ISASI FORUM

"Air Safety Through Investigation"

JULY–SEPTEMBER 2012

Investigating and Preventing the Loss of Control Accident, Part I

Four Snare ISASI's Kasputin Scholarship

Understanding Pilots' Cognitive Processes for Making Inflight Decisions Under Stress

Using 'ASTERIX' in Accident Investigation

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ABOUT THE COVER

This B-737 is on its takeoff roll at Schiphol International Airport (EHAM), Amsterdam, the Netherlands, with an airport vehicle in the foreground. By using ASTERIX CAT 11, an overview of airport surface movement can be obtained. If airport vehicles are equipped with "transponders," they can be tracked in the same way that aircraft are tracked. The so-called "cooperative mobile" is equipped with systems (transponders) capable of automatically and continuously providing information, including its identity to the A-SMGCS system. The ground radar data are sensed and recorded every second (1Hz), which allows for a high-fidelity information layer (see "Using 'ASTERIX' in Accident Investigation," page 20.) Photo: nustyR, the Netherlands

ISASI FORUM
"Air Safety Through Investigation"

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AIR SAFETY INVESTIGATORS
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Dick Wood 'Flies West'

By Frank Del Gandio, ISASI President

It is with sadness that I report the "Flying West" of ISASI Life Member and 2006 ISASI Jerome F. Lederer Award recipient Richard "Dick" Wood. Many of you knew Dick, and many more of you are recipients of his safety advocacy and his unequivocal allegiance to ISASI. He passed on February 3.

A member since 1972, he held various offices and committee positions, including twice president of the Los Angeles Regional Chapter. He authored nearly 30 professional papers, many presented at ISASI seminars, including his latest presentation at the 2006 seminar. He was a writer, lecturer, and consultant specializing in aviation safety and aircraft accident investigation. He participated in more than 125 civil and military accident investigations and served as a technical consultant in countless others. He was a person who gave back to his profession through publications and hands-on teaching, with eight books and manuals to his credit and 24 magazine articles. His textbook *Aircraft Accident Investigation,* coauthored with the late Robert Sweginnis, went into a second edition and is used throughout the world

Dick Wood displays his lively style of delivery during the presentation of his technical paper "Defining and Investigating Incidents" to the ISASI 2006 audience.

Dick's professional life was punctuated with countless contributions—both to ISASI and the industry. A pilot with 6,000 hours in transport, general aviation, and military combat aircraft, Dick began his life's work in the U.S. Air Force focusing on a career in aviation safety. Retiring in 1978, Colonel Wood was chief of the Safety Policy and Programs Division in the Directorate of Aerospace Safety Office. While there, he replaced "the primary cause" concept of accident analysis with the "multi-cause" system.

He then joined the University of Southern California as a professor of safety science, developing and teaching courses in aviation safety program management, investigation, maintenance, photography, and other related subjects. He was also an active consultant in aviation safety and aircraft accident investigation. Later, he became director of USC's aviation safety programs, specializing in developing and teaching many of the programs, until he left to help form the Southern California Safety Institute (SCSI). There, he became a member of SCSI's Board of Directors and advisors and was a 23-year Executive Committee member of SCSI's Cabin Safety Symposium.

The Jerome F. Lederer Award was created by the Society to honor its namesake for his leadership in the world of aviation safety since it infancy. Jerry Lederer "flew west" on Feb. 6, 2004, at age 101. The Award is conferred for outstanding lifetime contributions in the field of aircraft accident investigation and prevention. During the presentation ceremony when Dick was honored with the Award, he thanked all who played a role in his selection: the person who nominated him, the Awards Committee members scattered throughout the world in a fashion that attempts to duplicate the distribution of ISASI membership as closely as possible, and ISASI itself for having established such an award. He noted that he had a personal friendship with Jerry that dated back to 1973.

Dick authored nearly 30 professional papers, many presented at ISASI seminars, including his latest presentation at the 2006 seminar. He was a writer, lecturer, and consultant specializing in aviation safety and aircraft accident investigation.

Dick said at the time, "I am very, very proud to receive this Award." Then he explained that his plan was to hang it well away from his collected awards he had earned over 39 years and to place it close to the front door. He wanted people who came to visit him to look at it and ask about it. Then he would deliver a free 10-minute lecture on what ISASI is and what it stands for and who Jerry Lederer was. His words to the audience expressed gratitude and the implied veneration he held for the meaning of the Award.

His final words were more a whisper than a pronouncement, "I'm profoundly grateful to ISASI for giving me this reward; thank you." ◆

Dick Wood, right, accepts the Jerome F. Lederer Award from President Frank Del Gandio during ceremonies at the ISASI 2006 award banquet held in Cancun, Mexico.

Vice President Presents Report of Activities

By Paul Mayes, ISASI Vice President

It has been a busy time since the last edition of *Forum*. Since then, I travelled to Washington in May to meet up with the other members of the Executive for our annual meeting. That was combined with a visit to the ISASI office to spend some time on administration with Ann Schull, office manager, as well as attend the International Council Meeting, and the MARC dinner (see page 28). Travel from my home in New South Wales, Australia to Sterling VA, USA, takes 36 hours; so I tried diligently to maximise my four days in Sterling, attending meetings and attending to ISASI business.

The main issue under discussion at the council meeting was membership levels, and how to make the society more responsive to the members. Secondly, financial stability has always been a major concern as it is linked to our membership numbers and to our international seminars. Our membership numbers have remained relatively static for several years now. Each year we lose as many members as we gain new members. I undertook to try to improve the membership retention by understanding what ISASI can do better. To do this I am developing a questionnaire that we will send out to all the membership to get your ideas.

Financial stability has been an issue for as long as I have been on the international council. The profit from the international seminar held at Salt Lake City, Utah, USA, last year has put us in a good position, but we need a strategic approach to financial planning. I have always opposed raising membership dues without a full review of finances. I have seen how negative it can be to raise dues; so, to build our membership I would rather improve our services and meet our member's expectations.

The international seminar is the flagship of ISASI. It was disappointing that we did not have any bids for 2013 at the council meeting. I would like to see a proactive approach to the future seminars, so that we can build a program for several years ahead. On my return to Australia we looked at a bid for next year, but found the time frame was too short. However, we will bid to host the 2014 international seminar.

After a busy time in Washington, I headed home to finish preparations for the 2012 Australasian Safety Seminar in Sydney. These annual seminars held jointly between ASASI and NZSASI have become a feature of the safety calendar and

Regional seminars organized by the ISASI national societies are a very important feature of ISASI. They truly represent the "International" aspect of ISASI. We are extremely grateful for the work of members around the world who give their time freely to promote the goals of ISASI and promote the profession of aviation safety.

are a great promotion for ISASI in this part of the world. The delegates received a full technical and social program beginning with a welcome reception on the Friday evening. The Saturday and Sunday were devoted to technical presentations, with a gala dinner held Saturday evening.

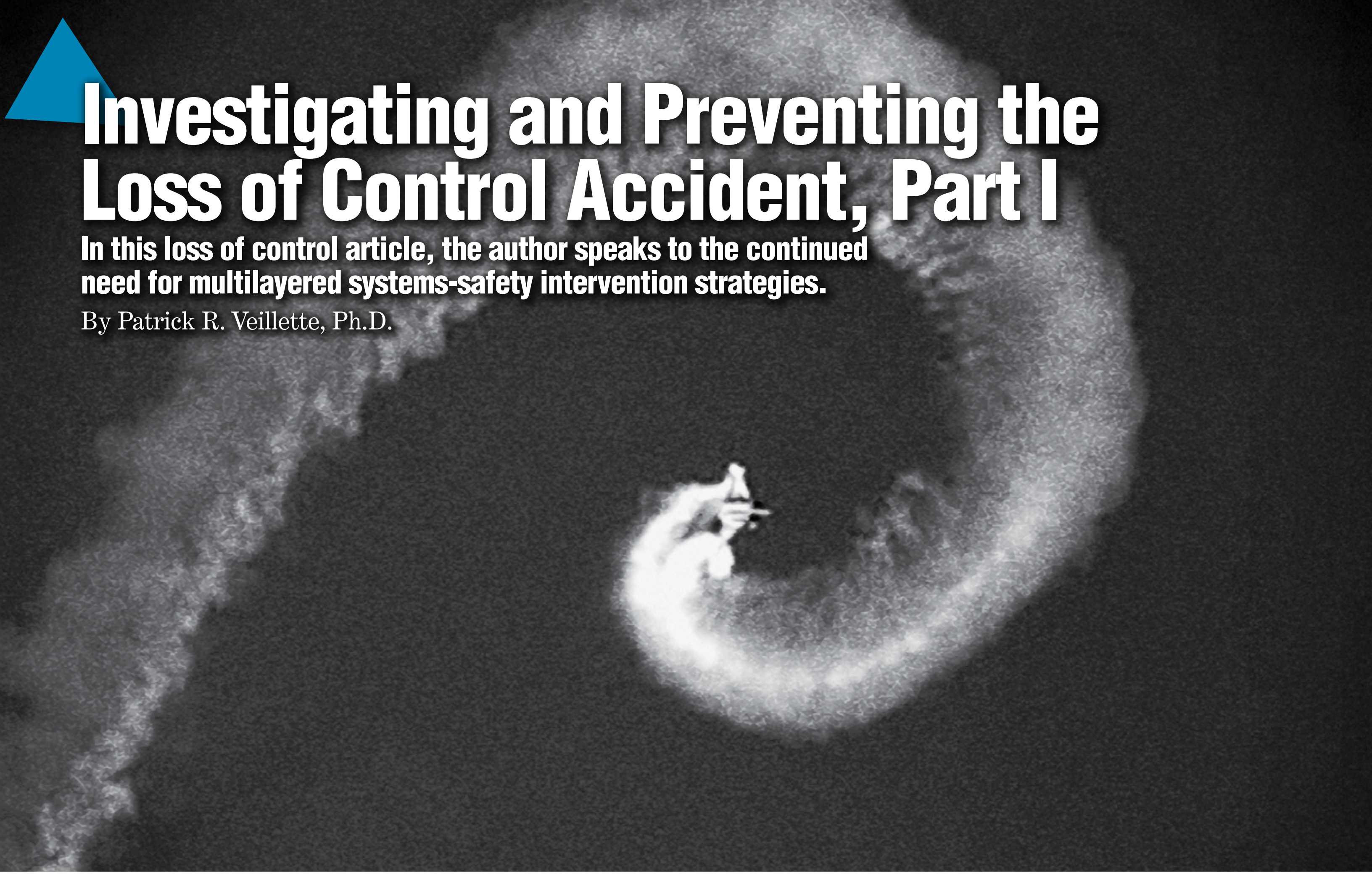
Through generous local sponsorship, registration costs were kept to a very affordable amount, which covered the cost of food and beverages for all the functions. We are indebted to the presenters, and delegates, some of whom travelled from Canada, USA and Europe as well as Australasia, for making the seminar a great success. The presentations covered the range of aviation safety from large civil transport accident investigations to military accident investigations; from the introduction of UAVs to developments in training airline pilots; from research into noise cancelling headsets to developments in safety management, and risk management.

The Chief Commissioner of the Australian Transport Safety Bureau opened the seminar. The keynote address was delivered by the head of the Australian Defence Force safety agency. Copies of presentations are available on the ASASI website (www.asasi.org), which has recently been updated with a fresh appearance. These types of regional seminars organized by the ISASI national societies are a very important feature of ISASI. They truly represent the "International" aspect of ISASI. We are extremely grateful for the work of members around the world who give their time freely to promote the goals of ISASI and promote the profession of aviation safety. ◆

Investigating and Preventing the Loss of Control Accident, Part I

In this loss of control article, the author speaks to the continued need for multilayered systems-safety intervention strategies.

By Patrick R. Veillette, Ph.D.



(This article is adapted, with permission, from the author's paper entitled Loss of Control: Investigating and Preventing the Loss of Control Accident—The Continued Need for Multilayered Systems Safety Intervention Strategies *presented at the ISASI 2011 seminar held in Salt Lake City, Utah, Sept.13–15, 2011, which carried the theme "Investigation—A Shared Process." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag ISASI 2011 Technical Papers. Owing to the paper's abundance of useful information for air safety investigators, this unusually long article will run in two parts. Part II will appear in the next issue of* Forum.*—Editor)*

Loss of control (LOC) is the leading cause of fatal accidents in several segments of the aviation industry, including large commercial jet and business jet sectors. According to data compiled by the Commercial Aviation Safety Team from 1999 through 2008, LOC in flight was the largest category of commercial jet fatal accidents worldwide, resulting in 4,717 onboard fatalities.

I recently completed the study "Investigating and Preventing the Loss of Control Accident" on which the paper I presented at ISASI 2011 was based. That paper, the source of this adapted article, delves into the study review of reports of business jet accidents that occurred in 43 countries from 1991 through 2010. This included aircraft being used under Part 135 and Part 91 flight rules (or the non-U.S. equivalent), which includes private, business, corporate, nonscheduled, and fractional operations. This focused on turbojet aircraft designed for the business industry, generally with fuselage-mounted engines. This study excluded large transports normally associated with scheduled airline operations. The study also excluded aircraft that were undergoing certification flight testing by test pilots.

The LOC accident is defined as "an aircraft put into an unrecoverable position due to aircrew, aircraft, or environmental factors, or combination of these." The study reviewed 71 business jet accident reports fitting the LOC definition.

While there are many important similarities between business jet and large commercial transports, there are also significant differences. Most business jets have maximum operating altitudes significantly higher than large commercial transports. Several have operating speeds above 0.9 Mach and maximum operating altitudes to FL510. The typical business aircraft has fuselage-mounted engines and has far less inertia in the roll axis than large commercial transports with wing-mounted engines and considerable fuel loads contained in the wings. A substantial percentage of the business jet designs have direct "cable and pulley" flight control systems. Some business jets are equipped with pneumatic de-ice boots for ice protec-

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FAA's Incident Database of 1,234 business jet incidents between Jan. 1, 1991, and Dec. 31, 2010, and

tion. Business aircraft frequently operate into uncontrolled airports, which lack precision approach navigational aids, terminal approach radar, air traffic control towers, weather reporting, runway condition reporting, etc. Several popular business aviation locations are surrounded by steep mountainous terrain.

The Aircraft Upset and Recovery Training Aid divides the major LOC causes into these subcategories:

- environmental factors: thunderstorms, windshear, microbursts, wake turbulence, turbulence, and icing;
- aircraft factors: flight instruments, flight controls, and autopilot malfunctions;
- pilot-induced upsets: incomplete instrument cross-check, inattention, distraction from primary cockpit duties, vertigo or spatial disorientation, pilot incapacitation, improper use of airplane automation, and improper pilot techniques.

The general categories of the 71 business jet LOC accidents are found in the box to the right.

unintentional stall	31
crew automation mismanagement	7
flight control malfunction	6
low-level windshear	6
intentional maneuver	5
undetermined	4
turbulence	4
wake turbulence	3
other	3
aeromedical	2

Forty-eight percent of the LOC accidents occurred during approach and landing, and 18 percent occurred during takeoff. Taken together, two-thirds of all LOC accidents occurred very close to the runway.

Fully two-thirds of the LOC accidents occur within 1,000 feet of the ground (see box below). Unfortunately, this means that most of the accidents occur with very little margin of safety.

Aircraft were configured with gear and flaps extended (either partially or fully) in 52 of the 71 accidents. This is significant to the discussion of the prevention of an LOC accident because the aircraft is in a high-drag configuration with less excess power available for aircraft acceleration, as well as the more restrictive load factor limits on the aircraft when the flaps are extended. Furthermore, in the slower speed regime, the aircraft tends to be at a higher angle of attack, which can further limit the aircraft's maneuverability without stalling the aircraft. Additionally, the aircraft is typically closer to the backside of the power curve, and at a slower airspeed with less kinetic energy to aid in a recovery.

Ground level to 1,000 feet AGL	45
1,000 feet AGL to 10,000 feet AGL	7
10,000 feet AGL to 20,000 feet AGL	4
20,000 feet AGL to 30,000 feet AGL	4
30,000 feet AGL	6
Unknown	5

The Airplane Upset and Recovery Training Aid defines an upset as "a pitch attitude greater than 25 degrees nose up or 10 degrees nose down, a bank angle greater than 45 degrees, or within these parameters but flying at an airspeed inappropriate for the condition." Nine of the 71 accidents involved a pitch and/or roll excursion beyond these limits.

This study also searched through the FAA's Incident Database of 1,234 business jet incidents between Jan. 1, 1991, and Dec. 31, 2010, and found 57 incidents in which control of the aircraft was temporarily compromised. These are included in the box on the top of the right column.

In addition, an exhaustive search of more than 6,300 reports from business jet pilots in the NASA ASRS database found 246 that involved deterioration of control of the aircraft. The leading categories of LOC incidents in the ASRS database are included in the box below.

flight control malfunction	18
stall (flare)	13
low-level windshear	10
automation mismanagement	10
clear air turbulence	6

wake turbulence	54
automation mismanagement	38
mountain wave	38
high-altitude aerodynamics	34
low-altitude stall	31
thunderstorm	18
flight control malfunction	11
low-level windshear	9
clear air turbulence	8
intentional maneuver	4
icing	3
others	3

Low-altitude stalls

Unintentional stalls, particular at very low altitudes during critical phases of flight, occurred in 31 accidents. An additional 31 ASRS reports indicated stalls at low altitudes in which control of the aircraft seriously deteriorated.

