.morphew@scsi-inc.com

Signature (required for credit card) ________________

Etihad Airways attendees pay rapt attention.

- investigation methodology,
- field investigation,
- off-scene follow-up work,
- technical investigations,
- flight operations investigations,
- crashworthiness, and
- crisis management (handling the news media and family assistance programs).

Additionally, a day was devoted to Safety Management Systems and risk management, as well as the preparation of the final report, identification of safety deficiencies, and the formulation of safety recommendations. The program also included an aeromedical/human factors presentation by Dr. Surendra Sodhi, Etihad Airways chief medical officer, and a presentation by Ibrahim Al Addasi, regulation and investigation inspector with the general civil aviation authority, covering the UAE legislation and regulations for aircraft accident investigation.

Completion certificates were awarded to the 29 participants from all operational areas of Etihad Airways. Each attendee also received a CD with published manuals and booklets and ISASI membership and corporate membership forms. Kevin Vandam, manager of emergency response planning, and Ahsan Naseer, manager of safety investigation, assisted by Francis Cabel, manager of emergency response plan facilities, made all the on-site arrangements. Instructor travel and accommodation was provided by Etihad Airways. ◆

Reachout No. 34

Nepal Airlines hosted the 34th ISASI Reachout Workshop in Kathmandu, Nepal. The Workshop, a two day event, opened on February 11 by Sugat Ratna Kansakar, managing director of Nepal Airlines. He reaffirmed Nepal Airlines' commitment to safety and outlined some of the expansion plans for the future.

Caj Frostell, ISASI instructor and ISASI international councillor, opened the first day with an executive session on Safety Management Systems (SMS), including SMS principles. Later he presented the ICAO requirements for a state safety program (SSP) and for operator SMS, the SMS framework, SMS tools and checklists, and SMS implementation strategy in an airline.

The second day focused on in-house occurrence investigation within an SMS program. The presentations included airline occurrence reporting and data handling, airline occurrence investigation within SMS, documenting an occurrence investigation, safety actions versus disciplinary actions, and a number of case studies on incident investigations. The examples highlighted airline flight data analysis monitoring and the role of airline policies, procedures, and training in aviation safety.

Management commitment to the SMS program was clearly demonstrated to the 25 participants from all of the airlines' operational areas. Management involvement included that of the chairman of the board, managing director, deputy managing director, director commercial, and director of quality assurance and flight safety. Also attending were members of the civil aviation authority of Nepal: Keshab Raj Khanal, director general of civil aviation, and T.R. Manandhar, general manager of Tribhuvan International Airport.

The arrangements at Nepal Airlines and in Kathmandu were accomplished by Mr. D.P. Rajbhandari, director of quality assurance and flight safety, and his deputy, Capt. Subash Rijal. The outstanding assistance and support rendered to the instructor by these gentlemen was invaluable in all aspects. Instructor travel from Bangkok to Kathmandu and return, as well the arrange-

Sugat Ratna Kansakar opens Reachout No. 34.

ments in Kathmandu, were provided by Nepal Airlines. ◆

ANZSASI 2009 Opens June 6 in Rotorua, NZ

The Australian and New Zealand Societies of Air Safety Investigators joint 2009 regional air safety seminar opens June 6 at the Distinction Rotorua Hotel, Rotorua, NZ. The regional air safety seminar is hosted alternately by the two Societies.

Seminar topics include reports on recent serious incidents in the region, Safety Management Systems, military flight safety, problems with using animations of incident and accident scenarios, separating safety and criminal investigations, and a review of human factors issues associated with RNAV approaches.

Registration forms for both the seminar and hotel accommodations are available on the Australian SASI website, www.asasi.org. Seminar registration costs are (in NZ$): Member: $300, after May 1, $350; Non-member: $350, $400. Methods of payment are explained on ASASI's website. No credit card payments are accepted. Hotel registration is open, offering a discounted rate of NZ$120 plus tax until May 15. Full details are on the registration form on ASASI's website.

For more information, contact Peter Williams at e-mail address p.williams@taic.org.nz; phone: +64 4 473 3112; fax: +64 4 499 1510. ◆

MARC Sets Annual Meeting

The Mid-Atlantic Regional Chapter (MARC) of ISASI will host its annual dinner meeting on Thursday, April 30, at the Crowne Plaza-Dulles Hotel in Herndon, Va. The dinner meeting will begin at 6 p.m. with a cash bar, followed at 7 p.m. with a buffet dinner.

The guest speaker is William R. Voss, president and CEO of the Flight Safety Foundation. The dinner meeting will coincide with the spring ISASI International Council meeting to be held on Friday, May 1. MARC President Ron Schleede says, "We expect a large turnout, and space is going to be limited. Companions and other guests are most welcome. Last year we had more than 90 professionals attend, including several from overseas."

