ISASI FORUM

"Air Safety Through Investigation"

APRIL–JUNE 2012

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During an air show practice at Lethbridge County Airport in Alberta, Canada, this CF18 experienced a loss of thrust from its right engine while conducting a high alpha pass at 300 feet above ground level (see article page 5). The pilot selected military power on both throttles to arrest descent. But with the aircraft at approximately 150 feet AGL and about 90 degrees of right bank, the pilot ejected from the aircraft. He landed firmly and sustained some injuries. (Photo: *Lethbridge Herald* photo by Ian Martens. The image is reprinted with permission from the *Lethbridge Herald*, which retains copyright.)

ISASI FORUM
"Air Safety Through Investigation"

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

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Editorial Offices: Park Center, 107 East Holly Avenue, Suite 11, Sterling, VA 20164-5405. Telephone (703) 430-9668. Fax (703) 430-4970. E-mail address isasi@erols.com; for editor, espmart@comcast.net. Internet website: www.isasi.org. *ISASI Forum* is not responsible for unsolicited manuscripts, photographs, or other materials. Unsolicited materials will be returned only if submitted with a self-addressed, stamped envelope. *ISASI Forum* reserves the right to reject, delete, summarize, or edit for space considerations any submitted article. To facilitate editorial production processes, American English spelling of words will be used.

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AIR SAFETY INVESTIGATORS
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International Council Meeting Highlights

By Frank Del Gandio, ISASI President

Last month I wrote about the new ISASI mentoring program that our International Council approved at its September 11 meeting in Salt Lake City. Today, I will center on the highlights of that meeting.

The historical importance of our meeting day was not lost upon those of us attending. We duly recognized it with a moment of silence for all those who lost their lives in the horrific acts of aerial terrorism that will never be forgotten.

Then we moved on to the business of the Society, the highlights of which include approval of the 2012 budget, which projects in "ordinary income/expense" an income of \$184,230 and an expenditure of \$186,547. In the "other income/expense" category, we have an income of \$10,080 and expenses of \$1,200 for a net income (both categories) of \$7,162. To reduce costs, we have initiated teleconference procedures for our Council meetings, thus reducing air travel expenses. In addition, the Council eliminated the publication of *ISASI Proceedings*. With the expected income of future annual seminars, I judge our financial health to be stable at this point.

We then discussed an invitation from the Military Air Safety Investigator Group, associated with Boeing defense systems, which expressed an interest in affiliating with ISASI. This led to ISASI attending the group's seminar meeting in Mesa, Ariz. I presented ISASI's role, objectives, and the advantages of affiliation. I am very pleased to report success: ISASI now has a Military Air Safety Investigator Working Group (MASIG). Many of the attendees were already long-time ISASI members, and we received more than 20 new members. The Group tentatively plans to meet about once a year. The Group's next seminar may be held in Albuquerque, N.M., and be hosted by the Air Force Safety Center. For further information, contact Bret Tesson (Boeing), Group chairman, at 314-777-7898 or via e-mail: bret.w.tesson@boeing.com.

Regarding working groups (WG), I briefed the Council about some member concerns that some ISASI WGs do not seem to be functioning as they should. I contacted all WG chairs to remind them of the value of their effort and to ask them to revalidate their commitment to leading their groups.

Membership enrollment is always a vexing situation in that our gains balance out our losses. We need to find a way to retain those members who decide not to renew their membership and continue our growth through new members. All Council members agreed to energize their efforts in this regard. We have already expanded our membership criteria, and we are searching for methods that will ease renewals through automatic dues payment systems. Vice President Paul Mayes completed a recruiting and retention of membership report. It will be discussed at the May Council meeting.

As I write this, the ISASI scholarship application period is about to close. Dick Stone is confident that there will be sufficient applications from which to make selections. This has been an outstanding achievement for the Society and strongly supported by the members. We have been notified that our President Emeritus Jerry Lederer bequeathed \$2,000 to ISASI, which will be placed into the scholarship fund.

ISASI 2011, held in Salt Lake City, Utah, was highly professional and successful. ISASI 2012, which is being held in Baltimore, Md., August 27–31, should also be very rewarding. This seminar will be slightly different in that the U.S. National Transportation Safety Board will be joining us and will have an integral role in the seminar. The agency will present a full-day tutorial in which participants include Airbus, Boeing, and Honeywell. In addition, two half-day tutorials on data recorders and metallurgy are planned. The Council is determining the value of "seminar evaluations," based on the belief that attendee feedback serves to improve presentations. As of this date, no applications have been filed by ISASI societies or chapters to host seminars in 2013 or beyond.

ISASI 2012 will be slightly different in that the U.S. National Transportation Safety Board will be joining us and will have an integral role in the seminar.

All of our societies have reported good health from an activity, membership, and financial standpoint. The initiation of annual seminars, similar to the Australian/New Zealand annual joint venture, has awakened a dormant interest within memberships and other parties.

The full minutes of the Council's September 2011 meeting will be posted on our website following the May 4 Council meeting.

Finally, I am saddened to report that Warren Wandel passed away on January 27. He was 65 years young. Warren, an ISASI member since 1978, was enthusiastic about the Society. His membership application letter personifies his safety interest: "To avoid unnecessary delays, please ensure all membership correspondence is posted by air mail…." Warren was a retired chief warrant officer Army helicopter pilot with a long and distinguished career. As a civilian, Warren was a safety officer and investigator for Bell Helicopter in Iran. He served as an NTSB investigator for 15 years and was considered one of the profession's finest. He was instrumental in starting the FAA's helicopter accident investigator school. The aviation community will miss him. ◆

Examining the Past to Aid the Future

By Paul Mayes, ISASI Vice President

I joined ISASI in 1977 after I had completed my initial training as an air safety investigator. ISASI was the organization representing air safety investigators, and we saw ISASI as our professional association. In those days, communication was much more restricted and slower than it is now, and ISASI was a means of keeping in contact with air safety investigators and safety issues around the world. Obviously, communications have evolved remarkably since then, and we have instant access to any events anywhere in the world. The 1970s were the age of the digital revolution with the introduction of computers into our daily office environment. Now, of course, that has evolved so that computers and the Internet in all its forms are in every part of our lives. With various communication channels such as LinkedIn, Facebook, etc., we can instantly exchange ideas and information. We carry our communication devices, such as smartphones, iPads, etc., with us, and we are bombarded with information.

ISASI remained the professional association through the 1980s and 1990s and grew in membership and activities. The working group structure of ISASI was particularly active. ISASI relied on volunteers to run the working groups, just as it does for all our activities. This was one of the strengths of ISASI, a society for individuals. Not only did individuals give up their valuable time to organize and support the work of ISASI, but there was support and encouragement from the aviation industry.

The Flight Recorder Working Group, for example, had several very successful meetings and workshops in Europe and North America and was instrumental in adding to the knowledge and the development of today's flight recording.

However, in recent years the working groups have waned. I am sure there are many reasons for this, including the pace and demands of modern business. People no longer seem to have "spare" time to take on more than their business commitments. Yet when we look at the ease of communications, it should now be more practical to generate an interest in and have an active exchange of ideas on any of the issues we face in aviation safety.

One of the working groups that has remained active and bucked this trend is the Asia Pacific Cabin Safety Working Group, which was set up by ASASI in 1993. Through the strong commitment of individuals—from operators to regulatory authorities—the Group has continued to meet three or four times per year and provide a successful forum for developing cabin safety and exchanging information. The Group most recently met in Brisbane, Australia, over two days in April, and there were in excess of 40 attendees from the Australasian region.

The Reachout program was a great initiative by a few ISASI members and has been successful in providing training in safety investigation and safety management systems to those areas of the world that cannot afford the cost of the training courses. The ISASI Executive was pleased to endorse the Reachout program without having direct input. It is organized and managed by members. Can this approach be a model for other programs?

I feel that we have not taken the opportunities that modern communications and technology can offer us as a society for safety professionals. ISASI is an international society and has members in more than 60 different countries. We have national societies with significant numbers of members in those areas.

On the positive side, the European Society and the Australian/New Zealand Societies hold annual conferences that are very successful ways of meeting the ISASI goals. These goals are to promote air safety by exchanging ideas, experiences, and information on aircraft accident and incident investigations; to promote technical advancement by providing professional aviation safety education through lectures, displays, and presentations; to broaden professional relationships among its members; and to promote the prestige, standing, and influence of air safety investigators in matters of aviation safety. Perhaps a regional approach may be a way to reinvigorate the working groups and foster activity among the members.

Some of the 40 members of the Asia Pacific Cabin Safety Working Group who met in Brisbane, Australia, in April.

North America is still the major area of membership, and the Executive is still very much North American centric. I am the only Executive member from outside North America. It concerns me that we are losing the true "international" nature of ISASI. This is reflected in the ISASI annual seminars in Salt Lake City, Utah, last year and Baltimore, Md., this year. As yet, a location for next year's seminar has not been selected.

ISASI faces many challenges, including remaining relevant to aviation safety people in the worldwide aviation communities, continuing to focus on sound financial planning, and developing active programs for meeting the goals of the Society. We need to get back to basics and encourage our members to become more involved, and we need the Executive to recognize the international nature of the Society and to take a fresh approach for the future. ◆

Video Tracking and Matchmoving Aids For Flightpath Analysis

Video analysis and visualization are capabilities that are complementary and have great potential to support investigation and improve flight safety.