While this leads to the logical recommendation of the need for additional emphasis on stall prevention training, common training practices have strong potential for negative habit transfer that are likely to exacerbate stall prevention and recovery.

Nine of the 31 stall accidents involved icing. John P. Dow, Sr., the recently retired subject-matter expert on icing issues in the FAA's Aircraft Certification Service, emphasizes a very important disparity between the "normal" stall recovery instilled during training and a "real world" stall induced by ice on the wing. The vast majority of commercial pilots are trained in simulators to respond to the first indication of a stall by applying power and maintaining pitch attitude, with the objective of minimizing altitude loss during recovery. The "standard recovery" procedures are somewhat dictated by the FAA's Practical Test Standards, which require recovery to be initiated at the first indication of an impending stall, as well as minimizing altitude loss. According to Daniel Meier, Jr., an aviation safety inspector, Flight Operations, FAA headquarters, "A stall caused by icing is extremely hazardous because you cannot conserve altitude by maintaining attitude. Adhering to the standard of minimum altitude loss ingrained in training has resulted in pilots' failing to recover from ice-related stalls and upsets that have resulted in altitude losses in excess of 5,000 feet…."

Since nearly all the approach stall accidents occurred with the aircraft in the fully configured configuration, a "standard stall recovery" would normally involve initial application of maximum available power and some retraction of flaps. Flight test data from several common business jets indicate that the application of power creates a strong adverse nose-down pitching moment. Conversely, retraction of the flaps creates a strong nose-up pitching moment in several popular models of business jets. Thus, the reality is that such "standard" stall recovery control inputs create a gyrating series of pitching moments that can be difficult to control.

Simulator training of stall entries and recoveries extends to portions of the simulator envelope in which extrapolations from actual aircraft performance and handling measurements are used

[shows] 57 incidents in which control of the aircraft was temporarily compromised.

and in which the simulator's aerodynamic model is highly questionable. Flight crew exposure to a simulator with insufficient fidelity of the aircraft's stall characteristics has led to pilots' making control column inputs that hindered recovery in the actual aircraft. The 1996 accident of a DC-8 in which the NTSB cited the differences in the aircraft's handling characteristics near the stall versus the handling characteristics programmed into the simulator pointedly demonstrate the severe consequences of such negative training.

The extensive discussions regarding simulator fidelity during maneuvers close to the aircraft's flight envelope after the Airbus accident at JFK in 2001 further heightened awareness of this problem. At present, there is no requirement for an evaluation of a simulator for physical fidelity, motion fidelity, visual fidelity, or cognitive fidelity to ensure that the simulator will accurately portray the airplane during the "edge of the envelope" maneuvers. There is a significant risk of negative training, and yet these practices are still common in the industry. Deeper evaluation of the stall accidents reveals the need for more focused preventive measures.

Thirteen of the 31 stall accidents occurred on takeoff. The effects of any combination of improper weight-and-balance calculations, lack of adequate acceleration, over-rotation, improper calculation of takeoff speeds, failing to unlock the parking brake, and/or lifting surface contamination didn't become obvious in these accidents until the flight crew rotated for takeoff. All of these aircraft struggled to remain airborne but couldn't. Twelve of these 13 accidents killed everyone on board and destroyed the aircraft. Whether additional "stall training" would be beneficial given these factors is debatable, as clearly several of these factors will render the aircraft unrecoverable very close to the ground. The emphasis should be on prevention of these factors. The remainder of the stall accidents (18 of the 31) occurred during approach and landing.

Most of the causal statements for the unintentional stall accidents contained the primary finding of "pilot failed to maintain adequate airspeed." While true, that doesn't dig deep enough to help us better determine "how" and "why" these accidents happened, nor has it been sufficient to provide meaningful preventive measures. Evaluation of these 18 accidents found that the leading contributing factors were inadequate cross-checking and monitoring; abnormal circling approaches; particularly in confined "mountain bowl" locations; and icing, most notably in aircraft equipped with pneumatic de-icing boots.

NTSB member Robert Sumwalt has clearly stated, "A flightcrew member must carefully monitor the aircraft's flight path and systems, as well as actively cross-check the other pilot's actions, or safety can be compromised." The LOC problem isn't the only undesired aircraft state caused by inadequate cross-checking and monitoring. A study of business jet approach and landing accidents found similar trends. Forty-three percent of the 132 approach and landing accident reports indicated inadequate monitoring. Most of the monitoring errors were associated with crewmembers preoccupied with other important duties, including communications, checklists, configuration changes, scanning for air traffic, reprogramming the FMS, and managing aircraft systems.

Poorly designed cockpit procedures negatively impact the flightcrew members' ability to focus on cross-checking and monitoring. That study found numerous problems with flight crew procedures, including noncritical items on checklists, checklists inducing high workload and requiring high communications during critical phases of flight, and nonlinear sequencing of items in the checklist. For example, a review of "Before Landing" checklists of several common business jets found very lengthy checklists, sometimes requiring more than 12 items to be checked after extending the landing gear.

Twelve items on a Before Landing checklist is an example of the "dumping ground" design philosophy. Event Review Committees from ASAP programs may (mistakenly) believe that adding an item to a checklist will be an effective method to prevent such an error in the future. Legal departments may want certain items added to a checklist as a guard against liability claims. Customer service departments will want their items added. Safety officials are always tempted to add additional items, hoping those line items will serve as memory triggers to prevent such events as forgetting to shut and lock external doors. Some managers, upon being made aware of a pilot making an error that is related to configuration, may feel that since one pilot could make this mistake, then the only way to prevent others from making the same mistake is to add new provisions to the checklist.

The problem with checklists becoming dumping grounds for everyone's pet peeve is that it creates worse problems. According to Dr. Wiener's studies, "A long and detailed checklist is no guarantee of absolute safety, as demonstrated by plenty of accidents in the past. Long and detailed checklists carry the risk that too many pilots will choose not to use the checklist or conduct it poorly because of its length." The FAA's Air Transportation Operations Inspector's Handbook sums up these three major issues very well. It states, "Each additional item that is added to a checklist increases the potential for interruption when the checklist is accomplished, diversion of the crew's attention at a critical point, and the missing of critical items."

Furthermore, according to the FAA's Human Performance Considerations in the Use and Design of Aircraft Checklists, "If the established flows are not logical and the checklist itself correct and consistent with procedures prescribed in related manuals, the probability is very high that the crew may revert to their own methods, cut corners, omit items, or even worse, ignore the checklist entirely."

Capt./Board member Sumwalt emphasizes, "Management of flight operations departments, as well as regulatory officials, must realize that it is incumbent on them to provide air crews with clearly thought-out guidelines to maximize their monitoring of aircraft trajectory, automation, and systems. Procedures that conflict with crew monitoring must be minimized or eliminated."

It is noteworthy to point out the success of properly integrated human-centered design and proper procedures for enhancing cross-checking and monitoring. Line Operational Safety Audits and Flight Operations Quality Assurance data have noted that the B-777, whose cockpit instrument layout, ergonomics, and flight crew procedures were intended at the very earliest design stages to enhance monitoring and cross-checking during terminal operations, has experienced a significantly lower rate of unstabilized approaches than its predecessors, and, to date, has not suffered a human-factors-caused hull loss or fatal accident.

When reviewing cockpit procedures, it is vital to analyze whether they aid the pilot in the following: recalling the process for configuring the airplane; providing convenient sequences for arm movements and eye fixations; providing a sequential framework to meet internal and external cockpit operational requirements. Checklists must be designed so that the flight crew can maintain an adequate visual scan and monitor air traffic control communications while simultaneously controlling the aircraft; avoid consuming valuable time by avoiding noncritical items on checklists; avoid communication-intensive verbiage during critical phases of flight; and do not create distractions from other cockpit tasks and duties. Checklists must aid mutual supervision, monitoring, and cross-checking among crewmembers; enhance a crew concept by keeping all members "in the loop"; dictate the duties of each crewmember to facilitate optimum crew coordination and distribution of cockpit workload, particularly in terminal airspace; serve as a quality-control standard; evaluate whether features of the aircraft design (systems deployment and instrument location) require extra attention during terminal phases of flight; and evaluate whether the placement of cockpit instruments and controls are awkward or inhibit timely and smooth checklist accomplishment.

Constrained maneuvering space/mountain airport operating environment

Twelve stall accidents occurred during circling approaches while the aircraft was in a bank angle. In other words, the aircraft encountered an accelerated stall. The "threats" in a circling approach are significant. Pilots have to focus attention outside the aircraft, which usually requires a lot of bending of the head, inducing sensory and perceptual illusions, without the benefit of vertical guidance information. Also, maneuvering in relatively confined airspace very close to the ground severely decreases the ability of the pilot flying to keep a close scan on the aircraft's airspeed, pitch, bank, and sink rate. When executed in limited visibility and/or mountainous terrain, the lack of a distinct horizon induces further visual illusions.

Of further concern is that many of the circling approach accidents occurred at "mountain bowl" locations. An additional 31 events reported to the ASRS indicated hazardous deteriorations of aircraft control while maneuvering for landing at a mountain airport destination. The ability to maneuver is severely restricted at many of the common business jet locations located in mountainous terrain (examples include Aspen, Colorado, and Truckee, California).

A Flight Safety Foundation study of business jet accidents found that constrained maneuvering room was a contributing factor in 22 of the 32 "mountain airport" accidents. One such example occurred on Feb. 13, 1991, to a Lear 35A that was executing the VOR/DME approach to Runway 15 at Aspen. The aircraft was seen below the cloud on the downwind leg of the approach to the west of the airfield. However, when turning onto final approach, the turn became very steep, being described by some witnesses as almost a 90 degrees bank, before the aircraft began to lose height. The aircraft hit the ground about a mile north of the airfield. Just before impact, someone on the Learjet was reportedly heard to scream "oh no (a) stall" over an open microphone.

A recent review of ASRS reports submitted by business aviation pilots conducting instrument approaches to "mountain bowl airports" found 128 reports in which severe, undesired aircraft states occurred after loss of visual reference with the runway due to rapidly deteriorating weather after continuing the approach from the MDA. Of particular concern is that many of these resulted in a serious degradation of aircraft control (which occurred in 24 percent of the sampled reports) or a serious loss of separation with terrain or obstacles (which occurred in 47 percent of the sampled reports). A temporary loss of situational awareness occurred in 84 percent of the sampled reports as the flight crews were suddenly surprised by the rapid change in visibility and did not have a preplanned action in case they had to go-around on the landing approach so close to the runway within the topographical confines. Many reports indicated that the crewmembers were confused listening to multiple confusing warnings, intense concentration on one task or multiple tasks, and visual fixation out the aircraft, such as on the runway environment.

Proximity to adverse terrain is not the only environmental factor contributing to the deterioration in aircraft control in these approaches. The significant density altitudes at these common destinations add an additional compounding factor. Higher density altitudes translate into higher true airspeeds, and a 10 percent increase in true airspeed increases the required turning radius by approximately 21 percent, further limiting aircraft maneuvering margins in the canyon terrain. The increase in the turn radius can quickly put an aircraft into a situation in which any continuation of the turn places the aircraft's future flight path into adjacent terrain. Even a relatively benign and undetected 10-knot tailwind can greatly increase an aircraft's turn radius beyond safe margins in the confined maneuvering space near these common destinations.

FAR Part 121.445 requires special training and qualifications for the pilot-in-command operating at airports determined to be unique due to surrounding terrain, obstructions, or complex approach or departure procedures. Part of the safety standards require Part 121 operators to do immensely detailed studies proving adequate terrain clearance even with an inoperative engine. The studies are conducted by highly qualified cartographers, aeronautical engineers, and regulatory compliance specialists using high-fidelity topographic and exceptionally detailed aircraft performance data.

These detailed studies take into account the aircraft's turn radius at the specific maneuvering speed, the degraded climb performance with an inoperative engine, the changes in aircraft performance during a configuration change, the effects of adverse winds on the turn radius, and even the loss of climb performance as the aircraft banks into a turn. These special procedures include the portion of the instrument approach descending from the relatively high MDAs on the approaches to "balked landing" maneuvers in case that a landing is no longer safe (loss of sight of the runway, etc.) when the aircraft is below the MDA no longer on a published segment of the IAP, and during "escape maneuvers" for an engine loss during takeoff.

mation in an AFM is accurate and sufficient.

It is worth noting that while the scheduled airline operators have been able to operate into several of the popular mountain locations without severe accident over the last two decades, which in part can be attributed to Special Airport Qualification Programs, the business jet industry largely operates without such defined procedures and training. The lack of rigorously defined maneuvers exposes flight crews to potential situations in which the aircraft is placed in hazardous proximity to nearby terrain from which recovery may not be possible.

The prevention of LOC accidents in this hazardous environment, as well as CFIT accidents and approach and landing accidents, is clearly enhanced by rigorous design-specific procedures to ensure adequate maneuvering margins while operating into the mountain airport location. Such procedures should specify exact aircraft tracks, altitudes, and configurations. Such procedures should guarantee the ability to execute an "escape maneuver" should the weather deteriorate at any moment during the visual segment of the final landing approach. Operators should also provide in-depth and sufficient training prior to allowing a flightcrew member to operate at the destination.

Icing

Icing was contributory in nine stall accidents. Three of the 13 takeoff stalls occurred when flight crews attempted takeoff without adequately de-icing the wings. Any form of wing contamination is an unacceptable risk prior to takeoff, and every operator should have a formal program for adequately inspecting, cleaning, and re-inspecting an aircraft prior to takeoff when surface contamination could be a possibility.

Special emphasis items to be investigated in this industry would include whether the operator has an adequate de-icing training program and procedures and whether adequate resources are available for de-icing, particularly at small general aviation airports, which frequently lack de-icing capabilities.

The other six stall accidents induced by icing occurred during approach and landing. Five of these six accidents occurred in aircraft equipped with pneumatic de-icing boots, and three of these involved flight crews who had deployed the de-icing boots during approach but still had residual ice on the boots. An additional three incidents in the ASRS database and three more in the FAA's incident database involved residual ice.

The University of Illinois-Urbana conducted a research project specifically aimed at determining the effect of residual and intercycle ice accretions on airfoil performance. The study concluded that the performance penalties due to the intercycle ice shapes were found to be very severe. Specifically, the study found that intercycle air accretions reduced the maximum lift coefficients about 60 percent from 1.8 (clean) to 0.7 (iced), and stall angles were reduced from 17 degrees (clean) to 9 degrees (iced). The effect of the small ridge-like features was local boundary layer separation on the airfoil's upper surface, particularly at higher angles of attack.

In the NTSB's investigation of the inflight icing loss of control of an Embraer EMB-120 on Jan. 9, 1997, the NTSB noted a lengthy chain of events leading to the LOC accident. The events included "the FAA's failure to establish adequate aircraft certification standards for flight in icing conditions; the FAA's failure to ensure that a Centro Tecnico Aerospacial/FAA-approved procedure for the accident airplane's de-ice system operation was implemented by U.S.-based air carriers; and the FAA's failure to require the establishment of adequate minimum airspeeds for icing conditions, which led to the loss of control when the airplane accumulated a thin, rough accretion of ice on its lifting surfaces. Contributing to the accident were the flight crew's decision to operate in icing conditions near the lower margin of the operating airspeed envelope and Comair's failure to establish and adequately disseminate unambiguous minimum airspeed values for flap configurations and for flight in icing conditions." Similar chains of events occurred in the icing accidents in this study, particularly for aircraft that utilize de-icing boots.

Perkins and Rieke of the NASA Glenn Research Center have stated, "The FARs do not address performance margins with residual ice accretion. Stall angles may be reduced sufficiently so that an aircraft may enter a stall prior to activation of stall warning devices."

In the aftermath of the Embraer accident and other similar accidents, the NTSB recommended "additional research to identify realistic ice accumulations, to include intercycle and residual ice accumulations…and to determine the effects of criticality of such ice accumulations; further, the information developed through such research should be incorporated into aircraft-certification requirements and pilot training programs at all levels…."

The NTSB also recommended, "Require manufacturers of all turbine-engine-driven airplanes to provide minimum maneuvering airspeed information for all airplane configurations, phases and conditions of flight (icing and nonicing conditions); minimum airspeeds also should take into consideration the effects of various types and amounts and locations of ice accumulations, including thin amounts of very rough ice…."

It is vital that aircraft be adequately certified for flight into likely icing conditions, and that the information in an AFM is accurate and sufficient. It is equally vital that pilots be properly trained in the employment of the anti-icing and de-icing devices; that pilots have adequate information to know the proper speed and configuration to fly in potential icing conditions (especially for that phase while slowing down to configure for landing and up to the point of touchdown); that these speeds be established with adequate stall margin, to include if ice remains on critical portions of the aircraft; and a proper recovery procedure at the first indication of loss of control. Questions remain whether the information regarding residual ice is sufficient and whether the safety margins are adequate.

Analysis of other icing-related incidents and ASRS reports brings into focus the airworthiness of all components of the anti-ice and de-ice systems. Examples are noted in the ASRS reports in which Tecalemit-Kilfrost-Sheepbridge Stokes (TKS) panels were found to only partially exude TKS fluid through a limited portion of the panel during an inflight icing encounter. Fortunately, in the incidents the flight crews detected the anomaly and were able to make inflight emergency diversions to warmer air, which aided melting off the asymmetrical ice ac-

(continued on page 31)

FOUR SNARE ISASI'S
Kapustin Scholarship

For the first time in its 10-year history, the ISASI Rudolf Kapustin Memorial Scholarship program issues four scholarships.