Several hotel rooms have been blocked out for overnight stays. For further information and meeting registration, contact Ann Schull, ISASI office manager, at 703-430-9668 or ISASI@erols.com. Meeting information is available from Ron Schleede at Ronschleede@cox.net or at the ISASI office at ISASI@erols.com. ◆

European Society Sets Second Air Safety Seminar

Following the success of its inaugural seminar in 2008, the European Society of Air Safety Investigators has scheduled its second air safety seminar to be held on April 20-21 at the historic Patriotosche Gesellschaft in the city center of Hamburg, Germany.

The 2009 regional air safety seminar will repeat the 2008 theme: air accident investigation in the European environment. Seminar emphasis will be on current European issues in the investigation and prevention of accidents and incidents. The program will address current issues in the European environment and the challenges of modern air safety investigations, including the investigation of the B-777 G-YMMM at Heathrow in January 2008.

The 2-day seminar is aimed at accident investigation professionals, providing an opportunity to update professional knowledge and skills and to meet and network with other active air safety investigators. ◆

CSASI, ACPA Present Winter Ops Conference

The Canadian SASI and the Air Canada Pilots Association's Technical and Safety Division jointly will present a 2009 International Winter Operations Conference to be held at the Fairmont Royal York Hotel in Toronto, Ontario, Canada, on October 7-8. CSASI's president, Barbara Dunn, said the joint effort carrying the theme "Winter Operations: Safety is no Secret" is an inaugural event that aims to bring together worldwide participants who are experts in the subject of winter operations.

Using a hypothetical winter storm as a framework for discussion, the experts will

MOVING?
Please Let Us Know

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Fax this form to 1-703-430-4970 or mail to
ISASI, Park Center
107 E. Holly Avenue, Suite 11
Sterling, VA USA 20164-5405

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Name ____________________

Address ____________________

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Address ____________________

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Zip ____________________

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*Do not forget to change employment and e-mail address.

ISASI ROUNDUP

Continued . . .

explain the newest technologies, operational procedures, and lessons learned in the field that can keep flights flying safely in winter weather. Presenters from the airlines, manufacturers, airports, central deicing facilities, and governmental agencies will address all aspects of winter operations, including airframe and engine icing, both on the ground and in flight, runway contamination, and takeoff and landing performance.

The inaugural event is designed for airline operational personnel, flight safety departments, safety managers, corporate and charter operators, national and regional airlines, airport authorities, military, business aircraft associations, general aviation, air traffic control, training organizations, pilot associations, flight attendant associations, aviation regulatory authorities, and investigative authorities.

For more information, contact ACPA at 905-678-9008 or toll-free at 800-634-0944, by fax 905-678-9016, or go to www.winterops.ca to register. ◆

ICAO Calls on ISASI Member

ISASI member Dr. Joseph Rakow and his colleague Dr. Alfred Pettinger of Exponent, Inc. have authored a chapter on the failure analysis of composite structures for the International Civil Aviation Organization's (ICAO's) "Manual of Aircraft Accident and Incident Investigation" (Doc. 9756-AN/965). The topics covered in this chapter are timely and relevant given the accelerating use of composites in nearly all aircraft markets, most notably in the Airbus A380 and the Boeing 787. The main points of discussion in the chapter are

- an introduction to the use of composites in aircraft structures,
- failure of metal structures versus failure of composite structures,
- typical failure features found in composite laminates, sandwich structures, joints, and repairs, and
- case studies and examples involving failures of composite aircraft structures

ICAO has made an advanced, unedited edition of the manual available to ICAO members on its website (http://www.icao.int/icaonet/). A finalized edition of the manual is expected to be available in English to ICAO's 190 contracting states within the next year. In the following years, ICAO will translate the manual into Arabic, Chinese, French, Russian, and Spanish.

Further information is available by contacting Joe Rakow at jrakow@exponent.com. ◆

President's View *(continued from page 3)*

ously unknown risks; they all involved the usual suspects. Though most of the 14 accidents remain under investigation, publicly available information points to a host of issues we have seen in all too many previous accidents, including crew failure to monitor instruments, mode awareness, maintaining a professional atmosphere in the cockpit, relatively abrupt disengagement of the autopilot when it reaches its maximum authority, icing, confusion between Western- and Eastern-built attitude indicators, very challenging airport environments, improper configuration on takeoff, and more.