By Major Adam Cybanski, Deputy, Promotion and Information, Canadian Forces Directorate of Flight Safety in Ottawa, Ont., Canada

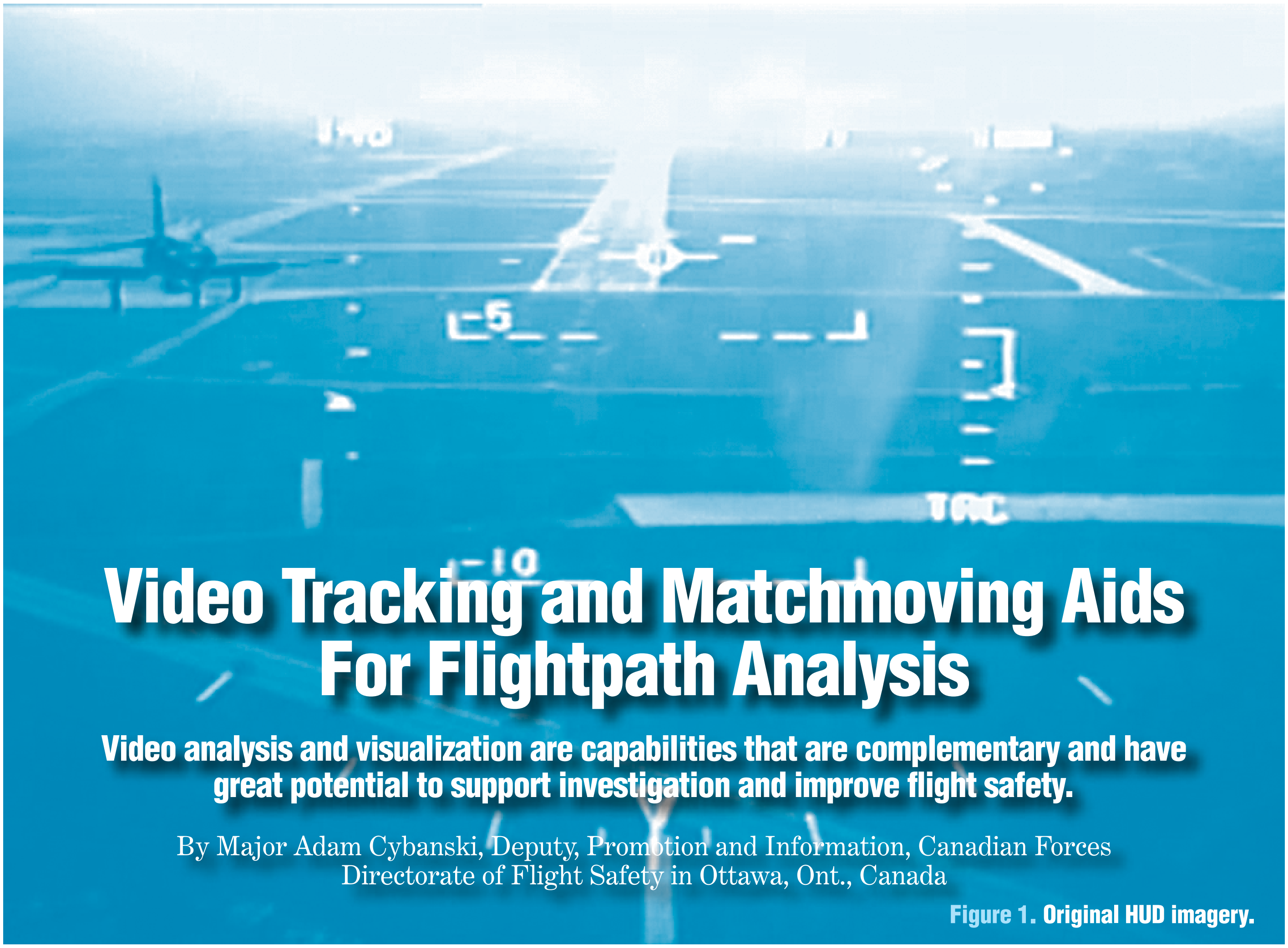


Figure 1. Original HUD imagery.

(This article is adapted, with permission, from the author's paper entitled Flightpath Analysis Based on Video Tracking and Matchmoving *presented at the ISASI 2011 seminar held in Salt Lake City, Utah, Sept.13–15, 2011, that 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)*

In the mid 2005s, the flightpath analysis, visualization, and crash site documentation capabilities of the Canadian Forces Directorate of Flight Safety (CFDFS) were limited. For aircraft not equipped with flight data recorders (FDR), it was difficult to obtain data on actual aircraft flight profiles. And even when equipped with an FDR, significant analysis was usually required to derive the actual flightpath. Animations were challenging to produce. The Directorate of Flight Safety (DFS) decided in 2009 to sponsor a pilot project within the Directorate to address this deficiency. The project was titled "Flight Safety Investigation Technological Upgrade." Its purpose was to use modern and relatively inexpensive technology to achieve flightpath analysis and visualization.

Visualizations of FDR flightpaths are used in accident investigation to validate witness testimony, determine flight profiles, calculate ground tracks, and to harmonize radar data, witness information, and FDR data. They also provide quick and intuitive lessons learned to a larger audience than just the pilots of the aircraft type. Unfortunately, many aircraft are not equipped with comprehensive FDRs and only use head-up display (HUD) or cockpit video to document aircraft flights. The CFDFS has developed a new capability to extract 3-D positional data from such video footage through photogrammetry and match moving and employ it in investigative and promotional visualizations.

CT155 Hawk formation landing, Sioux Falls, S.D.

This mission was a two-ship CT155 Hawk formation from Moose Jaw landing in Sioux Falls, S.D., for fuel. Just prior to flare during the final phase of landing, aircraft # two flew into the turbulence created by aircraft # one. Aircraft two's wingtip struck the runway. The aircrew executed an overshoot, declared an emergency, and continued around the traffic pattern for a safe landing. The CT155 Hawk is not equipped with an FDR but has a HUD. While the recorded HUD video (see Figure 1) could be useful for demonstrating the dangers of wake turbulence in formation, an animation showing the incident from the chase, top down, and tower, as well as the cockpit perspective, would better demonstrate the conditions, situation, and responses involved in the incident. Hence, this occurrence was selected for further video analysis.

Manual data extraction from HUD

For each frame of the video, HUD data were reviewed and noted. These included indicated airspeed, heading, altitude, vertical

Figure 2. HUD video enhancement.

speed indicator (VSI), bank, and pitch. The data were read off the scales on the display. The bank indicator has markings at the 0-, 5-, 15-, 30-, and 45-degree positions, left and right. Similarly, the pitch is marked in 5-degree increments and the altimeter in 20-foot increments. In order to interpolate between markings, a properly spaced paper scale was produced to improve accuracy of the readings.

Some of the symbology near the top of the video was illegible because of blooming. In this case, the gamma of the image was increased greatly, and additional enhancement made the symbology easier to discern and track (see Figure 2).

The values for airspeed, pitch, bank, heading, altitude, and VSI were recorded for each frame of the video (see Figure 3). From these initial values, additional information was derived. The VSI was integrated and compared to the altitude to produce much more accurate and responsive altitude readings. The pitch, bank, and heading values underwent exponential smoothing in order to interpolate values for those parameters, as they were displayed on the HUD at different sampling rates.

By synchronizing the calculated altitude with the airfield altitude at the moment of touchdown, altitudes were made to match the height above ground, independent of altimeter setting. These altitudes were used to calculate outside air temperatures throughout the sequence, which were used in the calculation of true airspeeds, which were used to derive instantaneous ground speeds. These ground speeds, together with corrected headings, were integrated to calculate positions of the aircraft with reference to the starting position. By anchoring this flightpath to the touchdown point on the airfield, latitudes (lat) and longitudes (long) for the sequence were calculated. By combining the lat/long, altitude, pitch, bank, and heading, an FDR-type flightpath was produced.

This FDR-type flightpath was played back in the flight simulator. When seen from the pilot's perspective in the simulator, the playback closely matched the real HUD display. This helped to validate the process and was an indication that the data were reasonable.

1	Seconds	1/8 Sec		IAS	Pitch	Bank	Hdg	Alt	VSI	Derived Alt
2										
3	0	0		149	-3.2	-3	210		-80	1715
4	0	1		149	-3.2	-2	210		-80	1713.333
5	0	2		149	-3.2	-2	210		-80	1711.667
6	0	3		149	-3.4	-2	210		-80	1710
7	0	4		149	-3.5	-1	210		-80	1708.333
8	0	5		149	-3.5	0	210		-80	1706.667
9	0	6		149	-3.5	0	210		-80	1705
10	0	7		149	-3.5	1	210		-80	1703.333
11	1	0		149	-3.6	1	210		-80	1701.667
12	1	1		149	-3.7	1	210	1700	-80	1700
13	1	2		149	-3.5	0	210		-80	1698.333
14	1	3		149	-3.5	0	210		-80	1696.667
15	1	4		149	-3.4	0	210		-80	1695
16	1	5		148	-3.3	0	210		-80	1693.333
17	1	6		148	-3.2	1	210		-80	1691.667
18	1	7		148	-3.2	1	210		-80	1690
19	2	0		148	-3.2	1	210		-80	1688.333
20	2	1		148	-3.1	1	210		-80	1686.667
21	2	2		148	-3.2	2	210		-80	1685

Figure 3. Manual parameter extraction.

Figure 4. Final visualization.

In order to model the movements of the lead aircraft, the visualization was frozen at several points, specifically when the video sequence started, upon ground touchdown, and at an intermediate point. Within the frozen visualization, a Hawk aircraft was moved left/right, forward/back, and up/down until its position and size in the visualization matched the lead aircraft seen in the corresponding frame of the HUD video. When the model and video matched, the lat, long, and altitude of the model were noted. Next, a linear interpolation was made between the aircraft positions for the length of the video, resulting in an approximate FDR-type recording of the lead aircraft. Pitch, bank, and heading from the second aircraft were reused for the lead.

Upon visualization in the flight simulator (see Figure 4), the pilot's perspective closely matched that of the HUD video. The visualization was recorded from several camera perspectives in the simulator, including a top-down view, a chase-plane view, a tower view, and from a virtual camera located at the touchdown

__Major Adam Cybanski__ is the deputy of promotion and information at the Canadian Forces Directorate of Flight Safety in Ottawa, Ont., Canada. He is a tactical helicopter pilot with more than 20 years and 2,500 hours on fixed- and rotary-wing aircraft, including the CT114 Tutor, CH139 Jet Ranger, CH135 Twin Huey, and CH146 Griffon. He completed a tour in Haiti as a night vision goggle specialist and maintenance test pilot and has managed the CH146 Griffon full-flight simulator. He is a graduate of the aerospace systems course and holds a BSc in computer mathematics from Carleton University.