By Esperison Martinez, Editor

Richard Stone and Ron Schleed, co-chairs of the ISASI Rudolf Kapustin Memorial Scholarship program, in naming the awardees, said that "for the first time, the Society has selected four recipients to receive the annual scholarship award." The awardees are Frederik W. Mohrmann, Delft University of Technology; Heidi E. Moats, Embry-Riddle Aeronautical University; Robert Geske, Purdue University; and Harding "Chip" Williams, Embry-Riddle Aeronautical University.

The Kapustin fund was established in 2002 to memorialize all deceased ISASI members. It was named in honor of the former ISASI Mid-Atlantic Regional Chapter president, Rudy Kapustin. He died in 2002, and throughout his long career he was always a safety advocate. In the early 1950s, he maintained aircraft for Trans World Airlines. In the early 1960s, he became an FAA inspector. The accident rate at that time was 16 accidents per 100,000 flight hours. Next, he joined the National Transportation Board, participating in and overseeing a significant number of major accidents.

Upon his passing, he was eulogized by many. *The Washington Post* had this to say: "Under public pressure for answers and scrutiny from lawmakers, his main job was to move the investigation along methodically and expeditiously, assess daily progress reports, ensure that legitimate lines of inquiry were pursued, and draft a final report with probable causes and recommendations to help prevent disasters…. Mr. Kapustin, who mentored other investigators, displayed a sense of integrity, an inquisitive mind, humble mannerisms, and a keen sense of humor wrapped in a rumpled exterior that reminded colleagues of Peter Falk's television character Lieutenant Columbo…. Like Columbo, Mr. Kapustin was a veteran and dogged investigator whose gentle personality belied a toughness and steely determination to get at the truth."

ISASI President Frank Del Gandio said at the time, "I had my first major accident investigation with him 20 years ago. It was the Air Florida accident…. He exhibited a relentless pursuit for the facts. He confidently relied heavily on his training, his experience, and his skill to put the puzzle together. Rudy never tried to impress anyone with his knowledge. He did just the opposite. He downplayed himself. As an aircraft accident investigator, he was second to none. There is a term for such investigators—'tinkicker.' Rudy Kapustin was a tinkicker extraordinaire."

The ISASI scholarship is intended to encourage and assist college-level students interested in the field of aviation safety and aircraft occurrence investigation, according to Stone. Contributions have and will continue to provide an annual allocation of funds for the scholarship. Contributions are tax-deductible in the U.S. and may be made in the name of a specific deceased member payable to the ISASI Kapustin fund and sent to the ISASI home office.

To date, 25 students have been awarded ISASI scholarships since 2002. What began as a single annual selection has now become four, thanks to generous tax-free contributions from ISASI members. Application and scholarship availability notices are posted in some 50 college and universities worldwide. You are encouraged to promote this scholarship to individuals, student groups, parents, and applicable departments of your alma mater. You are encouraged to assist in securing and completing applications for any appropriate student(s).

The deadline for applications is April 15 of each year. Full application details and forms are available on the ISASI website, www.isasi.org. The requirements are that applicants must be enrolled as full-time students in an ISASI-recognized education program, which includes courses in aircraft engineering and/or operations, aviation psychology, aviation safety and/or aircraft occurrence investigation, etc., with major or minor subjects that focus on aviation safety/investigation. Also, the student is required to submit a 1,000-word paper in English addressing "The Challenges for Air Safety Investigators."

ISASI presents a US$2,000 award to each student who wins the competitive writing requirement, meets the application requirements, and who registers to attend the ISASI annual seminar. The award's intent is to cover the registration fees, travel, and lodging/meals expenses to attend the respective year's ISASI annual international seminar on air accident investigation. Any expense above and beyond the amount of the award is borne by the recipient. In addition, the scholarship awards a one-year ISASI membership, and a fee-free attendance at an accident investigation course at the FAA's Transportation Safety Institute, the Southern California Safety Institute, or the Cranfield University Safety and Accident Investigation Centre in the United Kingdom. No dues funds are used to support this program. It is totally dependent upon voluntarily (tax-free in the U.S.) contributions.

Frederik Mohrmann, 24, is of Dutch nationality, but has lived mostly in Sri Lanka, France, South Africa, and the U.S. He is the oldest in a family of six, all of whom lived in separate parts of the world. He is completing his master's degree in aerospace control and operations, with electives in forensic

and safety engineering, maintenance, and structural integrity at the Delft University of Technology. He also earned his undergraduate degree in aerospace engineering at Delft and spent his high school years at the Washington International School in Washington, D.C. He returns to D.C. for an internship with the NTSB Department of Research and Engineering. He has a long-held interest in aviation and space. He holds a glider pilot license and is working toward his instructor license. After securing his masters, he will probably forgo pilot training and center on forensic and safety engineering opportunities. He expects "plenty of personal flight time on the side!"

His winning essay follows:

Running Out of Time: Advancing Accident Causality Models

By Frederik Mohrmann

An incident or accident occurs when a system fails to recover from an unintended course of action, within a certain timeframe. Many investigative models are capable of determining several causal factors responsible for the result: the chain of events. Consequently, these events are often the basis of recommendations aimed toward certain system changes. However, as systems become increasingly complex, simple methods to dissect and segregate the different components are insufficient in describing their interactions (Dekker, 2004).

The interactions between the different components are no longer static and readily determined. Rather, past actions influence the entire system, reshaping, adding, or eliminating causal possibilities. It is this insight which supports the claim that current modeling techniques may well provide an insight into what and how an accident happened, but they do not explain why the causal relations were as such. In other words, how the dynamics of the accident impact the eventual outcomes.

There are several causal relationship models currently in use. Benner (1985) ranked the different models used within the U.S. government. The report concludes that there is an unnecessary diversity of different models used. Two highly ranked models are the Event Sequence Diagrams (ESD) and the Fault Tree (FT). The ESD shows a graphical representation of a causal chain of events. An ESD makes itself useful by giving an overview of what has happened, and it can show multiple failure paths simultaneously.

"By introducing the dynamic effects of time, a method arises which can shift critical points of no return sooner or later, and determine what the maximum level of attainable recovery is at certain points in time."

A limitation is it only considers critical (directly contributory) factors.

The FT attempts to break down the causal factors for a specific incident. It can show gates preventing and pathways leading to failure in addition to being able to map risk to a system. The downside to FTs is that they can become expansive. A third method is using Bayesian Belief Networks (BBN). According to Luxhoej (2006), a BBN describes the relationship between different factors (nodes) by statistically linking them as random variables, using a conditional probability table. BBNs are especially useful in attempting to describe uncertainties often found in human factors research, as the variables can be discrete or continuous, increasing their descriptive power. The shortcomings of BBNs lie in the fact that some variables must be marginalized and/or integrated in order to become manageable. Hence, effects may be diminished or hidden behind more prominent interactions.

In the past decades, these models have also been integrated. Three examples of such all-encompassing models are described by Roelen (2011): the FAA's Hybrid Causal Logic (HCL) model, Eurocontrol's Integrated Risk Picture (IRP), and the Netherland's Causal Modeling of Air Transportation Systems (CATS). All three models have been designed to provide an all-encompassing risk analysis of aviation systems, from managerial levels down to software. However, these models rely largely on complex mathematical models and statistics. However useful to policymakers and government regulators, they have limited direct applicability to accident investigation.

Similarly, integrating these models from an investigative point of view may use the strengths of the different models to compensate for their individual shortcomings (Ale, 2009). However, that does not provide a better insight into the dynamic behavior of systems. For this, time must be included (Stoop, 2011). Currently, time is only being implemented via a rough time line, chronologically listing the contributory.

Investigators need to know how the interactions between different events, or factors, change over time. In a sense, the occurrence of one event may have (serious) ramifications for future options and event pathways. In some cases, the future time line may reduce to a single pathway. In other cases, the chronological separations between decision points become so small that there is no remaining response time. Depending on the skills, rules, and knowledge base of the human operator, and the capabilities of automated systems, this will result in an unstoppable conglomeration of events which culminate into the final moments before disaster.

Either way, by introducing the dynamic effects of time, a method arises which can shift critical points of no return sooner or later, and determine what the maximum level of attainable recovery is at certain points in time.

To illustrate this concept, during the Tenerife disaster, the maximum level of recoverability that the KLM captain could attain after he commenced his takeoff was very low. The poor visibility, in addition to the high speeds attained before visual contact was made, ensured that any form of accident would very shortly follow the point of visual contact, which is the first decision point that the captain had after initiating the takeoff roll. Had the fog been thinner, then this decision point would have been earlier, allowing the KLM crew for more time, making other event pathways available (i.e., braking, veering away, etc.).

Another example is the Qantas Flight QF32, where past decisions clearly had ramifications for future options. In reality, the crew managed to land the aircraft and recover the mission (including passenger and aircraft integrity) to a large extent. However, there is a point at which the growing fuel imbalance prevents controlled flight; their decision to land must precede the imbalance point by at least the time required to land.

Imagine if the crew reacted improperly and disabled the wrong engine, possibly leading to a hydraulic leak at the damaged engine. This degrades aircraft maneuverability, increasing the time to land with each passing minute. In this case, the latest point to commence landing is placed much earlier. In an extreme case, that point could be before the crew shuts down the wrong engine. Consequently, the point of no return is now at the point when the wrong engine was shut down, and not at the decision to land; the event pathways have been reduced to a single outcome, a severe accident.

The essence of the concept illustrated above is to provide a first insight into structuring a method which strives to incorporate the dynamics of an accident system into its modeling. The concept is the subject of the master's thesis of the author. The next development phase is the determination of all the possible pathways following a disturbance, irrespective of time, crew, and system capabilities.

This model will have duration and redundancy of linkages and events described by fixed or varied values, depending on the influences of other decisions, events, and/or durations. Such a very generalist model is subsequently trimmed for the aircraft, crew, and situation in question. This can be done using BBNs to identify the boundaries of the human factors, as done in already documented risk analyses.

Other pathways could be modified or trimmed by considering the situational and environmental status of the aircraft, and the limitations of the aircraft and its subsystems. The resulting diagram would be a biaxial graphical representation of the accident, plotting time against mission integrity (recovery level). This would clearly show the causal factors, the points of no return, and, most importantly, alternative paths and their expected levels of recovery. These results allow for much more precise recommendations following an accident or incident, and can even prevent drift into failure as it consistently shows the level of mission failure at each point in time (e.g., high risk nodes), irrespective of the final outcome. ◆

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Heidi E. Moats, 23, is a native and resident of Leesburg, Virginia, U.S.A. She has two siblings. Heidi is attending Embry-Riddle Aeronautical University while earning a master's degree in aeronautical science, with a duel specialization in human factors in aviation systems and aviation/aerospace management. She expects to complete her studies in 2013. Her undergraduate degree is a bachelor of science in safety science. She holds a commercial pilot certificate with airplane single and multiengine land privileges, as well as an instrument rating. She is working toward a flight instructor certificate and plans to take helicopter flight lessons to earn a rotorcraft-helicopter add-on rating. She has planned her immediate future: "I will continue working at the National Transportation Safety Board as a student career employee and finish my master's degree. After the completion of my post-graduate education, I will upgrade to an aviation accident investigator for the eastern regional office of the NTSB."

Her winning essay follows:

The Growing Challenge of Ballistic Parachute Systems for Air Safety Investigators

By Heidi E. Moats

In the accident investigation industry, the mission of air safety investigators is to improve aviation safety in order to help save lives. The paramount function of accident investigations is to generate safety accomplishments by improving procedures, clarifying instructions or diagrams, and inventing new products to increase the safety of the aviation industry. In the latter part of the 20th century, ballistic parachute systems were developed and started being installed on general aviation aircraft in order to elevate safety in general aviation (BRS Aerospace, 2012). Although ballistic parachute systems have improved the overall safety of general aviation, they pose a significant challenge to air safety investigators during the on-scene phase of an accident investigation.

"The paramount function of accident investigations is to generate safety accomplishments by improving procedures, clarifying instructions or diagrams, and inventing new products to increase the safety of the aviation industry."

The benefit that accompanies ballistic parachute systems in general aviation is saving lives by arresting the rate of descent of an aircraft, which the system has saved approximately 274 lives as of April 2012 (BRS Aerospace, 2012). The hazards associated with the system that generates challenges for investigators are determining if an aircraft is equipped with a ballistic parachute system and the components of the system, such as the igniter, the rocket, line cutters, and a deployed parachute.

When an air safety investigator initially approaches an accident scene, he or she assesses it for any potential hazards. One challenging element is determining whether or not an aircraft is equipped with a ballistic parachute system. Currently, Cirrus airplanes, numerous light sport aircraft, and various ultra-light aircraft are outfitted with ballistic parachute systems. In addition, ballistic parachute system manufacturers sell kits that airplane owners can purchase and have the system retrofitted to their aircraft. Cessna aircraft are the foremost certificated aircraft that are retrofitted, but a ballistic parachute system can be retrofitted to experimental amateur-built aircraft and light sport aircraft as well.

Recently, the National Transportation Safety Board (NTSB) conducted a study of experimental amateur-built aircraft that were involved in accidents. The study discovered that a little more than 1 percent of experimental amateur-built aircraft involved in accidents were equipped with a ballistic parachute system (NTSB, 2011). Although that is a small percentage, it indicates that homebuilt aircraft owners are beginning to construct airplanes with ballistic parachute systems. According to a manufacturer of ballistic parachute systems, there have been more than 30,000 systems installed on aircraft around the world, which is a rapidly growing number (BRS Aerospace, 2012). This creates a concern on scene because a sticker or placard that indicates the aircraft has been retrofitted with a ballistic parachute system is not always visible in aircraft wreckage. On more than one occasion air safety investigators have had to pull away on-scene personnel due to the unrecognized hazard of a retrofitted ballistic parachute system in the wreckage.

It is extremely important to notify first responders and air safety investigators of potential ballistic parachute systems. Giving a good description of the rocket case and components or showing an example photograph to personnel can help determine if an airplane is equipped with a ballistic parachute system. That way, the correct measures can be taken to begin the process of disarming the rocket.

Once a ballistic parachute system has been recognized in the accident wreckage, the next challenge for air safety investigators is to avoid accidentally initiating the rocket system. Investigators and on-scene personnel must be aware of the hazards posed by the igniter, the rocket, and the line cutter. The igniter initiates the parachute deployment by means of a high-temperature flame that detonates the rocket propellant. The actual rocket that deploys the parachute is the most dangerous part of a ballistic parachute system. The reason for that is, if fired, the rocket accelerates at 155 miles per hour out of the casing, which could strike or burn investigators (NTSB, 2011). Furthermore, it could potentially move the wreckage resulting in injury to personnel (NTSB, 2011).

The line cutter component of a ballistic parachute system does not cut the system with a sharp edge; it burns the system with an extreme amount of heat. The cutter is a chemically activated part that can reach a temperature of 1,125 degrees Fahrenheit (NTSB, 2011). The cutter creates a tremendous burn hazard for personnel and can even ignite spilled aviation fuel. If a person unintentionally moves the cable attached to the ballistic parachute system by shifting sections of the airplane wreckage, even as little as a half an inch, the rocket could fire, the igniter could detonate, or the line cutters could activate, which all potentially involve terrible consequences. The best way to mitigate the hazards of a ballistic parachute system that is armed is to have a ballistic parachute manufacturer representative or local fire department personnel disarm the device.

The last challenge that a ballistic parachute system imposes during an investigation is a deployed parachute. On-scene personnel might believe that since the parachute is deployed, all danger has been mitigated since the pyrotechnic components are inert, but a deployed parachute represents a significant hazard.

When an airplane is laying at rest after the accident and the parachute has deployed, winds could pick up and inflate the parachute canopy, subsequently shifting the wreckage and resulting in injury to investigators or on-scene workers. In addition, on-scene personnel could get entangled in the parachute lines or canopy, which might result in injury as well.

In order to mitigate the hazards posed by a deployed parachute, an air safety investigator or any on-scene personnel should weigh down the parachute by spraying it down with water. Another option is to park a vehicle on top of the canopy to prevent it from being picked up by wind. By weighing down the parachute canopy, air safety investigators greatly decrease the risk of injuring on-scene personnel (NTSB, 2011).

Air safety investigators must always assume that an aircraft is equipped with a ballistic parachute system when first approaching an accident scene. That way, they lessen the chance of being taken by surprise that could result in serious injury. By understanding the serious hazards that ballistic parachute systems impose, air safety investigators can move from a reactive position to a proactive position in order to mitigate on-scene challenges generated by ballistic parachute systems. ◆

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Robert C. Geske, 25, calls Grand Rapids, Michigan, U.S.A., home, where his parents reside. He is attending Purdue University, in West Lafayette, Ind., where he is in a master of aviation and aerospace management course of study. He expects to be graduated in 2013. His undergraduate degree is a bachelor of science in major aviation flight science from Western Michigan University. He began flying at age 16 and holds a commercial pilot multiengine land, instrument rating, and certified flight instructor license. Asked about his activities and goals he says, "My love and passion for aviation continues to this day as I divide my time between obtaining my master's degree and flight instructing for the undergraduate class. Only recently have I put serious thought into air safety investigation. During my time at Purdue, I have found human factors to be an area in which I will focus my research efforts. Additionally, human factors will be the main topic of my thesis. As an air safety investigator, I hope to be involved in the human factors area of investigations. Outside of aviation, I enjoy diving, water sports, and outdoor activities."