My point here is not that the world's commercial aviation system suddenly has become unsafe. That is not the case. We continue to move some 2 billion people annually around the globe with relatively limited fatalities over the long term. I hope, and I expect, that the rash of major accidents in recent months is no more than a random cluster of events. Nevertheless, they remind us that everyone in aviation must continue to pay attention to risks that have been documented time and again in accident investigations, and they remind us that common use of simplistic phrases can invite us to fall asleep at the switch. ◆

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Hong Kong Civil Aviation Department
IFALPA
Independent Pilots Association
Int'l Assoc. of Mach. & Aerospace Workers
Interstate Aviation Committee
Irish Air Corps
Irish Aviation Authority
Japan Airlines Domestic Co., LTD
Japanese Aviation Insurance Pool
Jeppesen
JetBlue Airways
Jones Day
KLM Royal Dutch Airlines
Korea Air Force Safety Ctr.
Korea Aviation & Railway Accident Investigation
Board
Kreindler & Kreindler, LLP
L-3 Communications Aviation Recorders
Learjet, Inc.
Lockheed Martin Corporation
Lufthansa German Airlines
MyTravel Airways
National Aerospace Laboratory, NLR
National Air Traffic Controllers Assn.
National Business Aviation Association
National Transportation Safety Board
NAV Canada
Nigerian Ministry of Aviation and Accident
Investigation Bureau
Northwest Airlines
Parker Aerospace
Phoenix International, Inc.
Pratt & Whitney
Qantas Airways Limited
Qatar Airways
Qwila Air (Pty), Ltd.
Raytheon Company
Republic of Singapore Air Force
Rolls-Royce, PLC
Royal Netherlands Air Force
Royal New Zealand Air Force
RTI Group, LLC
Sandia National Laboratories
SAS Braathens
Saudi Arabian Airlines
SICOFAA/SPS
Sikorsky Aircraft Corporation
Skyservice Airlines, Ltd.
Singapore Airlines, Ltd.
SNECMA Moteurs
South African Airways
South African Civil Aviation Authority
Southern California Safety Institute
Southwest Airlines Company
Southwest Airlines Pilots' Association
Star Navigation Systems Group, Ltd.
State of Israel
Transport Canada
Transportation Safety Board of Canada
U.K. Civil Aviation Authority
UND Aerospace
University of NSW Aviation
University of Southern California
Volvo Aero Corporation
WestJet ◆

Air Canada Pilots Association

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

The Air Canada Pilots Association (ACPA) is the federally certified bargaining agent for the professional pilots employed at Air Canada. The Association was founded to further the best interests of the Air Canada pilots and is organized and directed by the membership, for the benefit of the membership. ACPA headquarters is located in Toronto with regional offices located in Montreal, Winnipeg, and Vancouver.

The pilots of Air Canada recognize that their first and greatest responsibility is the safety, well-being, and comfort of the passengers entrusted in their care. With this responsibility in mind, ACPA embraces the motto "Safety with Integrity."

ACPA was founded by pilots to improve their professional lives and advocate for the highest levels of air safety. The Association continues to be governed by pilots with the same aim. Very simply, it is the members of ACPA who govern the Association and its activities. ACPA's strength lies in the voluntary participation in Association affairs by its individual members whose interests it protects.

There are three executive officers in ACPA: the President, Secretary-Treasurer, and Master Executive Council Chair. All officers at every level of representation, including the President, continue to maintain their aircraft proficiency to fly the line. This ensures that the leadership of the Association remains closely in touch with the daily realities of the airline piloting profession and is able to truly reflect the needs and wishes of the membership.

The Local Council is the basic participatory unit of ACPA. To govern their Local Council, members elect from among themselves a Local Executive Council (LEC) consisting of a Chair, Vice-Chair, and a number of Councillors. The LEC manages the affairs of the Local Council and represents its members. The LEC Chair and Vice-Chairs are members of the Master Executive Committee, which is ACPA's governing body. ACPA has more than 40 committees on which members can serve and play an active role in directing the Association to achieve its objectives. All committee work is done by volunteer pilots and reflects the "grassroots" democratic nature of the Association.

ACPA's activities are focused on its members' safety concerns, professional interests, and industrial and contractual affairs. With more than a half century of experience in promoting and protecting the piloting profession, ACPA's actions have benefited the travelling public and the airline industry as a whole. ACPA takes an active role in shaping the future of Canadian aviation. It continues to provide expertise to industry and government on a range of regulatory and operational issues.

The Association's Technical and Safety Division provides representation to Transport Canada, NAV CANADA, and other industry stakeholders by participating in committee work ranging from regulatory requirements to risk assessment. Recent examples include actively participating in NAV CANADA's visual separation trials and the upcoming Canadian multicrew pilot license regulations. ACPA accident investigators work closely with the Transportation Safety Board Canada (TSBC), often obtaining observer status on accidents or serious incidents. They also participate in TSBC workshops to provide TSBC investigators insight into airline operations and in return benefit from TSBC investigator training.

Also, the accident investigators work very closely with Air Canada's flight safety investigators providing input and feedback during and after significant events. The Association is very active in aviation security issues around the world and monitors security threats that may impact flight crews either while operating or laying over in potentially risky areas. ◆

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