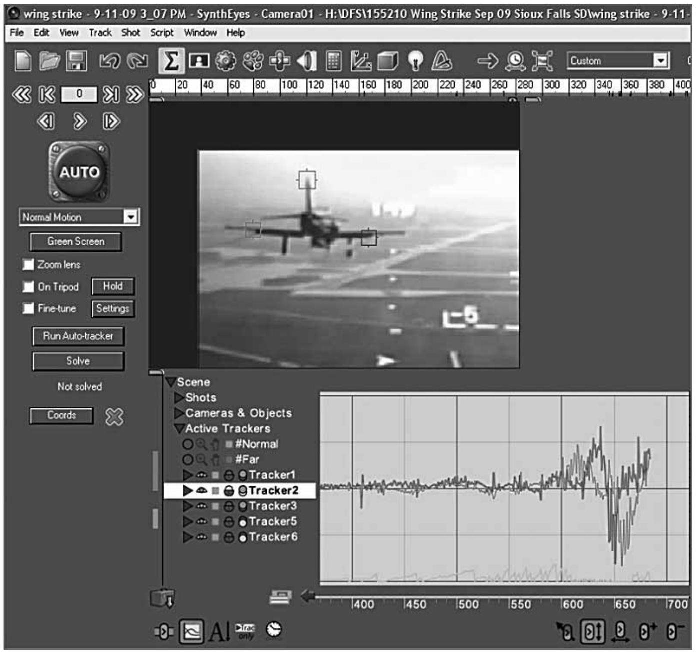


Figure 5. Automated aircraft tracking.

point on the airfield. The footage was synchronized and mixed with the original HUD footage in Adobe After Effects. It became clear that analysis of a video could result in a 3-D visualization that gave much more insight into the event than the original HUD video.

Automated data extraction from HUD

In 2010, the DFS employed SynthEyes software (used for special effects in video and film productions) to revisit the HUD footage to determine if some of the video analysis processes could be automated. Trackers were placed at the -45, -30, -15, -5, 0, 5, 15, 30 and 45-degree bank indicators, and their x-y positions were exported from the software. Next, a moving tracker was placed on the tip of the triangular bank indicator, which resulted in a spreadsheet depicting the position of the triangular indicator for each frame of the video. Using a mathematical formula that took into account the curve of the bank scale, interpolated bank values were calculated for each frame of the video. This showed that the manual time-consuming frame-by-frame data extraction could be replaced by even more accurate video tracking and analysis.

Trackers were also placed on the tail and flap/wing intersections of the lead aircraft (see Figure 5), and the resulting x-y data were reviewed. In some portions of the video, the aircraft could not be completely discerned because of blooming, which caused the trackers to lose lock. By enhancing the contrast and gamma of the video, successful tracking of the aircraft components was achieved. A 3-D Hawk model was imported into the software and matched to the aircraft in the video. Although the aircraft was not close enough to the camera to derive its distance and orientation throughout the sequence, there was some success that indicated this methodology could be useful in deriving an aircraft's position and orientation in space based solely on video.

CF188738 Hornet, Lethbridge, Alb., Canada

During an air show practice at Lethbridge County Airport, CF188738 experienced a loss of thrust from its right engine

Figure 6. CF188738 Hornet (left). Figure 7. Tracking features in video #1 (above).

while conducting a high alpha pass at 300 feet above ground level. Unaware of the problem but feeling the aircraft sink, the pilot selected military power on both throttles to arrest descent. The aircraft continued to sink, and the pilot selected maximum afterburner on both throttles. The aircraft immediately started to yaw right and continued to rapidly yaw/roll right despite compensating control column and rudder pedals inputs. With the aircraft at approximately 150 feet AGL and about 90 degrees of right bank, the pilot ejected from the aircraft. The aircraft continued to yaw/roll right with its nose descending in a tight right descending corkscrew prior to hitting the ground nose first (see Figure 6). The ejection and seat man separation worked flawlessly. But even under a fully inflated parachute, the pilot landed firmly and was injured when he touched down.

The CF188 Hornet is not equipped with an FDR, and it was not carrying an ACMI pod. Much of the recorded maintenance data were lost with the destruction of the aircraft. External video and photos of the subject flight were the only record of its flightpath prior to the accident. Luckily, it was media day at the airport, and the crash was caught by video cameras from several different angles. It was decided that the aircraft position throughout the incident would be determined through triangulation.

Triangulation

Webster's defines triangulation as "A trigonometric method of determining the position of a fixed point from the angles to it from two fixed points a known distance apart." In our case, we knew where the two videographers were located, and the bear-

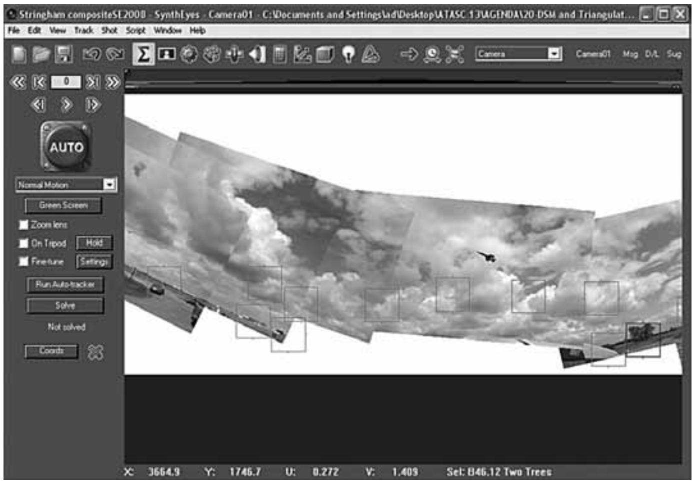


Figure 8. **Selection of features in first panorama.**

ing from each to the aircraft could be calculated by interpolating between know ground references.

The first step was to review video #1 in SynthEyes and track the center of the aircraft. Major ground features, such as the two trees and the small bush, were tracked throughout the entire video (see Figure 7, page 7).

The camera positions, as well as the tracked major ground features, were marked on a satellite image. The lat and long of each were determined and from that a bearing to each prominent ground feature was calculated using the course between points formula, which was based on the spherical law of cosines (aviation formulary by Ed Williams). It should be noted that we quickly checked these bearings with the Google Earth angle/distance function, and several minor mistakes were found and corrected.

In order to calculate a bearing to the aircraft, its position had to be interpolated between two known bearings in each frame. Unfortunately, the video rarely showed two prominent ground features in the frame. Consequently, prominent cloud features were chosen that could act as a bearing reference for the aircraft. As the clouds did not move significantly during the 30-second video, they could be used as a relatively stationary reference. These cloud features were also tracked within SynthEyes.

Sample video frames were stitched together in Photoshop to form a panorama covering all the ground and cloud references. Measurements of their relative positions were made in SynthEyes, and bearings for each cloud feature were calculated by interpolating their position between the known ground features. The bearing to the aircraft could then be calculated by interpolating between ground or cloud features.

Similarly, video #2 was reviewed, and prominent ground and cloud features were tracked. The tracker position data were saved and imported into Excel.

A panorama of the CF188 video #2 footage was also made. During the sequence, the camera was initially zoomed onto the aircraft, then zoomed out as the aircraft approached. As a result, when the stills were stitched together, they appear small on the

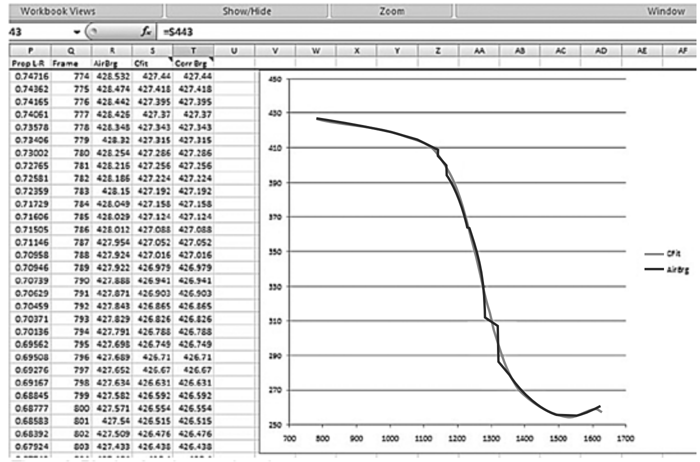


Figure 9. **Plotting bearings against time.**

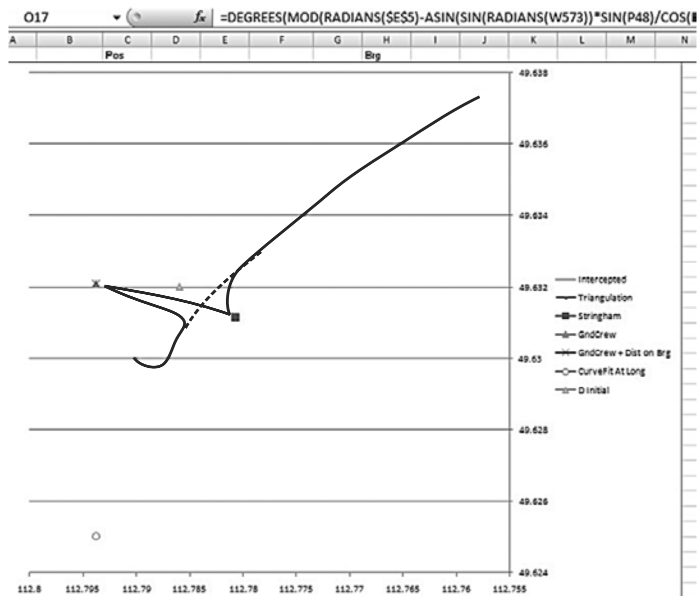
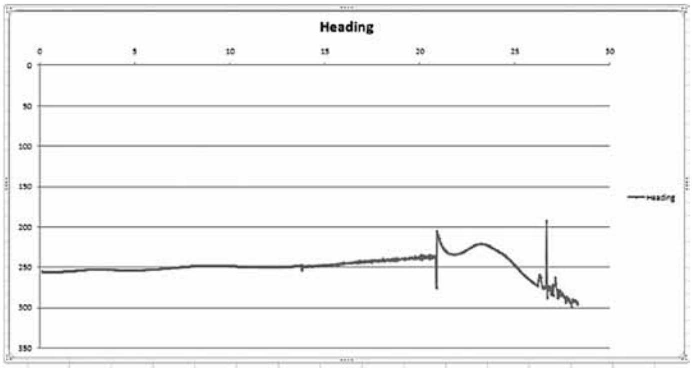


Figure 10. **Plot of lat/long position.**

left but large on the right. This did not appear to significantly affect results (see Figure 8).