His winning essay follows:

Determining the Probable Cause: The Challenges for Air Safety Investigators

By Robert Geske

One of the challenges for air safety investigators is determining a probable cause for an aviation accident. The advent of new technologies and better data capture has helped facilitate the air safety investigator's task of determining probable cause. Determining the probable cause relies on human perspective and one's ability to gather data, assists a situation, be objective, and attempts to summarize what may have occurred that led to the eventual outcome. Painting the picture presented by this information is a challenge where technology only assists in determining the probable cause.

Unlike automobile accidents, aviation investigations are usually highly publicized, due mainly to accidents occurring in full view of the public with large amounts of individuals involved. With the addition of news reporters from around the world attempting to capture the event, the public begins to take an interest often speculating about what occurred. Aviation accidents, to the media, create opportunities for speculation. Often the media will make false statements due to unprofessional reporting and misquoting reputable sources (Thoreau, 2011). The problem with public interest is that investigations often take longer than the public's patience. Leading some investigators to make rushed assumptions about what occurred.

For example, in the American Airlines Flight 191 a DC-10 that crashed at Chicago O'Hare International Airport, the public had demanded answers and National Transportation Safety Board investigators made statements that a sheered bolt was the cause of the accident. A press conference was held to show off the bolt. Shortly after the announcement, another National Transportation Safety Board investigator found evidence to suggest that the engine mount was the cause due to stresses observed on the metal. In the end, this was determined the probable cause for that accident.

While public interest may force undue pressure on air safety investigators, they still must cope with gaps in data. Few catastrophic accidents provide complete pictures. Investigators must sift through the remains for any clues that could assist them. Information from flight data recorders and cockpit voice recorders have proven helpful; however, some accidents have caused damage to these devices rendering their data unobtainable.

Furthermore, these devices may be intact but are unable to be found such as Air France Flight 447. New technologies may provide added captured data, helping to solve the above problems. Existing communications networks to transmit flight data, via ground stations and space-based stations, to receiving stations may one day replace the existing flight data recorder system (Kavi, 2010). The issue of how to interpret the data to determine probable cause of what happened is slightly more difficult.

Even with flight data and voice data, there is information missing. This is where

"The goal of an air safety investigator is to bring into focus potential problems and educate others in an effort to reduce accidents from occurring."

interviews help complete the picture. However, interview data do have associated bias. Following proper interview procedures allows for better information gathering and stronger evidence (Wise, Safer, & Maro, 2010). With eyewitness data being highly subjective and differing between respondents, interviews must extract information relevant to the investigation. The interviewer should avoid leading the witness by being careful of the questions being asked (Wise, Safer, & Maro, 2010). Interviews of family and friends, of air crews have often been extremely helpful in determining probable causes. These individuals have often been able to bring up data about individuals involved that would otherwise be unobtainable. Conversely, some interviews have led to false statement or information that misleads investigators. For example, the 1996 TWA Flight 800, where an eyewitness saw a missile strike the aircraft shortly after takeoff.

Lastly, perhaps the most difficult challenge for air safety investigators is the role of unquantifiable variables. For example, several fatigue studies suggest that performance and response time are influenced by the level of fatigue. However, as an investigator, how does one measure the amount of fatigue and its role in the accident? While an interview may be extremely helpful in determining that the individual involved has not been sleeping normal circadian cycles, how does an investigator determine that it is a probable cause of the accident?

Further, how does one evaluate stress in the life of the individual in question? As research indicates, stress causes problems in concentration, reaction, and performance, but the extent that stress causes a change in concentration, reaction, and performance is dependent upon the person. The individual stress may even vary by day, causing more difficulty for the investigator in determining probable cause.

Lastly, how do these two factors influence each other? While further research is being conducted to determine the extent of the effect these variable cause on an individual, only recently have air safety investigators begun to allude to these as possible causes of probable cause.

For air safety investigators, the challenge of determining probable cause is prevalent when the following factors are considered: public pressure, data availability, and quantifying fatigue and stress. Air safety investigators must overcome these and other challenges to determine probable cause for aviation accidents. Public pressure may lead to rushed statements before conclusion of the investigation. Data availability from flight data recorders, cockpit voice recorders, and eyewitness statements may not provide a complete or even accurate picture of the causes leading to the accident. Fatigue and stress are known causes for degradation of response time, performance, and concentration, but these factors are difficult to measure and are currently only alluded to in probable cause.

Furthermore, air safety investigators must exhibit the qualities of a patient, thorough, and objective person in order to paint the picture so others may learn from previous accidents to avoid future tragedies. The goal of an air safety investigator is to bring into focus potential problems and educate others in an effort to reduce accidents from occurring. ◆

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Harding D. "Chip" Williams III, 51, calls San Antonio, Texas, U.S.A., home. He is attending Embry-Riddle Aeronautical University at the San Antonio campus. He earned a BA in liberal arts and is presently enrolled in a master's program pursuing aeronautics. He will graduate

at the end of 2012. Asked for a thumbnail sketch of himself, he wrote, "Originally from the Washington, D.C., area, I was a firefighter/EMT for several years. Then I entered the Air Force, hoping for something related to or in aviation, another lifelong interest. I served 23 years as a computer support specialist, but I would rather have been dealing with aviation. I held second jobs as a 911 dispatcher in Virginia and Texas, as well as a flight coordinator for San Antonio Airlife. After retiring, I am free to pursue my interests. Originally I sought to fly but realized my opportunities in aviation would be on the ground. I chose aviation safety as my goal because accident investigation has always fascinated me."

His winning essay follows:

The Challenges for Air Safety Investigators

By Harding Williams

A student of aviation safety can only surmise what might be some primary challenges the air safety investigator faces. After some brainstorming and subsequent review of those results, I have chosen a few categories that make the most sense to me as bona-fide challenges of this demanding field. Those being resistance to outside pressures, professionally coping with unpleasant situations, and staying motivated to go the extra mile. There are no citations nor a reference list following my essay as this consists entirely of my own original thoughts.

During my studies in accident investigation and aviation law at Embry-Riddle Aeronautical University, I realized that air safety investigators are subject to pressures from various outside entities. An aircraft accident and the subsequent investigation outcome often pose grave concern for several of the parties involved. Timely resolution is the initial pressure for all concerned, and to be thorough despite the ticking clock poses a challenge. The employers of the crew, the victims' families, the lawyers representing both, and the FAA are some of the primary parties I see having a grave stake in the investigation's outcome. There may be court subpoenas and testimony to render that will affect the futures of many of the parties involved.

One scenario example would be the attorneys for the aircraft manufacturer attempting to sway the focus toward pilot error, while the airman's counsel are motivated toward the structural failure aspect. The air safety investigator is in the middle and must remain steadfast and provide only facts despite the legal tactics employed and any personal sympathies or biases that may exist. The pilot, air traffic controllers, airframe and powerplant mechanics, and aircraft manufacturers have a serious stake in the outcome involving possible fines, revocations, and suspensions, etc. Like many things in life, air safety investigation outcomes impact serious decisions based on dollars, culpability, and futures. To remain focused on the mission, improving the safety of future aviators and passengers despite these outside pressures pose a significant challenge, it would seem to me.

"The mission [air safety investigators] accept is more important than many other professions, thus making the sacrifices all the more worthwhile."

Professionals in many an arena have a list of disagreeable or unpleasant situations they must face and endure in order to remain viable in that profession. Not many of these lists, however, can compare to arriving on the scene of a recent air tragedy, often still smoldering with the lingering smell of demise and possibly physical evidence of those perished. This particular situation must be dealt with early on in the career, and not all those attempting it will possess the stomach for it. Contact with distraught loved ones and coworkers, possibly through interviews, is nowhere near the other person's list with the possible exception of medical and first responder personnel.

We can add to the discussion of disagreeable situations the accident that requires venturing into a remote location with challenging terrain and possibly terribly uncomfortable weather. Investigators must be ready to perform their duties anywhere and anytime. Of course, not all investigations are this dramatic; however, they are not an uncommon occurrence, and the air safety investigator could at a moment's notice be participating in such a scene. High on my list of challenges is this type of uncomfortable scene that must be dealt with using the same cool professionalism and adherence to proven methods as the accident scene encountered in "clear, blue, and 72" conditions where there were no injuries.

The final challenge investigators face on my list is that of going the extra mile. Of course, all employers want workers who exhibit this admirable work ethic, but in the case of the air safety investigator, it seems to me to be an additional challenge. The fortitude of going the extra mile, to be as thorough as possible, and to provide the best results of the investigation would require significant additional effort in some cases. External pressures described previously would weigh heavily on the investigator for timely resolution, but the willingness to put in the overtime effort for timely final report completion despite personal preferences and commitments requires someone who's driven to complete the investigation in as thorough a manner as possible despite outside pressures, both personal and professional.

Like the famous TV detective "Colombo," there's always another question to ask, one more stone to turn over. Going the extra mile to make that additional phone call that may seem insignificant, making that contact with a possible witness who is difficult to reach, and doing that extra research in some cases require vigilance that would seem at times to be challenging. To go the extra mile while shielding oneself from prevailing pressures and to provide the most accurate report possible despite these influences is to be true to one's self and profession.

The air safety investigator faces challenges not seen in other occupations to be sure. The mission they accept is more important than many other professions, thus making the sacrifices all the more worthwhile.

Improving the safety of the flying environment for future aviators and passengers is serving society as a whole in an unselfish manner. The resistance to outside pressures, professionally coping with unpleasant situations, and staying motivated to go the extra mile simply to improve a company's bottom line seem lacking in satisfaction and pales in comparison. Our nation's aviation safety record and its steady improvement over recent decades is testimony to the successful overcoming of these challenges by the profession as a whole. ◆

Understanding Pilots' Cognitive Processes For Making Inflight Decisions Under Stress

To find out how pilots make inflight decisions in such stressful situations, the study research team evaluated the situational awareness, risk management, response time, and applicability of four different decision-making mnemonics in six inflight scenarios.

By Wen-Chin Li, Head of the Graduate School of Psychology, National Defense University, Taiwan; Don Harris, Managing Director of HFI Solutions Ltd., United Kingdom; Yueh-Ling Hsu, Professor in the Department of Air Transportation, Kainan University, Taiwan; and Thomas Wang, Managing Director, Aviation Safety Council, Taiwan

(This article is adapted, with permission, from the authors' paper entitled Understanding Pilots' Cognitive Processes for Making Inflight Decisions Under Stress *presented at the ISASI 2011 seminar held in Salt Lake City, Utah, Sept. 13–15, 2011, which carried the theme "Investigation—A Shared Process." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag ISASI 2011 Technical Papers.—Editor)*

The advent of improved accident investigation technology in recent years, such as cockpit voice recorders, along with a more systematic review of accident statistics, has produced a growing realization of the significant role of pilot judgment errors in flight operations. In 1977, R. Jensen and R. Benel found that decision errors contributed to 35% of all nonfatal and 52 percent of all fatal general aviation accidents in the United States. A. Diehl in 1991 proposed that decision errors contributed to 56 percent of airline accidents and 53% of military accidents. Furthermore, W-C Li and D. Harris suggested that 69% of accidents were relevant to pilots' inflight decision errors. In 2003, D. O'Hare reviewed aeronautical decision-making and came to the conclusion that "It is difficult to think of any single topic that is more central to the question of effective human performance in aviation than that of decision-making." Current FAA regulations require that decision-making be taught as part of the pilot training curriculum; however, little guidance is provided as to how that might be accomplished, and none is given as to how it might be measured, outside of the practical test.

Aeronautical knowledge, skill, and judgment have always been regarded as the three basic faculties that pilots must possess. The requisite aeronautical knowledge and operating skills have been imparted in flight training programs and have subsequently been evaluated as part of the pilot certification process. In contrast, judgment has usually been considered to be a trait that good pilots innately possess or an ability that is acquired as a by-product of flying experience. A decision bias is not a lack of knowledge, a false belief about the facts, or an inappropriate goal, nor does it necessarily involve lapses of attention, motivation, or memory. Rather, a decision bias is a systematic flaw in the internal relationship among a person's judgments, desires, and choices. Human reasoning depends, under most conditions, on heuristic procedures and representation that predictably lead to such inconsistencies. It follows that human reasoning processes are error prone by their very nature. Although a great deal of research has demonstrated that decision-making is a primary component of pilot performance, this concern has not translated well into systematic training programs. Aviation specialists have suggested that rational judgment is a function of both motivation and information processing. Another approach to improving pilot decision-making is the use of prescriptive aids such as the ARTFUL decision tree. However, using these assumes that sufficient time exists to proceed through a prescribed decision-making checklist.

Literature review

Time pressure has several obvious but important implications for decision-making. Firstly, decision-makers will often experience high levels of stress, with the potential for exhaustion and loss of vigilance; secondly, their thinking will shift, characteristically in the direction of using less-complicated reasoning strategies. In 1993, J. Stiensmeier-Pelster and M. Schurmann indicated that time stress may affect the process of decision-making in a variety of ways depending on the type of decision. Time pressure may lead to reallocation of cognitive resources from the decision process to the stress coping process.

Time stress may also change the goals of the decision-making process. Under time stress, cognitive resources may be allocated from the decision-making process to monitoring the flow of time as part of a coping strategy, according to D. Zakay. G. Klein and M.L. Thordsen in 1991observed that decision-makers in difficult situations and under time stress did not appear to use the classical approach to make decisions, even when they were trained in that approach. Much of the research on qualitative changes in cognitive performance, when stressors such as time pressure are present, is broadly consistent with the conflict theory of decision-making proposed by I.L. Janis and L. Mann in 1997. Earlier, in 1993, A. Edland and O. Svenson found that under time pressure the following changes were observed in the decision-making processes: 1) an increased selectivity of input of information; 2) attributes perceived to be more important were given more weight under time pressure than in situations with no time pressure; 3) the accuracy of human judgment decreases; 4) the use of noncompensatory decision rules becomes more frequent than compensatory rules requiring value tradeoffs; 5) there is a decrease in the ability to find alternative problem-solving strategies; and 6) motivation is attenuated.

In 1996, L. Benson and L.R. Beach found that time pressure made the screening phase of problem identification less systematic. Unsystematic identification and screening processes can also occur in decisions concerned with ill-defined problems. The quality of decision-making may suffer even more from time stress in this case. G. Keinan found that under stress the range of alternatives and dimensions that are considered during a decision-making process is significantly restricted, compared with normal conditions.

In brief, the effects of time stress on decision-making are

- a reduction in information search and processing,
- increased importance of negative information,
- defensive reactions increase, such as neglect or denial of important information,
- bolstering of the chosen alternative occurs,
- forgetting important data,
- poor judgments and evaluation are more likely,
- there is a tendency to use a strategy of information filtration.

Information that is perceived as being the most important is processed first, and then processing is continued until time is up.

The processes of decision-making center around two elements: situation assessment, which is used as a precursor to generate a plausible course of action, and mental simulation to evaluate that course of action for risk management, wrote M.R. Endsley in 1993. If a pilot recognizes there is sufficient time for making wide-ranging considerations, he or she will evaluate the dominant response option by conducting a mental simulation to see if it is likely to work. If there is not adequate time, the pilot will tend to implement the course of action that experience (if any) dictates is the most likely to be successful.

G.A. Klein found that while experts used a recognition-primed or perception-based decision process to retrieve a single likely option, novices were more likely to use an analytical approach, systematically comparing multiple options. Klein notes that experience affects the processes of decision-making by improving the accuracy of situation assessment, increasing the quality of the courses of action considered, and by enabling the decision-maker to construct a mental simulation. Furthermore, M.R. Endsley defines situation awareness (SA) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the future." In a dynamic tactical environment, effective decision-making is highly dependent on situation awareness, which has been identified as a critical decision component. Situation assessment is the process by which the state of situation awareness is achieved and is a fundamental precursor to situation awareness, which is itself the precursor for all aspects of decision-making, according to C. Prince and E. Salas.

Automated aids in the aviation industry are designed specifically to decrease pilots' workload by performing many cognitive tasks, including not only information processing, system monitoring, diagnosis and prediction, but also controlling the physical placement of the aircraft. Flight management systems (FMS) are designed to keep the aircraft on course, and to assume increasing control of cognitive flight tasks, such as calculating fuel-efficient routes, navigating, or detecting and diagnosing system malfunctions. An inevitable facet of these automated aids is that they change the way pilots perform tasks and make decisions. However, the presence of automated cues also diminishes the likelihood that decision-makers will make the cognitive effort to process all available information in cognitively complex ways. R. Parasuraman and V. Riley in 1997 described this tendency toward over-reliance as "automation misuse."

In addition, automated cues increase the probability that decision-makers will cut off situation assessment prematurely when prompted to take a course of action by automated aids. Automation commission errors are errors made when decision-makers inappropriately follow automated information or directives (e.g., when other information in the environment contradicts or is inconsistent with the automated cue). These errors have recently begun surfacing as by-products of automated systems. Experimental evidence of automation-induced commission errors has also been provided by full-mission simulations in the NASA Ames Advanced Concepts Flight Simulator. J. Orasanu and U. Fisher investigated the five highest performance pilots and the five lowest performance pilots in a 1997 flight simulation study. They found a tendency for high-performance pilots to be more likely to use low-workload situations to make plans and collect more relevant information compared with the poorer performing pilots. High performance pilots also demonstrated greater situation awareness.

Study method

One hundred-fifty seven pilots, 57 captains and 99 first officers, participated in this research. One participant's data were missing. The full demographic data collected included teaching experience, flying hours, and training background.

Four aeronautical decision-making mnemonics (ADM) are noted:

- The SHOR mnemonic consists of four steps: Stimuli, Hypotheses, Options, and Response. It was originally developed for

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use by the U.S. Air Force tactical command and control, where decisions were required under high pressure and severe time constraint. In this situation, decisions require near-real-time reactions involving threat warning, task rescheduling, and other types of dynamic modification. The SHOR methodology is an extension of the stimulus-response paradigm of classical behavioral psychology developed to deal with two aspects of uncertainty in the decision-making process—information input uncertainty followed by the evaluation of the consequences of actions, which create the requirement for option generation and evaluation.

• The PASS methodology consists of four steps: Problem identification (define/redefine problems), Acquire information (seek more information), Survey strategy (survey/resurvey strategies), Select strategy. PASS was originally developed by Delta Air Lines to train pilots as part of a CRM training program. After the selection of a solution strategy, if the problem is not solved, then the pilot should re-enter the problem-solving loop once more.

• The FOR-DEC mnemonic consists of six steps: Facts, Options, Risks and Benefits, Decision, Execution, and Check. It incorporates an analysis of risk and benefits when handling inflight situations, including assessing the effects of time pressure, continually changing conditions, distraction, and having incomplete information.

• The DESIDE mnemonic consists of six steps: Detect, Estimate, Set safety objectives, Identify, Do, Evaluate. It was developed on a sample of South African pilots. The DESIDE method is a practical application to aid pilots in making inflight decisions adapted from the conflict-theory model of I.L. Janis and L. Mann.

Development of Six Inflight Scenarios: To develop scenarios for assessing the effectiveness of the noted ADM mnemonics that corresponded to J. Orasanu's six generic decision making categories, six focus groups were conducted, one for each scenario. Each focus group included two human factors specialists, three senior B-747 instructor pilots, and the director of Crew Resource Management Departments of the participating airlines. The purpose of these focus groups was to ensure that enough detailed information for pilots was included to enable the pilots to make a decision and, hence, to evaluate the performance of the four ADM mnemonics. These six scenarios developed were as follows.

1. Go/no go decisions: A Boeing 747-400 departed from Taipei to Los Angeles, takeoff weight of 833,000 pounds. The warning light of door 4L suddenly illuminated while the aircraft was taking off from Taoyuan Airport Runway 05 with an indicated air speed of 120 knots.

2. Recognition-primed decisions: A Boeing 747-400 departed from Los Angeles to Taipei with a landing weight of 533,000 pounds. The aircraft planed to land at Taoyuan Airport Runway 06, visibility 3,000 meters, cloud base 500 feet. Autopilot engaged during instrument approach, ILS signal is suffering interference, and glide slope indication is fluctuating.

3. Response selection decisions: A Boeing 747-400 departed from Hong Kong to Taipei, and planned to land at Taoyuan Airport Runway 05 with a landing weight of 533,000 pounds. ATC cleared "Direct to TONGA, descend and maintain Flight Level 290, clear to JAMMY via TONGA 3A RNAV ARRIVAL." When the aircraft is three miles from TONGA, communication is lost, and there is a failure to contact ATC.

4. Resource management decisions: A Boeing 747-400 departed from Hong Kong to Taipei and planned to land at Taoyuan Airport Runway 05 with a landing weight of 533,000 pounds. ATC cleared "Direct to TONGA"; descend and maintain 11,000 feet; clear to JAMMY via "TONGA 3A RNAV ARRIVAL." Three miles before BRAVO, the captain (PF) suddenly became incapacitated and provide no response to standard CALL OUT twice.

5. Nondiagnostic procedural decisions: A Boeing 747-400 departed from Taipei to Los Angeles from Taoyuan Airport Runway 05 with a takeoff weight of 833,000 pounds at 22:30 local time. When climbing to 1,000 feet with thrust reduced to CLB, the aircraft suddenly began to vibrate significantly. PM found No.1 engine vibration indication abnormal, although other engine indications were normal. By this time the aircraft has crossed through a cloudy area with light turbulence. It was difficult to judge whether the vibration was caused by the engine or turbulence; it was unclear whether to continue to destination airport or return to base.

6. Problem-solving decisions: A Boeing 747-400 departed from Taipei to Los Angeles from Taoyuan Airport Runway 05 with a takeoff weight of 833,000 pounds. During the climb through 1,000 feet after departure, the fire warning system of No. 4 engine was activated; 10 seconds later, the aircraft began to vibrate heavily and a big "BANG" was heard. The relevant No. 4 engine systems failed totally, and the fire warning disappeared.

ADM Evaluation Instrument: To develop a rating instrument for the subsequent evaluation of the suitability of the four ADM mnemonic-based methods in the six inflight scenarios, six focus groups were formed, one for each scenario. Each was comprised of two human factors specialists and three B-747 instructor pilots. The six selected scenarios were analyzed by the focus group members using all four mnemonic methods. This process provided the material for the construction of a rating form to evaluate the suitability of the ADM mnemonics for decision-making training. The narrative responses describing the decision-making process by which the participants would arrive at their decision was evaluated using the criteria of situation assessment, risk management, response time, and applicability.

Administration of Evaluation Forms: As a result of the length of the scenarios and the number of ratings required, each participant evaluated only the ADM decision techniques in three scenarios, either scenarios 1, 3, and 5 or scenarios 2, 4, and 6. The ADM rating forms were distributed to all pilots of the B-747 fleet of the participating airlines. Completed instruments were returned to the Crew Resource Management Department. For each participant, an overall score for each mnemonic method in each scenario was created by summing the scores across four dimensions of situation assessment, risk management, response time, and applicability giving a potential range of scales between 4 (low suitability) and 36 (high suitability).

Study results

Sample Characteristics: In total, data were collected from 1,871 evaluations of scenarios. There were 312 completed rating forms for the go/no go decisions scenario; 311 for the recognition-primed decision-making scenario; 316 for the response selection decision-making scenario; 310 for the resource management scenario; 312 for the nondiagnostic procedural decisions-making scenario, and 310 completed rating forms for

ITEM	N	M	SD
Scenario 1 SHOR	79	6.67	1.39
Scenario 1 PASS	78	6.42	1.63
Scenario 1 FORDEC	77	6.83	1.67
Scenario 1 DESIDE	78	6.43	1.51
Scenario 2 SHOR	78	6.41	1.56
Scenario 2 PASS	78	6.59	1.25
Scenario 2 FORDEC	77	6.99	1.30
Scenario 2 DESIDE	78	6.75	1.27
Scenario 3 SHOR	79	6.59	1.14
Scenario 3 PASS	79	6.81	1.03
Scenario 3 FORDEC	79	7.43	1.10
Scenario 3 DESIDE	79	6.99	1.21
Scenario 4 SHOR	77	6.83	1.47
Scenario 4 PASS	77	6.67	1.27
Scenario 4 FORDEC	78	7.11	1.41
Scenario 4 DESIDE	78	6.91	1.40
Scenario 5 SHOR	78	6.47	1.31
Scenario 5 PASS	78	6.72	1.11
Scenario 5 FORDEC	78	7.50	1.14
Scenario 5 DESIDE	78	7.08	1.09
Scenario 6 SHOR	77	6.81	1.46
Scenario 6 PASS	78	6.73	1.25
Scenario 6 FORDEC	77	7.20	1.33
Scenario 6 DESIDE	78	6.94	1.19

Table 1: The Mean Scores (M) and Standard Deviations (SD) for Four Different Mnemonics Decision-Making Methods in Each of The Six Scenarios. (N) = Participants

the creative problem-solving scenario (see Table 1).

Scenario 1: Go/no go decisions
The highest overall rating of suitability for the ADM mnemonics in the go/no go decision-making scenario by participants was FORDEC followed by SHOR, DESIDE, and PASS (see Table 1). There were no significant differences in the ratings of suitability among the four ADM mnemonics.

Scenario 2: Recognition-primed decision
The highest overall rating of the suitability for the ADM mnemonics by participants was for FOR-DEC followed by DESIDE, PASS, and SHOR (see Table 1). There were significant differences among the rated overall suitability of the four ADM mnemonics in this scenario.

Scenario 3: Response selection decision
The highest overall rating of suitability for the ADM mnemonics by participants was for FOR-DEC followed by DESIDE, PASS, and SHOR (see Table 1). There were significant differences among the rated overall suitability of the four ADM mnemonics in this scenario.

Scenario 4: Resource management decision
The highest overall rating of suitability for the ADM mnemonics in the resource management decision-making scenario by participants was FORDEC followed by DESIDE, SHOR, and PASS (see Table 1). There were no significant differences in the ratings of suitability among the four ADM mnemonics.

Scenario 5: Nondiagnostic procedural decision
The highest overall rating of suitability for the ADM mnemonics by participants was FOR-DEC followed by DESIDE, PASS, and SHOR (see Table 1). There were significant differences among the rated overall suitability of the four ADM mnemonics in this scenario.

Scenario 6: Problem-solving decision
The highest overall rating of suitability for the ADM mnemonics by participants was FOR-DEC followed by DESIDE, PASS, and SHOR (see Table 1). There were significant differences among the rated overall suitability of the four ADM mnemonics in this scenario.

In flight operations, pilots are confronted with many problems that occur in continually changing situations that do create a certain level of stress and lead to human error accidents. To make rapid decisions, pilots make decisions using a holistic process involving situation recognition and pattern matching. Within this framework, pilots' situation awareness becomes the driving factor in the decision-making process. In general, aviation training organizations do not have specific methods or techniques for decision-making instruction during ab-initio training. The ability to make decisions in the air has often been regarded as a by-product of flying experience rather than training.

However, the data obtained in this research suggest that the FOR-DE may be suitable as a basis for providing training that will be applicable for covering all six basic types of decision. FOR-DEC was evaluated as being the highest-rated scale for its applicability across six different decision-making scenarios. It was rated as potentially having superior performance compared to the other three mnemonic methods (SHOR, PASS, and DESIDE) in the go/no go decision, recognition-primed decisions, response selection decision, nondiagnostic procedural decision, and problem-solving decision scenarios (see Table 2).

G.L. Kaempf and J. Orasanu suggested in 1997 that under conditions of time pressure, decision-makers need help to determine what is occurring in the environment around them. Therefore, decision aids and training should provide decision-makers with the tools and skills necessary to accurately and quickly make situation assessments. FOR-DEC was rated highly for situation assessment, risk management, and applicability. It was thought to be comprehensive and thorough, clear about how to identify the safest actions, and had a logical order and was easy to remember. However, it did require much more time to perform this analysis and produce a response. The qualitative data suggest that SHOR was regarded by pilots as providing a method for a quick decision-making response in urgent situations with a logical order for flight operations safely. PASS also matched airline pilot training guidelines as it had clear and specific procedures to follow. DESIDE was regarded as being comprehensive, but enough time was needed to undertake this method. FOR-DEC was rated as the highest performance of all mnemonics. Pilots advised that practicing FOR-DEC in the simulator was extremely important before attempting to apply it in a real-life situation.
(continued on page 30)

SCENARIOS Mnemonics	Go/no go decision	Recognition-primed decision	Response selection decision	Resource management decision	Nondiagnostic procedural decision	Creative problem-solving
SHOR	2	4	4	3	4	4
PASS	4	3	3	4	3	3
FOR-DEC	**1**	**1**	**1**	**1**	**1**	**1**
DESIDE	3	2	2	2	2	2

Table 2: Summary of Rankings of the Five ADM Mnemonic Methods Across the Six Decision-Making Scenarios

USING 'ASTERIX' IN ACCIDENT INVESTIGATION

This article provides investigators with an introduction to a data standard in use by many of the Eurocontrol national authorities (ASTERIX). It considers and explores how the use of this standard to transform raw radar data to answer investigative questions can be of assistance to the accident investigation community.

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(This article is adapted, with permission, from the authors' paper entitled Using "ASTERIX" in Accident Investigation: Transforming Raw Radar Data to Answer Investigative Questions, *presented at the ISASI 2011 seminar held in Salt Lake City, Utah, Sept. 13–15, 2011, which carried the theme "Investigation—A Shared Process." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag ISASI 2011 Technical Papers.—Editor)*

ASTERIX is the Eurocontrol standard for the exchange of surveillance-related data. The acronym stands for "All purpose STructured Eurocontrol suRveillance Information eXchange." ASTERIX provides a structured approach to message formatting that is applied in the exchange of surveillance-related information for various applications. Developed by the suRveillance Data Exchange Task Force (RDE-TF) with its multinational participation, it ensures a common data representation, thereby facilitating the exchange of surveillance data in an international context.

ASTERIX is an application/presentation protocol responsible for data definition and data assembly developed to support surveillance data transmission and exchanges. Its purpose is to allow a meaningful transfer of information between two application entities using a mutually agreed to representation of the data to be exchanged. The ASTERIX standard refers to the presentation and application layers (layers six and seven) as defined by the Open Systems Interconnection (OSI) Reference Model (International Standards Organization (ISO) Standard 7498) [ISO/IEC 7498-1: 1994 [ITU-Rec.X.200 (19940] Information Processing Systems, OSI Reference Model-The Basic Model].

Philosophy of ASTERIX

The philosophy of ASTERIX can be described in two short phrases: "Distribute everything as required" and "Do not transmit more than necessary."

ASTERIX has been designed as a flexible way of encoding surveillance-related information to be exchanged between users. It is characterized by the grouping of information in data categories and the flexible generation of messages in order to save bandwidth in the transmission.

For the various applications within the surveillance domain, individual data categories are defined. This allows the designer of a system to implement exactly what is needed, no more and no less. The software to be implemented can be tailored exactly to the function of the respective system. Should additional functionality be required at a later stage, the necessary interface can easily be added by augmenting the ASTERIX category defined for the specific application.

The same flexibility applies to the generation of the ASTERIX message itself. Subdividing the complete set of possible information into individual data items, a message can be composed according to the information available. Items carrying no information are simply omitted when creating the message. The FSPEC, a sort of "table of contents" for each ASTERIX message, precedes the data items, indicating unambiguously to the receiving system those data items that are present and those that are not. This allows the processing to be adapted to the real message contents. There is no need to transmit useless bits and bytes or to skip unwanted information in a message.

The sequence of items in the message is defined in the so-called "User Application Profile" (UAP). It is the task of the "suRveillance Data Exchange Task Force (RDE-TF)" to manage and coordinate the maintenance and evolution of existing and new ASTERIX categories, as and when required. In most cases, this will be triggered by the launch of a new application (such as ADS-B or Multi-Lateration) or by the need to adapt an existing category to changing needs. In any case, the fact

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that this process is controlled by a body composed of members of most Air Navigation Service Providers (ANSPs) ensures that the results (e.g., a new ASTERIX category) are universally accepted and form the specification against which later implementation(s) will be validated.

What is a category?

To implement the ASTERIX data format in a structured way, the set of documentation has been subdivided into parts, each of which deals with the data for a specific application and purpose.

Each ASTERIX part contains one or more data categories. The information contained in these categories addresses a specific area of application and defines which data in what format is to be transmitted between the users of this application. Each category consists of a catalogue of data items, the data item being the smallest unit of standardized information.

This categorization serves three purposes:

- It's easy to identify the application.
- Dispatching the data to the appropriate task within the receiving system is facilitated.
- Only the category(ies) for applications in the user system has (have) to be implemented.

A total of up to 256 data categories can be defined, and their usage is as follows:

- Data categories 000 to 127 for standard civil and military applications.
- Data categories 128 to 240 reserved for special civil and military applications.
- Data categories 241 to 255 used for both civil and military nonstandard applications.

For data categories 000 to 127, the responsibility for the allocation of the number rests with the suRveillance Data Exchange–Task Force (RDE-TF), with endorsement from the Surveillance Team (SURT).

For data categories in the range from 128 to 240, the allocation of the category number is delegated to the issuing authorities. In the future, a closer coordination with Eurocontrol is envisaged wherever possible.

The specifications for the ASTERIX data categories (CAT) form part of the ASTERIX standard document. A current list of the ASTERIX documents is available through the Eurocontrol website: http://www.eurocontrol.int/asterix/public/standard_page/documents.html.

ASTERIX data block structure

All ASTERIX data are transmitted in a data block using the CAT specification. An ASTERIX data block consists of

- a one-octet field specifying the data category,
- a two-octet field block length indicator (LEN), and
- one or more record(s).

The one octet field data category (CAT) indicates to which category the transmitted data belongs. Next, the two octet field indicates the total length (in octets) of the data block including the CAT and LEN fields. An analogue of the ASTERIX block is the description of a library bookshelf. The LEN field indicates the number of books that are on the bookshelf.

ASTERIX data blocks comprise multiple records of the same CAT; both block and records have variable lengths. Each record starts with one or more field specification (FSPEC) octets that describe the data items (fields) embedded in that particular record. The FSPEC can be compared to a table of contents of a book and indicates the data items that are recorded in that specific record. After the FSPEC, the fields for the individual data items follow. A detailed description of the ASTERIX format is given at http://www.eurocontrol.int/asterix/gallery/content/public/documents/pt1ed130.pdf.

Presentation of radar data

Data received from airport sensors (radar) are processed and converted to targets that are shown on a controller's Plan View Display (PVD). An aircraft, vehicle, or other obstacle can be a target, and these (multiple) targets create an image or air situation picture. An aircraft target with a transponder can further be enhanced with other information, including but not limited to call sign, aircraft type, altitude, and speed. Each controller has a PVD, but the range, labelling, and details are dependent on the task of the controller.

Not all sensor data are transformed into information that is displayed to the controller. Certain information is not useful for the controller's task of directing air traffic; therefore, it is not displayed. To achieve a smooth data display for the air traffic controller, additional filtering and extrapolation of aircraft track data are usually implemented. Due to computer hardware limitations and features required by controllers, the application software optimizes the radar display for the user's task (display of air traffic important).