In order to calculate bearings to all the prominent cloud features, the positions of the ground features in the panorama still were plotted in Excel against the calculated bearing of each ground feature. A second order polynomial trend line was fitted to the data, and the curve matched the data well. By substituting the position, x of each cloud feature into the resultant polynomial, a reasonable bearing of the cloud feature could be calculated.

The data were transferred into a spreadsheet that contained the horizontal and vertical position of the aircraft, the position of a ground/cloud reference to the left of the aircraft along with its associated bearing, and the position and bearing of a ground/cloud reference to the right of the aircraft for each frame of video. The proportional distance of the aircraft between the left and right references was calculated and applied to the two associated bearings in order to derive an estimated bearing for the aircraft. The aircraft bearings were plotted against the frame number (see Figure 9). A sinusoidal curve was fit to the data in order to smooth it. The deviations from the gray curve near frame 1,300 occurred when the camera was panned far above the



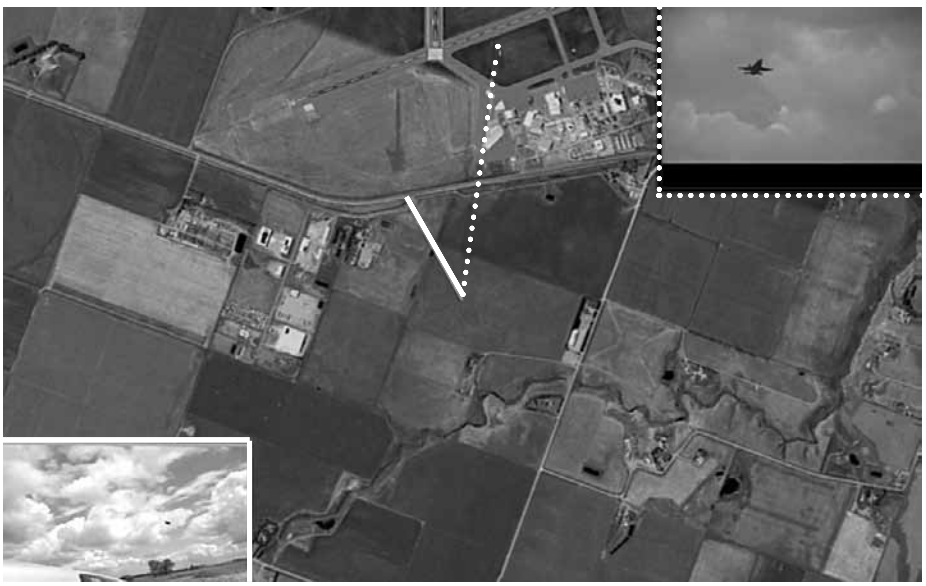


Figure 11. **Plot of heading against time (left).**
Figure 12. **Final composite visualization (below).**

horizon and may be an indication that it was not held level during that period. Regardless, reasonable bearing data were derived from the camera. The data indicated that the camera (video #1) followed the aircraft to the left then stopped and panned right near the end of the sequence. This can be verified in the footage.

For video #2 footage, the derived bearing data were even better. This is attributable to the fact that the camera was held level throughout the sequence. The graph showed that the camera steadily tracked the aircraft to the right, starting with a bearing of 77.3 degrees, until the end of the sequence. Again, this corresponds to what can be seen from the footage.

The data from the two cameras were synchronized. Frame 1574 of video #1 and frame 800 of video #2 both clearly show the pilot's ejection seat firing. As both videos were recorded at 29.97 frames per second, the data from the two cameras were synchronized. Using the lat and long of the two camera positions, the lat and long of the aircraft were calculated at each frame, using the intersecting radials formula, again based on the spherical law of cosines (see Figure 10). The solid black track clearly shows a problem near the end of the flightpath. This is caused by ambiguity. When the cameras are pointing at each other, it is clear that the aircraft is between them both but exactly where cannot be calculated by this means.

In order to address this ambiguity, an estimated path was produced and then the position along this path at each moment in time was derived. To get the path, all clearly ambiguous data were removed and a forth order polynomial curve was fit to the remainder, resulting in a curve (shown as a dotted line) that matched the data without ambiguity. Next a visual basic macro was produced that for each frame extended a line from the video #2 camera position to the polynomial curve at the calculated bearing to the aircraft. This gave a lat and long for the aircraft at each frame in the ambiguous range.

The resulting flightpath looked reasonable and matched the southwest trajectory of the actual aircraft. For the simulation, the expected heading was calculated for each frame. This was done by calculating the track from each lat/long position to the next. The results were surprising. As shown in Figure 11, they revealed a bias starting at the 20-second mark and a spike in the heading at the 27-second mark. The bias coincided with the end of the ambiguity zone previously calculated. As a result, a larger area of the ground track was removed and filled with the polynomial curve fit.

The spike in heading was found to coincide with frame 1,574 of the video #1 footage. At this frame, the tracker on the white sign clearly jumped from the center to the right side of the sign. The tracker was moved back to the center of the sign and the calculations were refreshed.

The two corrections dramatically smoothed the estimated heading. This showed how the graphs could visually lead the analyst to errors and improved the level of confidence in the process.

The data, including timestamp, lat/long, and heading, were input into the flight simulator (Microsoft Flight Simulator X). A recording of the flight was made in a top-down view. In post-processing (Adobe After Effects), a white line was drawn between the aircraft and the video #1 camera, and a dotted white line was drawn between the aircraft and the video #2 camera position. The synchronized videos from each camera were also displayed in the corners, surrounded by a white or dotted line frame (see Figure 12). The track was reviewed many times to confirm that the position and orientation to the cameras seemed correct. The visualization revealed previously unknown information. The aircraft approached the runway with a curving left turn, rather than a straight-in approach as originally thought. This makes sense, as the aircraft had circled the airfield to the left.

Developing the triangulation workflow was difficult and initially took a long time, but projects can now be done within a period

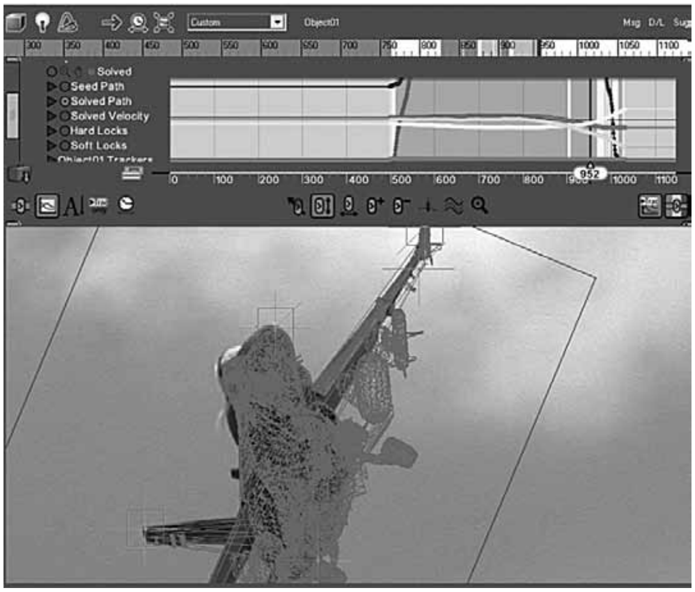


Figure 13. Matchmoving model to aircraft.

of days, using the workflows and spreadsheets. This process can also be applied to still photos, if they can be synchronized with the video. The next step will be to calculate the aircraft height above ground based on the video. This can be done by determining the camera focal length, then comparing the distance of the aircraft from the camera to the height of the aircraft image above the horizon. Calculating the focal length will be difficult but can be derived by comparing the measurements of a pick-up truck in the video to the actual measurements of the truck.

Matchmoving

Much more than position and altitude can be derived from videos. Hollywood has long used a technique called matchmoving in films to realistically add digital effects to a hand-held camera shot. In this process, the individual pixels in the film/video are tracked and the pan, tilt, zoom, and movement of the camera relative to the scene are mathematically calculated. This matchmoving process was conducted on footage of the crash to derive the height, position, pitch, bank, and heading of the aircraft for the duration of the footage.

Before the motion of the aircraft can be calculated, the movement of the camera must be derived. This ensures that a shake of the camera is not interpreted as a vertical jump of the aircraft. As the aircraft is moving independently of the camera and background, an exclusion rectangle is drawn around the aircraft so that it does not influence the trackers, which are trying to derive camera movement.

Once camera analysis is complete, the software knows exactly how the camera moved during the video—vertically, horizontally, forward/back, pan, tilt, roll, and zoom. With these parameters determined, analysis of the aircraft (object tracking) can begin.

This time, the scene is not tracked, but trackers are placed on the nose, tail, wingtips, exhausts, and other discernible points of the aircraft. A 3-D model of the Hornet is imported, and the aircraft trackers are matched to the corresponding nose, tail, wingtips, etc., on the model. The software is instructed to adjust the position, height, pitch, roll, and yaw of the model to match that of the aircraft in the video.

The software superimposes the wireframe model over the aircraft in the video so that the tracking and matchmoving can be visually validated (see Figure 13). The resulting position, height, and attitude calculated by the software can be employed as an FDR-type recording and analyzed to calculate flight parameters such as groundspeed, heading, roll rate, and other information.

Tracking and matchmoving are complementary. Tracking is useful for modeling the flightpath when the aircraft is very small in the frame. At these types of distances, matchmoving software is unable to detect changes in attitude or distance of an aircraft. Matchmoving is useful when the aircraft fills the screen and is relatively close to the camera. It can provide detailed attitude information that can be used in visualization or fused with other data, such as simulation.

Conclusion

There are ever-increasing sources of video that may capture a flight incident: cameras, smartphones, iPods, as well as security and airport ground surveillance systems. Many aircraft have onboard systems that record HUD or cockpit imagery. Analysis of even a single video can produce massive amounts of data that could be useful in an investigation. Analysis of this video imagery can be used to validate FDR flightpath data and in its absence can even replace it.