After a major event, it is possible to arrange a replay of the event flight at the air traffic service facility. Combining the replay with an interview of the on-duty controller is useful in an early stage of the investigation. It must be noted that different replays can be requested. The first, a controller replay, is a presentation of the radar data that were displayed on the PVD of the controller at the time of the event. This type of replay can aid in interviewing the on-duty controller. The replay can prompt a controller to remember significant events or occurrences that might unintentionally have been omitted in the aftermath of an occurrence.

However, it may also alter or revise the recollection of the event when faced with information from other information sources, in particular if evidence from automated systems and communications transcripts are included. For investigations, it is useful to request a screenshot of the controller display or make a digital video recording if exporting the replay to a practical format is not possible.

Another point that investigators need to keep in mind is that fact that air traffic systems process sensor measurements to derive kinematic information about targets. This kinematic target information is subsequently used by the tracking algorithm to reduce the uncertainty of the target state and consequently to improve the accuracy of the "predicted target state." A predicted target without a positive radar return ("ghost" target) can be displayed to the controller for up to eight seconds. These ghost targets may explain why a controller might be convinced that a lost aircraft is in a different location than where it actually crashed. In accident investigation, therefore, making the distinction of the target return state (measured/actual versus derived/predicted) is crucial. For a controller replay, the previous remarks should be kept in mind; but notwithstanding these comments, the controller can provide vital information on the event.

In order to overcome the ghost targets, the second type of replay, a technical replay, can be requested. In a technical replay the radar data are used in a similar fashion to data used for verification and testing purposes. Depending on available equipment, it may be possible to display the recorded radar data including the source (available) information. This way of presenting data is, however, not always possible. Furthermore, obtaining and extracting data in a presentable format useful for further investigation may prove difficult or impossible.

The available ATC facilities and equipment may not always be functional in an investigation. The equipment available is intended to support air traffic services and not as an aid to accident investigation. It is, therefore, worthwhile and more informative to look at the total recorded (raw) data. Both the DSB and AAIU have developed in-house tools to transform the raw radar data to information useful for accident investigation. These tools are used to make the third and most useful type of replay, an investigator replay. The goal of the investigator replay is to read and analyze the raw data. This is in most cases data that were hidden by the tools used by the air traffic service provider and may be of most use to an investigation.

The different types of replay may be summarized as follows:

- Controller replay—Presentation of the radar data on a radar display as used by the controller.
- Technical replay—Replay of the recorded data using analyses and verification display.
- Investigator replay—Raw analyses of the recorded unfiltered data that are then displayed.

Remember that investigators will be working with raw data formats that the users, even the technical personnel like surveillance engineers, will probably never have seen or worked with. This can become an issue when the investigator seeks clarification regarding the data. For example, during an Irish investigation a clarification was sought as to whether the recorder altitude data in ASTERIX CAT 30 were corrected for pressure on the day. Confirmation was received that the data were indeed corrected for prevailing pressure. However, further analysis by the investigation revealed that the data were based on standard pressure. When this was thoroughly explored, it emerged that the data as presented to the controller are corrected for prevailing pressure, but the data as recorded are based on standard pressure, another example of the difference between the controller's view and the investigator's view.

A key advantage of ASTERIX data is that many of the categories provide data from multiple, geographically remote radar sensors in an X-Y Cartesian coordinate system referenced to a selected system origin. And as a Cartesian coordinate system, it is amenable to calculation using simpler formulae than those required for manipulating latitude/longitude coordinates. The Cartesian origin can be chosen to best suit the system designer's objectives. For example, the origin for the ASTERIX data used at Shannon Airport is actually based at 53N 15W (in the Atlantic Ocean) to facilitate maximal tracking of transatlantic traffic.

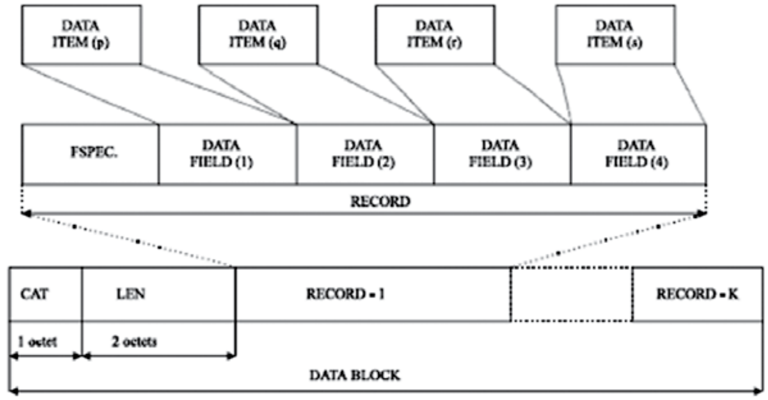


Figure 1: Overview of the ASTERIX data block structure.

A fundamental tenet of the ASTERIX format is that each participating country is assigned a specific nationality code known as a System Area Code (SAC). This code can be very useful when reading the data. However, both Dutch and Irish investigations have encountered data where the SAC code is not correctly coded as per the ASTERIX specification. For example, ASTRIX CAT 10 data at Dublin Airport are recorded with an SAC code of 114 (Hex 72), which is Ireland's assigned SAC code. But the CAT 10 specification stipulates that for local flows, an SAC code of Hex 00 should be used. So for investigators faced with reading ASTERIX data, it is a good idea to explore the data in the first instance using a hexadecimal byte reader.

Data recording and acquisition

The recording of radar data is detailed by the International Civil Aviation Organization (ICAO) in Annex 11. Historically, it was recommended to record surveillance data from primary and secondary radar equipment. Furthermore, it was recommended that recordings should be retained for a minimum of 14 days. ICAO has specified in a state letter (AN 13/13/1-05/37) that "radar recording of primary and secondary surveillance data is no longer recommended but mandated" as of Nov. 23, 2005. "Automatic recordings shall be retained for a period of at least 30 days. When the recordings are pertinent to accident and incident investigations, the recordings shall be retained for longer periods until it is evident that they will no longer be required." One can conclude that an international protocol is in place for the preservation of radar data for accident investigation purposes, though implementation of this protocol is a matter for local regulation.

Eurocontrol requires recording and replay facilities for incident and accident investigation, search and rescue support, noise abatement, training, technical analysis, and statistics. This means the ANSP must have a backup of radar data for accident investigation purposes for 30 days. In practice, most air traffic services retain the data for a longer period of time.

An important note—radar surveillance data supplied to the display system shall be recorded continuously. As described in the previous paragraph, the recording shows what was displayed to the controller.

Eurocontrol requires that regular performance verification be carried out using live radar data obtained from opportunity traffic. The data are also recorded for 30 days. Both the DSB and AAIU have found that requesting the data for accident investigation is of more benefit as it usually contains significantly more data than displayed to the controller.

Conclusions and recommendation: *It is recommended to check the duration for which radar data are saved and request an overview of available data from the air traffic service provider. Preplanning and making contact with the air traffic service provider before a major event will be of future benefit. Be careful to ask about the data formats that are recorded*

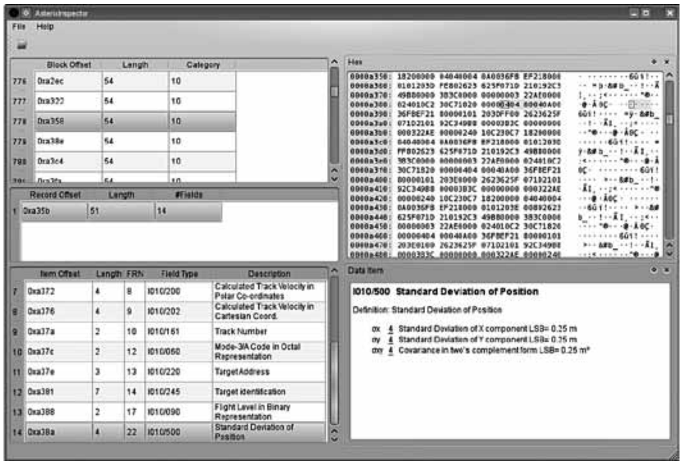


Figure 2: Screenshot of the Asterix Inspector.

and archived, NOT the data formats that are used. In Dublin, for example, CAT 11 data are used but not recorded.

Data processing and conversion

Once the data of a particular category have been received, the next challenge is to process and convert the data into a form that can be readily viewed and analyzed. A free readout program of the ASTERIX format called Asterix Inspector is available on the Internet (http://sourceforge.net/projects/asterix). For now, Asterix Inspector (Version 0.6.1 win32) was reviewed. Although in its early stage of development, the program looks promising. The main goal of the program is to develop a tool to read ASTERIX data in a development and testing environment. Current available features of Asterix Inspector include

- block-level decoding of all Asterix categories,
- record- and item-level decoding as for certain implemented categories,
- handling of standard data field formats: fixed, variable, and compound,
- HEX display of input file with selected data element highlighted, and
- in-depth data item view with field annotations.

Features useful and sometime necessary for accident investigation are not (yet) available.

Both the DSB and the AAIU have programs written for the specific goal of using ASTERIX data for accident investigation. Because of the dynamic nature of accident investigation, an adaptable in-house tool can create specific results for an investigation. The DSB has developed specific tools for Amsterdam Schiphol Airport and a general tool for analyzing the radar data for the Netherlands. The AAIU has developed tools to analyze two categories of data from all radar sites nationally as well as a specific tool for the multi-lateration data available at Dublin Airport.

To analyze the ASTERIX data, one must first find the CAT octet of the category of data of interest. The CAT octet can be compared to a flight data recorder sync code, and this methodology is similar in the way FDR data are analyzed. Because the ASTERIX data format is flexible, once a tool was developed to analyze one category the same programming framework can be used to read out other categories. The development of readers for other categories was made with less effort and validated rapidly.

Although the ASTERIX format is described in Eurocontrol documents, the range of different raw data formats provided to the DSB and the AAIU has been fascinating. Both authors have had their share of exotic formats that, when looked at closely, did contain ASTERIX-formatted data but oftentimes wrapped in proprietary formats intended for other purposes, e.g., proprietary video replay systems. The difference in the equipment used by the air traffic service provider has resulted in exporting the same ASTERIX category data in widely different data formats. Once the format is understood, the data provided can be transformed for investigative purposes.

Conclusions and recommendation: *Tools available at the air traffic service provider can be used for investigation purposes. A replay of data on a terminal or, for example, an Albatross display can give a good insight. However, when detailed analyses are required, specific programs should be used to process the recorded data.*

Event reconstruction: creating information layers

For the detailed analyses, the data are converted and displayed as an information layer. This layer is not the same as the controller's display data. In most cases, the accident investigator is interested in a different set of data than that used by the radar controller. Also a three-dimensional visualisation of the data is often more insightful.

Three examples of an information layer will be given. The first is an example typical of the analyses of traffic flow. The second example will examine the possibility of in-

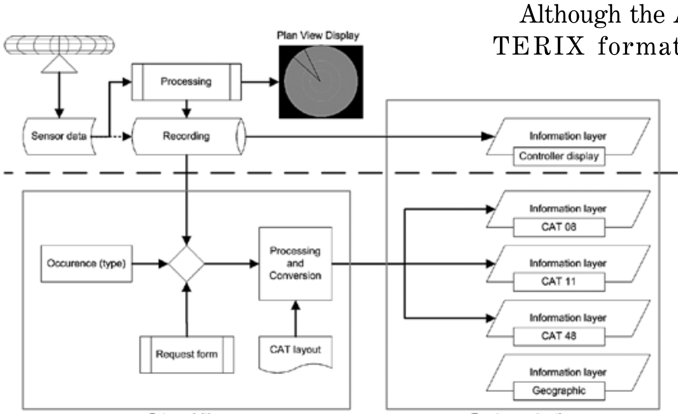


Figure 3: Overview of the transformation process of radar data into an information layer.

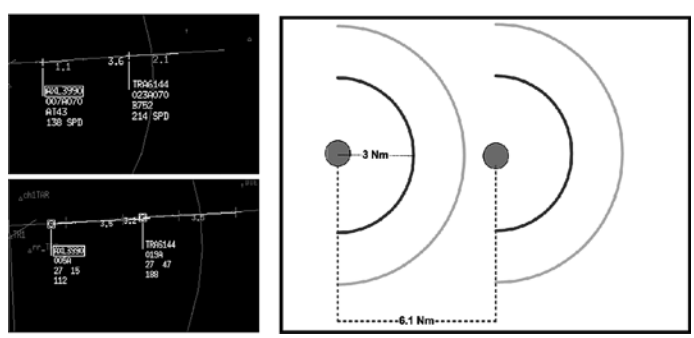


Figure 4: Left (top), example of two targets on a PVD display with a Wake Vortex Vector of 1.1 and 2.1 nm. Left (bottom), example of a 3.5 nm Wake Vortex Vector with and actual distance of 3.2 nm between aircraft. Right, distance calculation using ASTERIX data between aircraft on approach 6.1 nm for accident investigation purposes. A 3- and 5-nm distance ring indicate procedures established for this case.

corporating weather information. The third example will give an overview of the application of ground radar in an investigation.

Flow of traffic

During the early stages of a major investigation conducted by the DSB in 2009, the news media and other sources suggested that a commercial aircraft had crashed due to wake vortex (turbulence) from a preceding aircraft. In this particular investigation, the DSB followed normal procedure and requested the data from all available radars and in all available categories. Using in-house analysis tools, the data were transformed to examine the wake vortex theory.

In examining literature and ATC, the DSB was aware of tests that were conducted to enhance radar displays with a Wake Vortex Vector (WVV). The tests evaluated the WVV information that was presented as an enhancement on the controller Plan View Display. In essence, the WVV is a vector trailing a target (aircraft), indicating the prescribed separation distance. Although the WVV enhancement is still in its testing phase and being evaluated, the principle and theory may have future application(s) in accident investigation.

Using this knowledge, the distances between all the aircraft that were on approach during the event flight were calculated and analyzed. Recorded aircraft positions, together with geometric calculations, were displayed and analyzed for possible wake turbulence effects. Using the ASTERIX data, the wake turbulence hypothesis was examined at an early stage of the investigation and found not to be a contributing factor. The use of ASTERIX data was convenient as there was no need to download, correlate, and analyze four flight data recorders.

Conclusions and recommendation: *In cases where distance calculations between different aircraft are required, ASTERIX data will allow for a fast and easier analysis. Using programs that read ASTERIX data may validate or discount hypotheses at an early stage of an investigation.*

		Follower		
		Heavy	**Medium**	**Light**
Leader	**Heavy** *MTOW≥136 tons*	4 NM	5 NM	6 NM
	Medium *7 tons ≤ MTOW<136 tons*	*Radar Separation minimum*	*Radar Separation minimum*	5 NM
	Light *MTOW<7 tons*	*Radar Separation minimum*	*Radar Separation minimum*	*Radar Separation minimum*

Table 1: ICAO Distance-Based Separation Minima for the Approach

Incorporating meteorological information

Weather forecasting is an integral part of aviation. TAF (prediction) reports and METAR (time interval weather "point" measurement) are routinely used for accident investigation. However, depending on the sampling rate and area of reporting, these reports may be inaccurate at times.

Using aircraft ADS-B, meteorological information like the air temperature, wind velocity, and direction are transmitted by aircraft. This ADS-B message is recorded in CAT 21 Item 220, which can be combined with the aircraft (GPS) position and altitude resulting in an information layer containing temperature, wind speed, and wind direction. This general overview for wind and temperature can be useful when investigating weather-related events. However, ideally an accident investigator would like to have the "now cast" or real-time weather for an area around the event during a certain period of time. If this was available, the presentation of the weather would allow for improved event reconstruction.

ASTERIX CAT 08, transmission of monoradar-derived weather information, contains data regarding precipitation zones. A precipitation zone is represented by a set of consecutive summit points that constitute a closed area contour. This contour describes the area and intensity of precipitation, and each intensity level can be coupled to a different color for presentation purposes.

In a DSB investigation, the information from the weather radar was obtained and analyzed. Although the controller has the capability to overlay weather information, the overlay update rate was determined to be once a minute. Analyses of the weather radar data showed the radar was providing information every 12 seconds. For the controller overlay, the weather data for a period of time were interpolated and subsequently outputted to the controller display. This interpolation of data is another example of the difference in the controller display and actual raw (investigator view) data. The 12-second weather imagery can be combined with the flight track position data used for the investigation. This reconstruction substantiated (and quantified) the pilot account of heavy rain experienced during the approach.

Furthermore, it gave investigators an insight into why particular runways were in use as the runway configuration during the event was exceptional. Analyses of the precipitation zones showed that areas of high precipitation intensity were just overhead the approach paths for two of the runways that would normally be in use. The explanation of runway usage found by reconstruction and the precipitation analyses were later confirmed by controllers.

Conclusions and recommendation: *Evaluation of the weather radar (precipitation) data in this investigation showed additional data were available, enhancing*

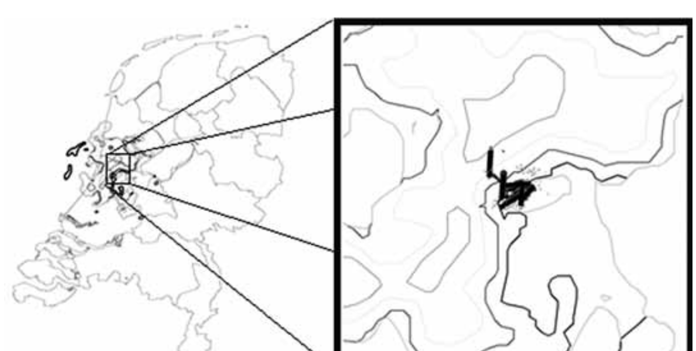


Figure 5: CAT 08 weather picture of the Netherlands (left) and detailed view of Schiphol Airport (EHAM) showing the rain areas (right).

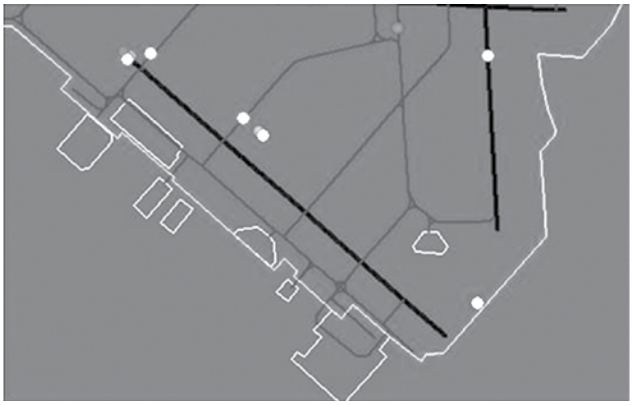


Figure 6: Example of ground radar. Top left, aircraft (blue) after a runway (black) overrun event at Schiphol. Other vehicles include fire rescue (light blue), ambulance (light gray), and airport assistance vehicles (white).

understanding of the event. Furthermore, analyses of the radar data gave insights into runway usage, which did not come to light during controller interviews.

If possible, an overlay of precipitation should be made as it can help to better understand the event. It is recommended to verify the different intensity levels and range of the weather radar as these are individual radar settings.

Using ground radar

In the past, airport surface surveillance was accomplished by means of a rapid rotating antenna. The antenna was typically mounted on top of the control tower for optimum view of the airport surface. Unfortunately, infrastructural developments at many airports meant that the radar's line of sight became compromised by, for example, terminal buildings, hangars, etc., obstructing the antenna's view of movement areas. This problem was addressed by advanced systems called A-SMGCS (Advanced Surface Movement Guidance and Control Systems). The A-SMGCS system still uses the primary radars (SMR) to detect ground movement, but it is enhanced by additional sensors. These sensors mitigate the limitations, shadowing effects, and multiple reflections that can adversely affect the primary radar. The A-SMGCS is currently being deployed at many of the world's major airports. The A-SMGCS data are transmitted as ASTERIX CAT 11.

Using CAT 11, an overview of airport surface movement can be obtained. In addition, if airport vehicles are equipped with "transponders," they can be tracked in the same way as aircraft. The so-called "cooperative mobile" is equipped with systems (transponders) capable of automatically and continuously providing information including its identity to the A-SMGCS system. The ground radar data are sensed and recorded every second (1Hz), which allows for a high-fidelity information layer.

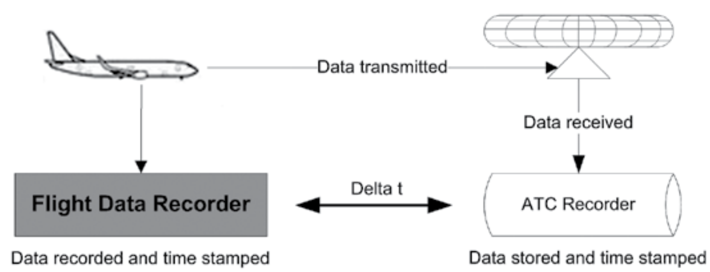
For runway incursions, the ground radar can be a valuable tool in the reconstruction of the event. The ground radar allows investigators to replay the event and can be combined with audio recordings to provide valuable information. Furthermore, the data can be used to create a time line of the rescue vehicles and airport assistance after an event. This information is particular useful when investigating the performance of the emergency services in the aftermath of a rescue effort.

When the (onboard) flight recorder data and the A-SMGCS data are compared on a common time base, differences will be observed. This is especially true for broadcast GPS position data. The onboard "time of position measurement" is recorded on the FDR but not transmitted, as this message format does not comprise the respective data item. The (receiving) ground station does provide a time stamp, but this is the "time of reception." Due to processing and transmission, the time of reception may be up to two seconds later than the time of measurement on board the aircraft. This time latency is not constant and may actually vary continuously. This latency is the same system timing delay issue previously discussed by Roberts, et al. However, for events involving two or more targets (aircraft or ground vehicles), the radar data's common time base is a distinct advantage, and the latency is not a concern as it is the same for all targets.

In a recent DSB investigation (ground event), noticeable "time" differences between obviously identical aircraft information were present. The variation of aircraft track data (positions) was minimal; the time difference, on the other hand, was calculated to be just less than two seconds. This example shows that care must be taken when identical information of two distinct data sources, in this case the FDR and ASTERIX, are being correlated and fused together. In CAT 21 ADS-B cat-

(continued on page 30)

Figure 7: Explanation of difference in time position between flight data recorder and ASTERIX data.



				Flight phase						Events			Meteo		
	ASTERIX CATEGORY	Description	Remarks	Approach	Landing	Taxi	Takeoff	Cruise (flight path)		Airprox	ACAS report		Meteorological data	Precipitation		Validation and performance
CAT 01	Monoradar Target Reports	Transmission of monoradar target reports from a stand alone radar .	Radar data not usefull for low altitude and ground events.	±	-		-	+		+						
CAT 02	Monoradar Service Messages (CAT 01)	This category is for the status and the services of radar station.	Validate operation of radar and UTC time stamp.													+
CAT 08	Transmission of Monoradar Derived Weather Information	Location of areas of significant meteorological activity (precipitation).	Precipitation information is limited by range of the radar.											+		
CAT 10	Monoradar Surface Movement Data	Location of aircraft and ground vehicles with (operational) transponders.	Radar data usefull for ground events and events at low altitude.	+	+	+	+			±						
CAT 11	Surface movement A- SMGCS data	Location of aircraft and ground vehicles with (operational) transponders.	Radar data usefull for ground events and events at low altitude.	+	+	+	+			±						
CAT 21	ADS-B reports	ADS-B broadcast of aircraft received by ground station.	The ADS-B reports included ACAS Resolution Advisory Report and MET reports (wind and temp).					+			+		+			
CAT 34	Monoradar Service Messages (CAT 48)	Transmission of monoradar target reports from a stand alone radar.	Validate operation of radar and UTC time stamp.													+
CAT 48	Airspace Mono target reports	Transmission of monoradar target reports from a radar station.	Radar data not usefull for ground events.	±	-		-	+		+						
CAT 62	System Track Data	Transmission of system track data.	ACAS and flight pland data included.	±	-	-	±	+		+	+					

Figure 8: Overview of ASTERIX categories and quantitative indication of the data category that aid in a specific type of investigation or phase of flight.

ISASI 2012 Awaits Attendees

The technical program schedule of ISASI's 2012 international conference on air accident investigation, being held in Baltimore, Md., U.S.A., August 27–31, is now complete. With the final piece of the conference in place, officials are ready for the registration of the 250 persons expected to attend.

The conference has multiple parts, each of which requires a separate registration. The parts are tutorial workshops, one day; technical program, three days; and optional tour, one day. The technical schedule uses the center three days of the week, while the bookend days are for related activities.

The heart of the activities is the speakers' program. This year, planners are presenting 20 speakers, four panel discussions, and three keynote speakers throughout the Tuesday–Thursday schedule. An awards banquet, at which the author(s) of the "outstanding paper" of the conference are recognized and the prestigious Jerome F. Lederer Award is presented, closes the technical program. Also occurring during the three-day schedule are evening social events, companion day activities, and plenty of "break time" for networking and renewing acquaintances.

Keynote speakers are Tuesday, the Honorable Deborah A.P. Hersman, chair of the U.S. NTSB; Wednesday, the Honorable Wendy Tadros, chair of the TSB, Canada; and Jean-Paul Troadec, director of the BEA, France. In a first for an ISASI annual conference, four NTSB members will each moderate one of the scheduled panel discussions. Panel titles are "Laboratory Support of Accident Investigation, Challenges, and Opportunities"; "Challenges Associated with Parallel Investigations"; "Covering the Gap from the On-Scene Phase to the Final Report"; and "Developing and Fostering Safety Awareness."

Speakers will address the conference's theme "Evolution of Aviation Safety—From Reactive to Predictive" by focusing on 1) the historical evolution from reactive to predictive; 2) the interaction between accident or incident investigation and accident prevention or analysis; 3) the analytical processes that identify, monitor, or assess emerging risks; and 4) the practical application of those processes to minimize the risk of accidents.

Full details on all aspects of the conference are available on its website, which is accessed through ISASI's website, www.isasi.org. There you can register for the seminar, make hotel reservations, get information on the partner airline for travel arrangements, find the sights and sounds of the city of Baltimore, and get full technical program details. The costs associated with conference activities and hotel registration are posted on the conference website.

To help with the attendees' air travel cost, planners secured Lufthansa German Airlines as a conference partner. The airline is offering special prices and conditions that apply to participants, companions, visitors, exhibitors, and invited guests. Make reservations at www.lufthansa.com/event-booking_en, and enter the access code USZAXT in the Access to Event Booking area. NOTE: Pop ups must be enabled or the booking platform window will not open. These promotional fares are also available through your IATA/ARC travel agent.

The Society's 43rd annual international conference is being held at the Baltimore Marriott Waterfront Hotel, located on the water's edge in Baltimore's East Harbor, eight miles from Baltimore Washington International (BWI) Airport. The guest rooms feature many high-tech and luxurious amenities offered at the special seminar room rate of US$159.00 (plus taxes) based on single or double occupancy. This rate includes daily room Internet access and use of the hotel's fitness facilities and is available for three days pre- and post-seminar (Aug. 24 to Sept. 3, 2012). The cutoff for reservations is Aug. 4, 2012.

Committee members for the seminar are Frank Del Gandio, Seminar chair; Barbara Dunn, Registration chair; Robert Matthews, Technical Committee chair; Ron Schleede, Sponsorship chair; and Candy Del Gandio, Companion program chair. ◆

Don't Forget to Vote; Polls Close August 1

Voting is a right; don't give it away. The 2012 ISASI International Council election voting period is taking place as this issue goes to press. The Executive officers standing for reelection are President Frank Del Gandio, Vice President Paul Mayes, and Secretary Chris Baum. Standing for election to the office of Vice President is Ron Schleede, immediate past vice president. He is running against incumbent Paul Mayes. Bob MacIntosh is standing unopposed for election to the treasurer position (see the April-June issue of *Forum,* page 26, for his biography). The current international councillor, Caj Frostell, and U.S. councillor, Toby Carroll, are standing for reelection.

Voting, which closes August 1, is being conducted electronically via the Internet using VoteNet. Connect to VoteNet through the ISASI website, www.isasi.org. Click on the link and read the easy-to-follow instructions. Three ballots are available: one for U.S. members, one for members of national societies, and one for international members. When you input your member number, the correct ballot will automatically appear. There will also be a box for a write-in-candidate. Voting is strictly confidential, and the results are available only to the Ballot Certification Committee. ◆

ISASI Member Leads Czech Safety Efforts

Ten years ago, Ladislav "Ladi" Mika of

LETTER TO THE EDITOR

Helen Reidemar's article regarding standardization [Human Factors Standardization in Safety Applications, *ISASI Forum* April–June, page 16] should be required reading for all aviation safety officers both in the civil and FAA environment. Education and standardization are essential in our aviation community if we desire to reduce accidents, injuries, and deaths. Because of the recent FAA philosophy of reducing flight standardization and regulatory enforcement training for its aviation safety inspectors, it is now incumbent upon the industry to pick up the gauntlet and ensure that all means are employed to encourage crews to learn and practice safe procedures. Aviation safety inspectors assigned to an air carrier will be limited in their ability to engage in comprehensive discussions on matters of standardization to include accepted crew resource management practices. This same limitation is being extended to all aspects of crew certification.

I feel confident that through efforts generated by ISASI and professionals like Ms. Reidemar, aviation safety can be maintained regardless of the failures of the FAA.

—Jack A. Milavic, Ph.D., FAA Aviation Safety Inspector, Ret.

the Ministry of Transport of the Czech Republic led the effort for his country to host the first ISASI Reachout workshop training sessions. He has continued to be at the forefront of all the safety training occurring in the Czech Republic since then. ISASI corporate member the Southern California Safety Institute (SCSI) has delivered much of that training and education to improve the skills of aviation investigators.

Mika said, "As an initiator and cofounder of the training effort, I am very proud that during 10 years of existence of these courses approximately 400 safety persons from different parts of world have participated in the Prague courses. The effort is our contribution to increasing aviation safety. Many participants were already or have become ISASI members. Others left the training with full knowledge of our Society and an invitation to become members."

In April and May, a series of three international courses were conducted in Prague through a joint Ministry and SCSI effort. More than 50 persons participated. Among the instructors were William Fowler and Alec Muffat, both ISASI members. ◆

ISASI Conducts First Middle East Regional Meeting

ISASI held its first Middle East regional meeting in Abu Dhabi in early June. The meeting, hosted by the Air Accident Investigation Sector (AAIS) of the General Civil Aviation Authority (GCAA) of the United Arab Emirates (UAE), took place in the GCAA's National Center for Aviation Studies Auditorium.

Ismaeil Abdul Wahed, executive director of the Air Accident Investigation Sector of the GCAA, welcomed the attending 40 ISASI members and guests. Caj Frostell, ISASI international councillor, offered information on ISASI including its purpose, educational activities, and membership procedures.

Guest speaker Capt. Adrian Aliyuddin, head of Corporate Safety, Etihad Airways, spoke on "Effective Communication Post Accident—An Operator's Perspective." His presentation outlined appropriate communications and strategies in the aftermath of an accident to maintain public and industry confidence.

Participants included members and guests from the UAE, Kuwait, and Saudi Arabia. ISASI members and supporters attending the meeting included Mohammed Aziz from MEA in Lebanon and Tom Curran (ex-Air Lingus) from Ireland. Ismaeil Abdul Wahed and Capt. Elias Nikolaidis of the GCA/AAIS, arranged the meeting. ◆

PNRC Mourns Dick Wood Passing

The Pacific Northwest Regional Chapter (PNRC) lost a valuable member recently with the death of Richard "Dick" Wood (see "President's Viewpoint," page 3). While many ISASI members knew Dick through his books or seminar presentations, many of the PNRC members were fortunate to have him as an instructor during their accident investigation training.

PNRC members were able to see Dick apply his extensive safety background in very practical ways. His presentations at Chapter meetings were always well attended for both the professional content and the outstanding Q-&-A sessions that followed. In honor of Dick, the PNRC will be making a contribution to the Kapustin Scholarship Fund in his name. ◆

Haueter Departs NTSB; DeLisi Named Director OAS

Tom Haueter, director of the Office of Aviation Safety, NTSB, retired in June. John DeLisi was named by NTSB Chair Deborah A.P. Hersman to assume the office. Haueter has served the NTSB as a technical expert in charge of major accidents and as an ambassador for aviation safety all over the world. His portfolio of investigative work has encompassed everything from small general aviation crashes to some of our nation's largest and most complex accidents involving major air carriers.

"Tom Haueter has served the NTSB with distinction, and the agency has benefited greatly from his steady, professional leadership," said NTSB Chair Hersman. "Through his work, he has made aviation safer for us all. He will truly be missed."

In announcing DeLisi's selection, Hersman said, "With more than two decades of outstanding accident investigation experience, John has made significant contributions to safety and to the NTSB. I look forward to continuing to work with him to further improve the safety of air travel." DeLisi has been serving as the deputy director of OAS since 2007. During his 20 years with the NTSB, he has overseen numerous major investigations, including the January 2009 ditching of US Airways Flight 1549 in the Hudson River and the February 2009 Colgan Air accident near Buffalo, New York.

He is a cum laude graduate of the University of Michigan with a degree in aerospace engineering, and has done graduate work in engineering management at Washington University in St. Louis, Missouri. He holds a private pilot certificate. ◆

(continued on page 30)

Continued . . .

MARC Spring Meeting Features NTSB Member Sumwalt

ISASI'S Mid-Atlantic Regional Chapter meeting held in early May featured NTSB member and long-term ISASI member Robert L. Sumwalt as its guest speaker for the event. He was recently sworn in for his second five-year term as a member of the National Transportation Safety Board. Nominated by President Obama, his term of office will run until Dec. 31, 2016. Sumwalt was first designated a Board member on Aug. 21, 2006, by President Bush and served as vice chairman of the Board for a two-year term. His ISASI membership precedes his NTSB service, joining in the mid-1990s.

Prior to his NTSB appointment, Sumwalt was a pilot for US Airways and Piedmont Airlines for 24 years, logging more than 14,000 flight hours on five different types of airplanes before retiring in 2005. During this time, he served as a member of the Air Line Pilots Association's (ALPA) Accident Investigation Board from 2002 to 2004 and chaired ALPA's Human Factors and Training Group. In 2003, Sumwalt joined the faculty of the University of Southern California's Aviation Safety and Security Program, where he was the primary human factors instructor. From 1991 to 1999, he conducted aviation safety research as a consultant to NASA's Aviation Safety Reporting System, studying various issues, including flight crew performance and air carrier deicing and anti-icing problems.

In addressing the 78 attending MARC members and guests after dinner, Sumwalt shared the experiences that have shaped his aviation career; he also shared the NTSB's plans for the coming months.