One video can provide a significant amount of information, but additional videos or photographs taken from a different location can reveal, by triangulation or other processes, more than could otherwise be found. This fusion of data from multiple sources can be further improved by combining it with data from an FDR, radar, or simulation to produce an optimal collaborative representation of the event. Even a single video can reveal the final flight parameters of an aircraft through the process of matchmoving. This data can be played back in a simulator to visualize the event from any perspective, including the aircraft cockpit. Visualization can be critical in helping to understand why an accident took place and to help others understand in order to prevent reoccurrence. Video analysis and visualization are capabilities that are complementary and have great potential to support investigation and improve flight safety. ◆

(This article is adapted, with permission, from the authors' paper entitled Hands Across the Sea: Teamwork in the Cause of Aviation Safety *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 and original 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)*

On Nov. 27, 2008, the Airbus A320 registered D-AXLA operated by XL Airways Germany crashed into the Mediterranean during approach to Perpignan Airport in the south of France. There were no survivors among the seven aviation professionals on board. Apart from a few pieces of wreckage, most of the airplane sank within minutes. The flight crew had lost control of the aircraft while demonstrating—rather than checking—the functioning of the aircraft's high angle of attack protections.

The BEA launched a safety investigation that involved several investigation authorities from around the world. In accordance with French law, a parallel judicial investigation was conducted under the responsibility of an examining judge, working with judicial experts and the gendarmerie.

This safety investigation clearly emphasized the need to coordinate and to share information, not only within the safety investigation team but also, to different degrees, with the judicial authorities. It also showed the need to take into account the right of the families of the victims to be informed as well as news media expectations. It illustrates that a safety investigation is a challenging experience, demanding not only technical skills but also effective communication in order to facilitate work with a large number of organizations.

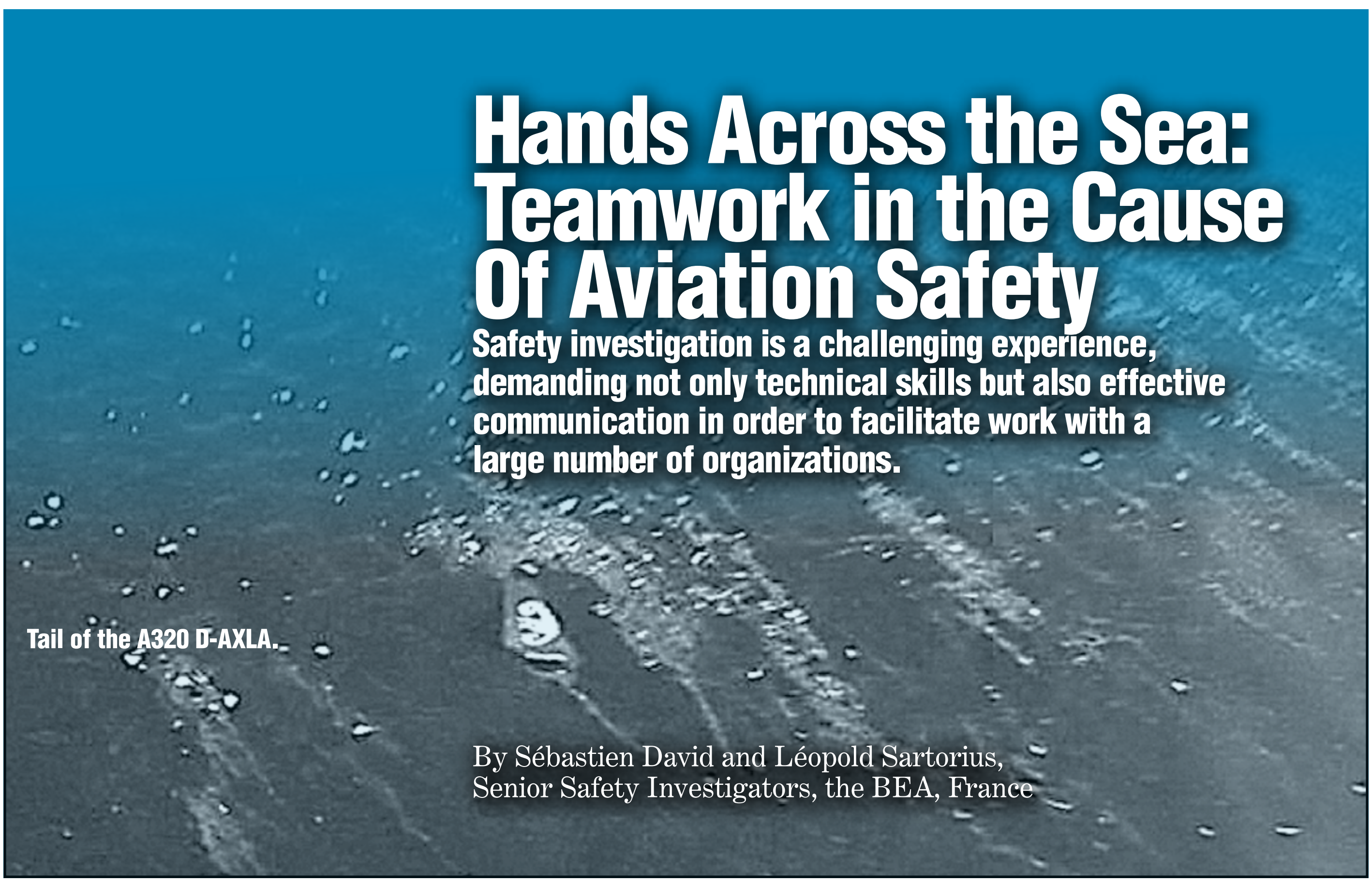
The inherent pressure linked to the accident

Over the years, the International Civil Aviation Organization (ICAO) has adopted measures to organize accident investigations and since 1994, incident investigations. The general organization of safety investigations is codified, and Annex 13 provides a framework for multilateral cooperation between States.

However, ICAO international norms and recommended practices leave room for interpretation as they have to be transposed into national laws. The interpretations made by States are mainly driven by cultural considerations, and this may result in slight differences in the way safety investigations are conducted. Because ICAO Annex 13 cannot take into account all the challenges that have to be faced, notably during the first few days after an accident, safety investigators need to adapt to unique situations.

The accident airplane was owned by Air New Zealand (ANZ) and crashed exactly 29 years after an ANZ DC-10 hit Mount Erebus in Antarctica. The Airbus A320 (Perpignan) accident, which caused the death of five New Zealanders, generated very high news media pressure in New Zealand that had an effect on the safety investigation.

In this context, the request by TAIC, New Zealand's investigation authority, to participate in the investigation was accepted by the BEA. The TAIC accredited representative asked for assistance from the AAIB and accredited representatives from the BFU, the state of registry and the operator of the aircraft. The NTSB,



Hands Across the Sea: Teamwork in the Cause Of Aviation Safety

Safety investigation is a challenging experience, demanding not only technical skills but also effective communication in order to facilitate work with a large number of organizations.

Tail of the A320 D-AXLA.

By Sébastien David and Léopold Sartorius,
Senior Safety Investigators, the BEA, France

the state of design of the aircraft's engines, also joined the safety investigation team.

As a result, five investigation authorities were associated with this investigation. The four accredited representatives were assisted by advisors from XL Airways Germany, ANZ, Goodrich, and International Aero Engines. The BEA was assisted by Airbus, the DGAC, and the EASA, as well as the maintenance organization EAS Industries. In the end, the safety investigation team was composed of about 25 people, and numerous challenges appeared because of external pressure, as soon as the investigation started.

Two investigations

If an aircraft accident in which people are fatally or seriously injured occurs in French airspace or territory, a judicial investigation is undertaken in tandem with the safety investigation. These two investigations have totally different objectives: the judicial investigation aims to determine responsibility. In France, although these two investigations are independent, they have to work with the same factual information. Regular coordination between the investigator-in-charge and the judicial authority is then needed. The safety investigation must remain objective and totally impartial and must also be perceived as such, as defined in European regulation No. 996/2010.

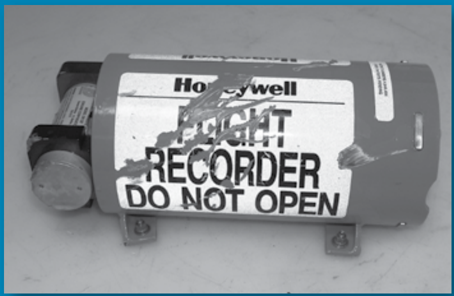
The flight recorders were found within three days of the accident and handed over to the BEA on Nov. 30, 2008. Despite many attempts to read both recorders using different types of independent equipment, we could not safely recover the recorded data.

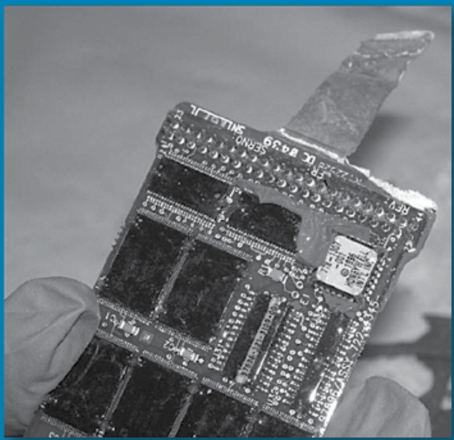
The flight recorders' electronic boards remained in the custody of the judicial authorities, whose approval was therefore needed before any work could be performed on them. After much delay, they were finally examined in the manufacturer's facilities in the United States on Jan. 5 and 6, 2009, in the context of an International Commission of Inquiry. Short circuits and damaged components were discovered on the boards and eliminated, allowing full data recovery from both recorders. The recordings were of good quality, and the whole flight was included. Nevertheless, the fact that it had not been possible to read the data from the two recorders added some pressure on the safety investigation team and hampered the progress of the investigation.