As a 17-year-old, he heard a car radio report of a plane crash near his hometown airport. Approaching the crash site, he "saw the coroner and decided to tuck in close to him. As he walked toward the accident site, I stayed close to him. And as the law enforcement officers raised the yellow tape for him, I slipped in with him.… And on the way home, I drove by the airport and stopped in to Miller Aviation and signed up for flying lessons." Other incidents that have shaped his work include a 1976 CFIT accident in the Virginia mountains in which his parents were survivors; a 1981 plane crash that took the life of his best friend; and the 1994 USAir 1016 accident in Charlotte in which his brother-in-law was a passenger—an accident that claimed 37 lives.

From these latter experiences comes the insight of "someone who has been there. I can tell you that the families and friends of victims count on us to get it right." He noted: "What drives me each and every day, and what I suspect drives you, is the knowledge that our work is important. It does matter. It does make a difference, and it does keep people from dying in airplane crashes."

Member Sumwalt then turned to his NTSB work. He spoke of the Board's streamlining its "Most Wanted List," which involves about two dozen areas. He rhetorically asked, "How do you focus on that many different areas?" He replied, "We reengineered it. We now only have 10 items on the List. We want the List to be relevant. We want it to reflect those areas that affect the highest risk factor in transportation safety or warrant special attention. I think you will see the List changing and being more dynamic in years to come."

Six of the 10 items have a direct relationship to aviation:

- General aviation safety—GA continues to have the highest aviation accident rates within civil aviation: about six times higher than small commuter and air taxi operations and more than 40 times higher than larger transport-category operations.
- Pilot and controller professionalism—A disturbing number of accidents involving a lack of professionalism have occurred. Many organizations are working on increasing professionalism, including ALPA.
- Runway safety—This area has been broadened from just runway incursions to incorporate excursions and runway confusion, such as attempting to take off or land on the wrong runway or on taxiways.
- Safety Management Systems—This is a recommendation for SMS in all modes, including the railway industry.
- Recorders—With appropriate protections on their use and data disclosure, improved recorders could be used for safety-related purposes.
- Human fatigue—Fatigue continues to be a huge issue across all modes of transportation.

Member Sumwalt speaks about his experiences.

After outlining the NTSB's upcoming safety conference and forums for the coming months, Sumwalt turned to a more audience local subject, saying, "I'm really pleased to say that NTSB board members will play a big role at this year's ISASI conference. Since I've been at the Board, I've wished NTSB would have a greater presence at ISASI conferences.

MARC President Schleede speaks about the ISASI new member kit.

This year all five Board members will be there, and each will lead panels on a range of topics. It should be interesting, and we look forward to it."

In closing, he said: "I want to emphasize that the work you do as professional air safety investigators is so important. I know that because I have an unusual perspective. Keep up the good work."

Other meeting events

The event opened with a "refreshment hour" that relaxed the atmosphere for the all-important networking that occurs at the spring meeting. Inside the banquet room, a sumptuous buffet dinner awaited as guests strolled by the table displaying the many door prizes donated by Airbus Industries, the University of Southern California, Omega Travel, RTI Group, Safety Research Corp. of America LLC, Lufthansa Airlines, Airlines for America, and Crowne Plaza Dulles Airport Hotel. Top prizes included round-trip tickets for two from Southwest Airlines and "reward" points from JetBlue Airlines. Guest speaker Sumwalt donated several signed copies of his just-released book *Aircraft Accident Analysis: Final Reports.*

Ron Schleede, MARC president, welcomed all and urged participation in a special fund-raising challenge for the ISASI Kapustin Memorial Scholarship (see page 10.) He described the funding methods used for the scholarship, noting that contributions made in the U.S. to the fund were tax-deductible and that all funding comes from contributions. He noted that the largest fundraiser is the spring MARC meeting.

Responses to the donation challenge came quickly and unhesitatingly. The donation total reached $4,525. The winning challenge was $1,000 by the Canadian Society of Air Safety Investigators. Other donors are listed in the adjacent sidebar.

Richard Stone, co-chair of the scholarship program, noted in announcing the 2012 winners that for the first time the Scholarship Committee awarded four awards on the basis of the excellent 1,000-word essays addressing "The Challenges for Air Safety Investigators." Awardees are Frederik W. Mohrmann, Delft University of Technology; Harding "Chip" Williams, Embry-Riddle Aeronautical University; Heidi E. Moats, Embry-Riddle Aeronautical University; and Robert Geske, Purdue University.

The MARC meeting is held in conjunction with the spring ISASI International Council meeting, which meets the next day. ISASI President Frank Del Gandio addressed the group and talked about the ISASI Reachout program. He said that more than 2,000 persons have been trained through the workshop-style training sessions. Of those attending, he said, "Many generally don't have the opportunity to get the same type of training that many of us have had. Reachout is cost free to attendees, and instruction is by ISASI volunteers." He also provided a quick summary of the Society's financial and membership status. In closing, he introduced three individuals who became members at the meeting: Nobuyo Sakata with Airlines for America and Thomas B. Littleton and Katherine A. Lemos, both with the FAA. Todd Wilson from ERAU and John DeLisi from the NTSB received information kits. ◆

Guest speaker Sumwalt, right, poses with, left to right, Katherine A. Lemos and Susan and Robert Benzon.

MARC Meeting Donation List

ISASI Kapustin Memorial Scholarship
(In memory of all ISASI members who have died)
Chris Baum
Toby/Kathy Carroll
Canadian Society of Air Safety Investigators
Frank/Candy Del Gandio
Robert Francis
Clifton E. Gee
David J. Haase
Candace Kolander
Tom/Ginger McCarthy
John Purvis
RTI Group—Joe Reynolds
ISASI Northeast Regional Chapter
Ronald Schleede
ISASI Southeast Regional Chapter
Richard/Ruth Stone
ISASI Mid-Atlantic Regional Chapter
ISASI Dallas-Ft. Worth Regional Chapter

ANSV Reports Italy's Civil Aviation Safety Status

The Italian Air Safety Board (ANSV) 2011 report on civil aviation safety in Italy notes receiving 2,361 warnings of events concerning flight safety. Only a limited number of the events were ruled a crash or severe occurrence.

In 2011, the ANSV opened 83 inquiries for crashes/severe occurrence, compared to 95 in 2010. The majority of them (47) concerned events to recreational airplanes. "This sector continues to present heavy criticalities for flight safety. In particular, there is a lack of an appropriate flight culture, not only at the pilot level, but also at ground organizations," said the report.

Of the 13 accidents occurring in 2011, 7 of them involved helicopters in the professional air services (PAS) field. Recreational aviation and the PAS sector accounted for 21 of the 23 fatalities in 2011.

The agency underlined in 2011 the operating capacity of its technical laboratories, in particular those used to decode and read data inside the flight recorders (black boxes). "Some foreign investigating authorities, thanks to the high technological and professional level reached by ANSV, make use of its laboratories for the own investigations," a spokesman noted. ◆

Aviation Statistics for 2011 Show Slight Increase In Accidents

The National Transportation Safety Board (NTSB) released, in late April, preliminary aviation accident statistics showing a slight overall increase in U.S. civil aviation accidents for 2011 from the previous year. Marked increases were seen in accidents involving on-demand Part 135 operations. However, for the second year in a row, there were no fatal accidents involving scheduled Part 121 air carriers or scheduled Part 135 commuter operations.

U.S. civil aviation accidents rose from 1,500 in 2010 to 1,550 in 2011. Fatalities also increased, from 469 in 2010 to 485 in 2011. All of the fatalities were in general aviation and on-demand Part 135 operations (charter, air taxi, air tour, and air medical operations). Twenty-eight accidents were recorded for scheduled Part 121 air carriers, and four accidents were recorded for scheduled Part 135 commuter operations.

Total accidents involving on-demand Part 135 operations climbed from 31 in 2010 to 50 in 2011, while fatal accidents rose from 6 to 16 and fatalities rose from 17 to 41. The accident rate per 100,000 flight hours for on-demand Part 135 operations experienced the most dramatic rate increase among major U.S. civil aviation segments, rising from 1.00 in 2010 to 1.50 in 2011.

General aviation accidents, which continue to account for the greatest number of civil aviation accidents, reversed their downward trend over the previous two years increasing from 1,439 in 2010 to 1,466 in 2011. However, there were 263 fatal general aviation accidents in 2011, down from 268 in 2010. General aviation fatalities declined from 454 in 2010 to 444 in 2011. While the number of general aviation flight hours increased in 2011, the accident rate per flight hours decreased from 6.63 in 2010 to 6.51 in 2011.

The 2011 statistical tables showing accidents, fatalities, and accident rates for major segments of U.S. civil aviation can be found at http://www.ntsb.gov/data/aviation_stats_2012.html. ◆

Using 'ASTERIX' in Accident Investigation *(continued from page 25)*

egory, aircraft GPS data and the "time of reception by ground station" are included. This indicates that Eurocontrol has also identified similar issues in correlation of data and processing.

Conclusions and recommendation: *The use of ground radar is very useful during ground event investigations. The high update rate and accuracy of ground radar will facilitate a high-fidelity reconstruction. Care must be taken when fusing other sources of data, for example, the FDR, as time differences may exist.*

Conclusion

ASTERIX is a flexible data format that can be processed to aid accident investigators in answering investigative questions. Understanding the ASTERIX data format and its capabilities makes it possible to write programs to adapt ASTERIX in a way beneficial to an investigation. Depending on the type of accident, ASTERIX data may be helpful in establishing a time line, putting the event in a weather context, and providing additional insight(s). The table below, although not complete, shows the categories the DSB and the AAIU have identified that are useful and have benefits to use in accident investigations. ◆

Understanding Pilots' Cognitive Processes for Making Inflight Decisions Under Stress *(continued from page 19)*

FOR-DEC was rated by cadet pilots as the best ADM mnemonic-based decision-making method for promoting good resource management decisions, as would be expected of a methodology originally developed to promote good CRM. The qualitative data elicited from pilots showed that FOR-DEC has characteristics to deal with nonurgent situations as a result of its good situation assessment and risk management characteristics. FOR-DEC was thought to prompt a comprehensive approach in terms of the number of factors that it encompassed in the decision-making process. Also, it was regarded as providing a specific and clear approach to analyze a situation, and it possessed a logical order that was easy to remember. However, it did require more time to undertake the required steps and to analyze and respond to the changing situation.

An implication of the fact that many decisions must be made under stress is that training should include extensive practice to learn key behaviors, according to J. Driskell and E. Salas. However, earlier, D. Zakay and S. Wooler found that practice without time pressure did not enhance decision-making under time constraints. This suggests that, if decision-making is likely to be required under time pressure or other stressful conditions, practice should include task performance under those conditions.

SHOR, as noted earlier, was developed for use in U.S. Air Force tactical command and control scenarios, where decisions were likely to be made under high pressure and within severe time constraints. These situations involve making near-real-time decisions involving threat warning and rescheduling and often require dynamic modifications to plans. The contents of SHOR match the requirements of the scenarios requiring urgent decisions. As SHOR is basically an extension of the stimulus-response (S-R) paradigm of classical behaviorist psychology, it explicitly addresses the requirement to deal with two aspects of uncertainty in the decision-making process—information input uncertainty (relating to hypothesis generation and evaluation) and consequence-of-action uncertainty (which creates the requirement for option generation and evaluation).

SHOR is able to promote quick responses in a time-limited situation. It also corresponds to the basic principles of briefing during tactical training. The qualitative data from pilots also revealed that the four steps in SHOR fulfilled the requirements to deal with time-limited, urgent situations. SHOR has simple steps with high applicability; it is easy to practice and it promotes the logical procedures required for safe action. J.W. Payne, J.R. Bettman, and E.J. Johnson found that, under time pressure, a number of heuristic choice strategies are more useful than attempts to apply a truncated normative model. Subjects adapt their decision-making strategies in reasonable ways when placed under time constraints. Under time pressure, the likelihood of making serious errors increases. Decision-makers tend to ignore relevant information, make risky decisions, and perform with less skill.

Pilots consistently selected FOR-DEC as the best mnemonic-based decision-making method in the go/no go decision, recognition-primed decision, response selection decision, resource management decisions, nondiagnostic procedural decision scenarios, and in problem-solving decisions; all of which were urgent, potentially high risk, time-critical situations and required prompt actions.

The pilots' comments suggested that FOR-DEC had the required characteristics to deal with urgent situations as it promoted quick responses. FOR-DEC was simple and easy to remember; it fitted the constraints inherent in time-limited and critical situations; it matched the general format of a preflight briefing; it was easy to put into practice; and it was thought that its logical procedures promoted safe action.

Our current research study suggests that the FOR-DEC mnemonic forms a suitable basis for decision-making training that encompass the requirements for these six basic decision-making situations.

The principal limitation of the study was that it only elicited pilots' opinions about the efficacy of these decision-making techniques. As a result, research needs to be undertaken to produce empirical performance data to establish if training in the use of ADM mnemonic-based methods such as FOR-DEC can actually improve pilots' inflight decision-making. There is a need for future study to justify the effectiveness of aeronautical decision-making mnemonics training interventions based on FOR-DEC mnemonics methods across all different types of decision-making scenarios encountered in stress situations. The cognitive processes employed by pilots also need to be investigated in a series of reliable tools.

Conclusion

J. Orasanu in 1993 suggested that the six basic types of decisions each impose different demands on the decision-maker and require different approaches. Our current research study suggests that the FOR-DEC mnemonic forms a suitable basis for decision-making training that encompass the requirements for these six basic decision-making situations. FOR-DEC was rated as being the best ADM mnemonic method in critical, urgent situations and was regarded as superior for knowledge-based decisions that required more comprehensive considerations. To optimize the effectiveness of decision-making training, the study suggests that it will be necessary to deliver instruction using the FOR-DEC mnemonic-based method. ◆

Investigating and Preventing the Loss of Control Accident, Part I

(continued from page 9)

cumulation on the wing. A sample test of TKS panels during preflight inspections found frequent occasions in which TKS panels were not fully exuding fluid along the full length of the panel. Obviously, the inspection intervals and maintenance practices of these critical items must be monitored and reviewed to ensure proper operation prior to flight into possible icing conditions.

In several incidents the "automatic" timer mode was disabled by a mechanical failure and allowed to be deferred. During high-workload departure or arrival phases of flight the flight crew became overloaded with workload and failed to continually activate the de-icing switches. The potential for being distracted from activating the "manual" mode of a de-icing switch is very high, especially during terminal operations. De-icing and anti-icing systems should be fully functional for any flight into IMC conditions that contain the possibility of ice, and the practice of allowing minimum equipment lists to defer items within anti-ice and de-ice systems should be questioned. Reconsideration should be given to the deferral status of components of anti-ice and de-ice systems. ◆

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WHO'S WHO

FedEx Express Maintains Safety As a Core Value

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

FedEx Express provides customers and businesses worldwide with a broad portfolio of transportation and business services. With annual revenues of $24.6 billion, the company offers integrated business solutions under the respected FedEx brand. Consistently ranked among the world's most admired and trusted employers, FedEx Express inspires its more than 140,000 team members to remain "absolutely, positively" focused on safety to achieve the highest ethical and professional standards and to meet the needs of their customers and communities.

With more than 690 airplanes and 4,500 crewmembers flying more than 280 million air miles per year—the equivalent to flying to the moon and back more than 500 times—safety is a core value at FedEx Express. The company's pilots and maintenance personnel receive ongoing safety communications, and the company's training programs meet or exceed FAA standards.

FedEx Express ensures safe and efficient flight operations through strong policies and procedures, effective communication, training, and the use of technology. Examples of its innovative safety technology include a head-up display (HUD) combined with an infrared Enhanced Flight Vision System (EFVS) on the company's MD-10/11 airplanes, improving flight safety by increasing visibility for pilots during adverse weather conditions and darkness and providing detailed flight guidance cues.

In addition, FedEx Express was the first major commercial carrier in the airline industry to receive a supplemental type certificate from the FAA for an automatic main-deck fire suppression system installed on the company's fleet of Boeing MD-11 freighters. FedEx Express is planning on adding these technologies to other airplanes in its fleet.

FedEx strives to be an environmental leader in the transportation industry. By 2020, FedEx plans to reduce carbon dioxide emissions from its airplane fleet by 20 percent and improve the fuel efficiency of its FedEx Express vehicle fleet by 20 percent. FedEx Express is currently upgrading its fleet with fuel-efficient B-757s and B-777s and operates the largest fleet of electric vehicles in the transporation industry. ◆

FedEx Express facts

History—Founded in 1971 as Federal Express Corporation
Headquarters—Memphis, Tenn.
Average Daily Volume—Approximately 3.5 million packages and 11.5 million pounds of freight
Air Operations—More than 375 airports served worldwide
Service Area—Provides express delivery to more than 220 countries and territories
Delivery Fleet—Approximately 45,000 motorized vehicles
Operating Facilities—1,057 stations (676 in the U.S., 381 outside the U.S.) and 10 air express hubs ◆

Recent awards

- Great Place to Work Institute: "World's Best Multinational Workplaces," Top 5 Ranking (2011)
- *Reader's Digest:* "Asia's Most Trusted Brands, Services & Retail" (2011)
- University of Michigan America Customer Satisfaction Index: No. 1 Customer Satisfaction, Express Delivery Industry (2010)
- *Black Enterprise* magazine: "Top 40 Best Companies for Diversity" (2010)
- World Air Cargo Awards: "International Express Operator of the Year" (2010)
- *Logistics Management* magazine: "Quest for Quality Award—Air Express Carriers" (2010)
- Wal-Mart: "Small Parcel Carrier of the Year" (2010)

For more information about FedEx, visit www.fedex.com. ◆