Waiting for action via the International Commission of Inquiry could also have had an effect on aviation safety. In February 2009, the Flight Safety Foundation sharply criticized the interference of prosecutors in ongoing aviation accident investigations in Italy and France, warning that such interference impedes efforts to improve aviation safety and prevent similar accidents in the future. Two months after the release of the final report, Article 12 of European regulation No. 996/2010 took effect at the end of 2010 for all European Union States and clearly takes into account this aspect. Article 12 states that if an agreement from the judicial authority is not obtained

Sébastien David *joined the BEA Engineering Department in 1998 to initially work on flight recorder readouts and performance studies. He now works as a BEA senior safety investigator and has participated in many major investigations as investigator-in-charge or accredited representative, as well as working group leader for the human factors group during the investigation of the Air France A330, Flight 447 accident. He has a CPL, is type rated on the Dassault Falcon 7X, and has a masters degree in human factors.*

Léopold Sartorius *joined the BEA Engineering Department in 2002. Initially he was involved in the development of the BEA's in-house flight data analysis software. Since 2003 he has participated in many international investigations as accredited representative and as working group leader for the systems and flight recorders groups during the investigation of the Air France A330, Flight 447 accident. He is now head of the BEA Flight Recorders and Avionics Systems Division. He has a PPL and a masters degree in human factors.*





FDR CSMU (above). FDR electronic board (right).

"within a reasonable time and not later than two weeks following the request, it shall not prevent the investigator-in charge-from conducting the examination or analysis" of the flight recorders.

Need for cooperation and technical partnership

Apart from the pressure linked to the news media, the judicial investigation, and all of the organizations involved in the safety investigation, the context of the flight also made the investigation more complex.

During a typical scheduled airline flight, the management and the conduct of the flight are well defined by procedures and teamwork. This accident occurred during a nonrevenue flight, in the context of returning to its owner, ANZ, an A320 leased to XL Airways Germany. The leasing agreement specified that maintenance and painting operations would be carried out, as would what was called a "test flight."

Further, the agreement established that the program for these flights should be in accordance with "Airbus check flight procedures." However, it became clear that check flights of this type are not described in the manufacturer's manuals or documentation. ANZ submitted a program to XL Airways Germany of inflight checks developed on the basis of the program used by Airbus for customer acceptance flights. The airplane transfer flight, in May 2006, for its delivery to XL Airways Germany, had already been based on this ANZ program, which was to be used during the flight before return to ANZ.

It could easily be believed that when a final report is published, the safety investigation is closed. In reality, issuing safety recommendations represents the beginning of a new shared process, even for the investigation team.

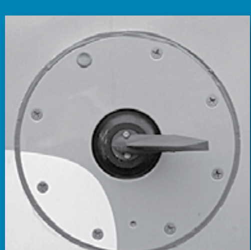
The flight crew consisted of two qualified pilots from XL Airways Germany. However, they did not have the training or experience required to perform the planned flight program, even if this was not defined as a test flight. An ANZ pilot, who was in the cockpit, participated actively in following the program of checks. This program specifically included checking how the high angle of attack protections functioned but was not identical to the Airbus program concerning the altitude range at which this check should be carried out.

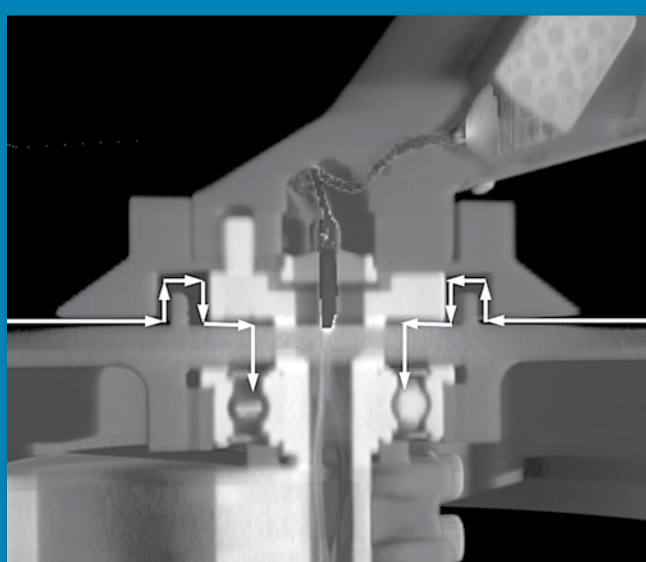
The maintenance and painting work had been carried out and checked on the premises of an approved EASA Part 145 workshop, EAS Industries. In order to eliminate the dust that had settled on the fuselage, a rinse with cold water was completed three days before the accident without following the applicable procedure and specifically without protecting the angle of attack sensors.

Takeoff: 15h44, Nov. 27, 2008

In France, flights of a specific nature are subject to advance permission from ATM services, without which the flight may be subject to real-time modifications or may be refused. The official AIP request procedure was not followed, though the captain had informally asked Perpignan ATC on the morning of the accident if the planned flight required specific airspace. The Perpignan TWR controller suggested that this was not necessary. However, during the flight, the French southwest ACC controller refused the requests from the crew to perform some maneuvers because the filed flight plan did not include them. The crew then adapted the program of checks in an improvised manner according to the constraints imposed by the flight plan and ATC.

Two of the three angle of attack sensors, located symmetrically on each side of the fuselage, stopped moving at identical values during cruise when water present inside the sensors casing froze. It was later demonstrated that applying a high-pressure jet of water onto an airplane without following the recommended procedure can cause a small quantity of water to penetrate into an angle of attack sensor, which when frozen would be sufficient to block the sensor.





Above: Angle of attack sensor on aircraft. Right: Route of water penetration following specific rinsing conditions.

Above: Amount of ice in the housing of the angle of attack sensor after the water exposure test.

Water exposure test performed in the context of the investigation

At an altitude of about 4,000 feet during the approach, the crew improvised the check on the angle of attack protections in normal law. However, the blockage of the two angle of attack sensors at identical values had inhibited the functioning of these protections and led to an erroneous display of the characteristic speeds identifying these protections.

The crew reduced thrust to allow the speed to decrease and, somewhat passively, waited for the protections to trigger. The stall warning eventually sounded, in normal law, at an angle of attack close to the theoretical stall angle of attack in landing configuration, indicating that the third angle of attack sensor was functioning at that time. The captain reacted in accordance with the approach-to-stall technique by increasing engine thrust and reducing longitudinal pitch.

Shortly after this, the flight control law changed from normal to direct. The autotrim system, which had progressively moved the horizontal stabilizer to the full pitch-up position during the deceleration, was no longer available. Under the combined effect of the thrust and the increase in airspeed, the airplane was subject to a pitch-up moment that the captain was not able to counter. He did not make any inputs on the trim wheel nor command a sustained engine thrust reduction. He lost control of the airplane, which after reaching a pitch attitude more than 50° nose up and climbing about 1,000 feet began to descend and eventually crashed into the sea.

Promoting a comprehensive systemic approach

For many years now, a systemic approach has been adopted when conducting safety investigations in order to "identify the underlying causes in the complex air transportation system" (ICAO Circular 240-AN/144). The D-AXLA accident resulted from a combination of factors, including

- latent failures, which existed since well before the accident, and
- active failures, whether a few days before or in the last few seconds of the flight, during painting operations and planning, preparation, management, or conduct of the flight.

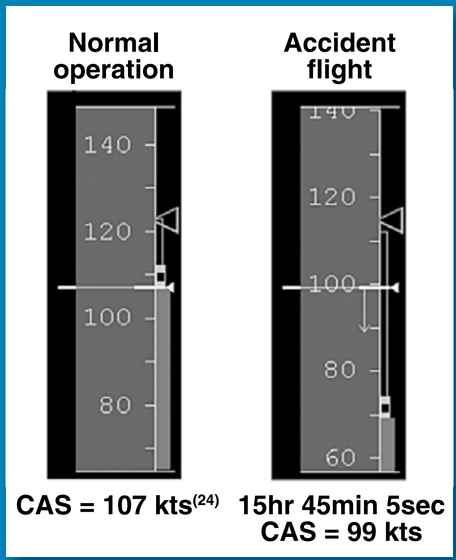
The actions and decisions of the crew during the accident flight revealed, in particular, these latent failures

- the decision in 2006 to perform so-called "test flights" for the handover of the airplane within the framework of the leasing agreement,
- the decision to use a manual used by Airbus for A320 customer acceptance flights as the reference to draw up the program described in the leasing agreement,
- a lack of training specifically adapted to this type of flight,
- a lack of regulations regarding nonrevenue flights, and
- a deficiency in the qualification process for onboard equipment.

The inappropriate rinsing of the airplane at the end of painting operations was an active failure that revealed a latent failure in the equipment qualification process. Indeed, it was noted that for impermeability tests, undertaken for the qualification of the equipment, the installation conditions could be different from those on the airplane. Even if this difference with real operating conditions was not a contributing factor in the accident, it certainly constituted a safety loophole.

Accidents seldom originate exclusively from errors by frontline operators, but accident causation usually concerns a limited number of components in the air transportation system. For example, an accident can be qualified as an "operational accident," and the systemic approach consists mainly of finding the interaction of latent and active failures within the operational area.

In the case of the atypical nature of the D-AXLA accident (airplane of French design, equipped with American angle of attack sensors, operated by a German airline, and owned by a New Zealand operator), the systemic approach to the investigation required continuous coordination among all investigation authorities and organizations involved in the safety investigation. It also required sharing all available information and regular consultations. The investigation authorities and the operators, manufacturers, and regulators all had to work together extensively.



Accredited representatives and their advisors, therefore, all participated effectively during the investigation process. For the consultation phase, they contributed to the quality of the final report.

Publication of the final report

Wishing to be as effective as possible, the BEA sent the draft final report out for review and planned a three-day meeting with all the accredited representatives (without advisors) at the end of the 60 days to discuss initial observations.

A few days after this meeting, an amended draft final report was sent to the accredited representatives, who were asked to respond with official comments as soon as possible. The aim of this shared process was to ensure there was no misunderstanding in the draft final report or in the comments received by the BEA. This resulted in the final report being improved by consensus. Only one comment had to be appended to the final report.

This clearly demonstrates the need for technical and communication skills in order to facilitate work with an investigation team made up of a large number of international organizations. It demonstrates to the international community that a joint effort by all the investigation authorities involved (the AAIB, the BEA, the BFU, the NTSB, and the TAIC) benefits the cause of aviation safety. It also underlines the content, the recommendations, and the lessons learned from the investigation, compared to a report with many appended comments.

Two years after the D-AXLA accident, the EASA issued a Safety Information Bulletin on "Functional Check Flights," an example of nonrevenue flights, which was also the subject of a Flight Safety Foundation symposium and actions from aircraft manufacturers.

The consultation phase showed cultural differences between investigation authorities. ICAO Annex 13 does not clearly detail the exact consultation process. The BEA only provides accredited representatives with the draft final report, and only they make official comments. They may consult with their advisors before commenting. Nevertheless, this case showed that a State might relay others' comments on the draft final report, such as from families of victims or lawyers.

Of course, families of victims also need to be informed on the progress of the investigation, which the BEA strived to do. This resulted in presentations on the conclusions of the investigation being developed by the BEA in coordination with the BFU and the TAIC in order to be presented to the victims' families in Germany and in New Zealand the day before the official publication of the final report.

It could easily be believed that when a final report is published, the safety investigation is closed. In reality, issuing safety recommendations represents the beginning of a new shared process, even for the investigation team. Follow-up necessarily implies that the investigator-in-charge must be kept in the safety loop.

Four safety recommendations were issued in the D-AXLA final report. These dealt with nonrevenue flights, equipment qualification, consequences of reconfiguration of flight control laws, and approach-to-stall recovery techniques and procedures. Of course, issuing a safety recommendation does not necessarily mean that action will be taken.

Regarding the recommendation on nonrevenue flights, the BEA and the AAIB—after a serious incident that occurred during such a flight in England—took coordinated action in jointly demonstrating to the EASA the need for better oversight of those flights.

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Human Factors Standardization In Safety Applications

The author presents a conceptual proposition for developing standardized human-factors-based synergistic strategies in the operation of an airline, its aircraft, data collection and analysis, and investigation of incidents and accidents to improve the safety culture.

By Helena Reidemar, a B-757/767 first officer at a major airline

(This article is adapted, with permission, from the author's paper entitled Human Factors Standardization In Safety Applications *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)*

Human-factors-attributed aviation accidents and incidents have remained high and constant for the past several decades despite increasing efforts and interest in the subject by government, the private sector, and the research community. Aerospace and aviation technologies have had great success in developing highly reliable, sophisticated, and automated aircraft, but the statistics for pilot/human error have not shown any signs of decreasing. In 1995 the FAA published *Human Performance Considerations in the Use and Design of Aircraft Checklists*. This paper outlined the best combination of available human factors research to date for checklist design, but seemingly it never gained widespread use or acceptance.

Manufacturers create their own in-house checklists and procedures, while all airlines streamline checklists and procedures to suit their specific operation. Throughout the manufacturing industry, teams of experts within the human factors realm are employed to develop the manufacturers' products, but the actual use and operation of those products is determined by the individual airline. Today, this means that every airline operates differently, and though there are guidelines and recommendations, there is no requirement to adhere to them. The Certificate Management Offices (CMOs) of the FAA have no official directives to enforce human factors best practices, nor has there been an emphasis on training and education for the FAA field agents.

There is growing awareness of human factors concepts and principles showing that, at a minimum, contributory causes are identified in nearly every airline accident and incident in recent memory as having substantial human factors implications. The aviation industry will have to look to interdisciplinary human factors science and technology for answers, and then for a solution to reduce the human-performance-related events. The human factors standardization solution will be able to provide much greater data integrity and quality for safety departments and organizations looking at risk indexes and matrixes, as well as industry comparisons and accident investigation tools.

Initial steps in the process of creating a human-centric philosophy in the organization should be to embed the human factors requirement within the Safety Management System (SMS) program. This is a pilot program that is focused on the safety of the operation and is supported through safety reporting programs that essentially collect a great deal of human factors data, in addition to many other parameters. The SMS program requires a risk management program that identifies hazards and mitigation strategies and involves a closed-loop process to communicate and redistribute information to the pilot group. The quality-assurance aspect of this program could be greatly improved by including a human factors standardization solution. Policy within the SMS program should include the requirement to have a human factors expert analyze safety information collected through the safety reporting programs and then bring this information to the procedural development programs' fleet experts and technical writers.

In order to promote this type of safety culture at an organization, it has to be embraced from the top down. In many organizations, this is done through education and regulation. The vision statement of an organization needs to directly and clearly define the philosophy of the operation. Human factors language and principles can provide the necessary links in this mapping strategy. This organizational philosophy guides the development of procedures so that even in the absence of a policy in every situation, a well-articulated philosophy will still permeate operationally.

The organizational culture molds procedures, and this should be consistent throughout all levels of management so that there is always unambiguous guidance. An explicitly articulated process connected and driven by data for the development of procedures to ensure clear, coherent, consistent, and comprehensive methods is a cornerstone of effectively balancing practical and reasonable procedural development. If the process through the operating system is standardized, the outcome will therefore be standardized. By adopting general human factors concepts as foundational while appreciating the complexity of the environment, in the operational design of procedures they can become linear, predictable, and controllable.

Utilizing a common language and framework of human factors principles as guidance eases modification to reflect the needs of an organization to significantly improve the risk management process. A common problem in organizations today is the absence of an adequate connection between safety data and procedural improvement based on that data, due to historic and cultural barriers. These types of issues can only be overcome through education and the understanding of the massive contributions available through embracing a human factors approach.

Educate and train

There is presently a need to educate and train the FAA field offices and CMOs in interdisciplinary human factors concepts. Through education, this application process of human factors can become part of the design. In the future, there will be a necessity for air carriers to employ their own in-house human factors specialist for both procedural development issues and training. This expert can advise in the developmental aspects as well as the analysis of safety-related issues as they arise in the operation.

Once human factors guidance becomes the norm for the industry, there will very likely be a marked decrease in issues of pilot/human error. According to published research, a large air carrier conducted a thorough human factors analysis of its procedures and checklists, resulting in considerable time and effort spent to update them to reflect the best human factors concepts and research. Reportedly, the airline showed an 80 percent improvement in performance after the implementation. This example definitively demonstrates the potential of this type of approach.

By using rigorous human factors intervention strategies and scientific, systematic methodologies in the developmental process by presenting a common language and framework with awareness of biases, conflicts, and constraints, one could resolve many issues investigators are faced with today.

Since today every airline has a different operating environment, it is difficult to measure data points in the investigative process. Creating a basis for standards would allow analysts a premise for evaluation. Accident investigations would be simplified because a common procedural benchmark would be established. Programs for measuring data between air carriers would be able to provide more meaningful comparisons and would support the entire industry.

Once human factors guidance becomes the norm for the industry, there will very likely be a marked decrease in issues of pilot/human error.

Supporting the problems of human performance as a core technology through effective transfer of human factors knowledge and information is imperative as this plan moves forward. Also needed is a broader understanding and acceptance to managing human errors through multidisciplinary human factors strategies, with a focus on the science.

Essential elements of a program should

1. determine specific human factors principles that will enhance safety and efficiency.
2. provide new or enhanced methods and techniques to measure, assess, and improve human performance in the cockpit environment.
3. determine system needs and methods for information transfer among crewmembers, ATC, support organization, and analysis functions.
4. define how standardized human factors management and embracing error resistance techniques in procedures can best be applied and integrated to enhance safety and efficiency.
5. assess training needs and develop improved techniques and strategies for selection, training, and evaluation of pilots, instructors, and support staff.
6. develop standards, methods, and procedures for the training and validation of pilots and the human factors support staff. This will ensure the validation of human engineering in the design, testing, and implementation of any operational element.

The existing body of human factors knowledge, data, and methods for assessing and predicting human performance

***Helena Reidemar** is currently a B-757/767 first officer at a major airline. She has chaired the ALPA Human Factors Committee at two major airlines for a combined total of 10 years. In this capacity, she has conducted the human factors portion of internal investigations and has also been a member of the ALPA go-team. She is a coordinator for her airline's Critical Incidence Response Program, where she evaluates daily events to determine the need for crew contacts for potential post-traumatic stress disorder and also acts as a peer support volunteer in this work. She is also a member of ALPA's national Human Factors Committee. A long term ISASI member, she joined as a student member 15 years ago while getting her master's degree in aeronautical science.*

needs to be expanded. The requirements of flight crews in this increasingly complex aviation system must be specified. Methods must be developed for the transfer, management, and integration of strategies necessary to reduce the chance of an accident due to human error.

If all airlines—regional network carriers, large network carriers, and cargo airlines—regardless of mission, adhered to standardized human factors principles with consistent mapping among philosophy, procedure, and checklists, the investigation and analysis of incidents and accidents would be dramatically simplified.

Training is the cornerstone of the human factors approach. Training of the entire system starts with a shift in the organizational culture to embrace this new approach.

The listing shown in the adjoining sidebar serves as examples of standardization in procedures and checklists. As the list clearly indicates, safety programs can no longer exist in isolation, moving away from compartmentalizing and separating operational aspects. They must create a trajectory for the future of safety in aviation through a synergistic approach using human factors as the fusing mechanism. Building a system that uses data to generate improvements in the procedural and checklist applications is a necessity.

Improving analysis capabilities

Better data quality and integrity would significantly improve analysis capabilities. This new level of consistency will decrease insulation and can then inspire better quality investigative techniques. A majority of larger incident and accident investigations today do not include a human factors group. This can be considered an oversight given that every aspect of an accident needs to be thoroughly investigated, particularly when acknowledging the frequency that pilot actions or inactions are named as a probable cause. Perhaps human factors technologies, a fairly new science, hasn't been fully accepted as an equal player in the accident investigation community, but how can human factors then be so frequently named as a contributory factor in accidents and incidents?

In order to institutionalize human factors sciences in our safety lexicon throughout the aviation industry, one has to take an in-depth assessment of training programs. There is a great deal of research in training practices, but this highly technically skilled industry requires specific methodologies. "To fly airplanes safely, a person must learn how to process a flood of stimuli arriving from separate sources, identify which among them to attend to, generate from a repertoire of discrete procedures an integrated plan for responding to the relevant stimuli, and perform a series of discrete acts, such as positioning levers, switches, controls, and continuous manual control movements requiring small forces and adjustments based on counter pressures exerted in response to the control movement." (Pohlman & Fletcher, 2010, page. 21).

Future training programs need to be expanded, instead of the ever-decreasing training footprint we are now just starting to realize the effects of through recent high-profile accidents. As automation interactions become increasingly complex, future training needs will have to be expanded.

The national airspace system is moving forward to next-generation technologies. ADS-B will revolutionize the manner in which we operate aircraft and expand multidimensionally. This evolution will certainly require a human-factors-devised approach to usage and training. Information integration through new technologies will require not just a renewed effort to maintain manual flying skills, but also methods of handling the increased cognitive load. To understand the interactions required, it is necessary to appreciate the true ability of the human at the center of the interface. This can only be done by characterization of the environment through human-environment equilibriums. Training this confluence of skills is not a simple process. It needs salient and visceral procedures and processes.

To ensure greater success, a necessary aspect of this process is the data collection techniques used to ascertain efficiency and usability. New and inventive methods of soliciting this information are imperative in this process. The synthesis of known training techniques and methods in conjunction with out-of-the box thinking from traditional training programs will be required. The benefit of most human-factors-based programs and processes is their innate logic, which can synchronize what makes sense intuitively and identify and then negate design errors.

Through the proliferation of a global human factors perspective, the genesis of the next generation in aviation safety can emerge. Here is an example of a specific problem: As we have moved into more technically evolved aircraft, pilot monitoring skills have been revealed as problematic. But through human factors processes, we can develop strategies and organize information in ways to aid in mitigating this emerging issue.

Training is the cornerstone of the human factors approach. Training of the entire system starts with a shift in the

Examples of Standar

1 An evenly and equitably distributed workload between pilots—including a preflight that is correctly populated and appropriately intuitive and that is standard, linear, and predictable for each flight.

2 Checklists that are set up by logical flow patterns that follow how the task is actually conducted and specifically does not move around erratically or illogically.

3 Checklists that are limited to critical safety items.

4 Checklists with specifically named switch positions, i.e., elimination of checked/set/on/off style of responses unless accurate for that switch.

5 Elimination of split checklists that require returning to a checklist after completing one or more sequenced items. This is not a read and do list.

6 A flap setting procedure that involves actions or verbalizations of both crewmembers that is initiated by a robust and specific cue and is followed by a checklist item that references the data source, the flap handle, and the gauge.

7 Reduction in the number of checklists by consolidation. For example, the taxi checklist items can be done prior to taxi. Configuration

dization in Procedures and Checklists

items such as flaps, trim, and power setting can reside in a before-taxi checklist to verify these items.

8 No ACARS nuisance calls or interphone communications between the cockpit and cabin during taxi prior to takeoff unless there is a problem or the cabin is not prepared for takeoff.

9 A before takeoff checklist that is concise and will always be conducted prior to crossing the runway hold short line, containing only safety critical items, ensuring proper runway/departure selection.

10 A quick reference guide containing a specific minimum of critical items. Briefing cards for all approaches should be included.

11 No checklists should be conducted during high workload times, for example, competing task demands will always make taxiing a high workload time.

12 A specific requirement to have defined primary items and secondary items of criticality, with specific guidance to have both crewmembers focused only on primary items when they occur.

13 One simple stabilized approach criteria with specific guidance when a go-around is required, and the clear authorization that when the pilot monitoring calls for a go-around, regardless of seat, that the pilot flying must comply.

14 Ensuring that all checklist items that are configuration-related are responded to by both pilots, including arming the spoilers.

15 A manual system with "standard text" established for all fleets at airlines with multiple fleets so that maximum commonality exists.

16 A standard operating procedures with the recommended and approved best practices section in the normal procedures manual that explains the linear time flow of events for a flight including cues/triggers for flows, commanded items, and checklists.

17 To provide quality assurance of all procedures, a human factors expert employed by the company who ensures best practices for every aspect of the operation, procedures, checklists, tools (weight data format, flight releases, takeoff data, flight planning, weather, electronic flight bags).

18 Continuous auditing ASAP/FOQA/LOSA programs to identify human factors weaknesses in the system and to address them through a standard process developed in the SMS program.

19 A crew resource management system that expands on the current approach by addressing the value of respect and judgment of the other pilot rather than a singular focus on command at the expense of a cooperative environment.

20 A manual system that ensures logical placement and easy access to information.

21 A flight operations process that strives for continuous improvement by studying incidents and events with regard to procedures and checklists, i.e., What role did the procedure or checklist have in the incident? This moves away from a punitive environment that does not solve the problem.

22 Developing strategies that improve (pilot) monitoring skills.

23 An automation policy that reflects the most recent research and information. This should be studied with regularity as automation use and design are continuously evolving.

24 As new technologies are introduced to the flight deck, the human factors expert is involved with expanding the new role at the airline and with training development. ◆

organizational culture to embrace this new approach. Once the system is in place to support the evolution of this new operational concept, a new era of safety in aviation operations is ensured.

To gain this assurance, every part of the system will require training and education. Last in that change process is the pilot group that operates within it. Government agencies, particularly the FAA and the NTSB, will need to be at the frontlines of this movement. The FAA in its oversight role can require rigorous human factors intervention strategies at every level of the operation through the SMS risk management directive.

Additionally, the FAA needs to establish a detailed human factors education program for its field officers. There is a great deal of human factors research conducted by the FAA. This needs to filter down through the organization to the field offices and certificate management offices, principal operating inspectors, and evaluators.

Leading by example, the NTSB can create greater awareness of systemic human factors concepts by generating attention for this science and investing far more time and effort into the human factors specifics of every investigation—addressing it as a stand-alone item rather than attaching it to other parts of an investigation.

Formalizing the human factors process is not an immediate possibility, but rather a long-term goal. Taking the initial steps toward achieving this is solidly within reach. The training of an organization is a slow process but can be moved along expeditiously by radical improvements in safety metrics. Cost benefits over the long term can be a huge motivator, but how do we monetarily quantify accidents that don't occur?

That question has mystified safety professionals for many years. The answer may lie with our insurance companies; they quantify statistics and determine risk probabilities. If insurance company analysts and underwriters were educated about the potential savings of a human factors approach to the operation, in all likelihood they would reward human-factors-compliant customers with potentially significantly lower premiums. Airline management would likely be in a rush to

(continued on page 30)

(This article is adapted, with permission, from the author's paper entitled Timeliness, An Investigator's Challenge *presented at the ISASI 2011 seminar held in Salt Lake City, Utah, Sept. 13–15, 2011, that 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)*

Timeliness

An Investigator's Challenge

The author explores several theoretical notions regarding dynamic behavior, systems states, and safety enhancement interventions. The dimension of time is explored in its practical application as a diagnostic dimension to be applied in safety investigation theory and practices.

By John Stoop, Lund University, Sweden, Delft University of Technology, the Netherlands

Persons in the academic community who are interested in accident investigation theory and practices debate the use and usefulness of accident modeling. Based on methodological grounds, the use of generic and linear models such as the Swiss Cheese model are criticized, if not rejected all on theoretical grounds, by J. Stoop and S. Dekker, among others. Instead of modeling accidents, a systems approach is favored in not only dealing with the event itself, but also in dealing with higher systems levels, taking into account chaos and complexity notions. Such a dynamic systems perspective should be applied in the forensic phase of an investigation as well as in the analytical phase, bearing consequences for the eventual recommendations and the nature and scope of the subsequent safety measures.

Sophisticated system theories and change management concepts are mobilized to provide a trustworthy explanation of the occurrence, based on the safety criticality of the factors that emerge from the investigation of the event and the analysis of the aviation system itself. To achieve a sustainable improvement in the aviation system's safety performance, Stoop and Dekker propose a synthesis of safety critical factors into credible and plausible accident scenarios. Such scenarios may serve as critical load cases to test and validate safety solutions, which are designed based on recommendations formulated during accident investigations. Such a systems engineering perspective focuses on the dynamics of the event itself in the context of the system's design and operating conditions. Other perspectives, however, focus on the resilience of organizations within the system to enhance safety performance, adding a recovery potential from critical loads that are considered emergent properties of systems. Both perspectives deal with a specific class of systems, the so-called Non-Plus Ultra-Safe systems.

These two perspectives stem from different paradigm in the scientific community, emerging from either the socio-technical disciplines or the socio-organizational disciplines. In safety thinking, three consecutive paradigms have been developed that exist concurrently in practice—

• A technical paradigm, based on the load concept, dealing with failure, cause, and design envelopes. This load concept has evolved from mechanical loads toward mental loads and from a deterministic, analytical approach toward a probabilistic, reliability, and availability modeling. The concept deals primarily with engineering design of technical system components in establishing a design and performance envelope that deals with reliability, redundancy, and robustness.

• A medical paradigm, based on the transfer of hazards as a specific type of "disease" and the consequences of an exposure to this disease. This exposure concept focuses on (re-)gaining control over the exposure, minimizing losses, and reducing deviations from standards in performance indicators. The concept primarily deals with control over operational performance from a managerial perspective by preventing deviations from a normative performance level.

• A biological paradigm, based on a mutual and dynamic adaptation of an agent and its systemic environment. This adaptation is based on feedback and achieving transparency over the primary processes of an organization by responding to emergent properties during operation by monitoring, anticipating, and learning. The concept focuses on recovery from disturbances outside the operating envelope by adhering to a systems engineering approach in designing properties into the system, such as recovery, resilience, reliance, rescue and emergency, reintegration, and rehabilitation.

Technological complexity

Systems with a very high level of technological complexity, in general, also require a very high level of safety performance, such as in aviation, maritime, railways, process industry, and (nuclear) power supply. Current safety enhancement strategies aim for complete elimination of technical breakdowns and human error. However, such strategies separating technological design engineering from human and social intervention seem to have reached their limits. The addition of new strategies to the exist-

__John Stoop__ graduated in 1976 as an aerospace engineer at Delft University of Technology and earned his Ph.D. on the issue of safety in the design process. He is a part-time associate professor at the Faculty of Aerospace Engineering of the Delft University of Technology and is a guest professor at Lund University (Sweden). Stoop has completed courses in accident investigation in the Netherlands, the U.S., and Canada. He is an affiliated member of ISAS, and has been actively involved in accident investigations and has been a safety analyst in maritime, railway, and aviation accidents.

ing arsenal seems to lead to overextensive linear extrapolation of protective measures.

On one hand, more sophisticated mathematical modeling and knowledge-based engineering principles are developed to cope with the complex interrelations between systems functionalities and embedded subsystems architecture. These principles are based on neural networking, Bayesian belief, and semantic networks. On the other hand, from a sociological perspective, a more encompassing integral approach seems to become inevitable by introducing concepts such as resilience engineering.

These developments have demonstrated a gradual shift in systems modeling, which can be expressed as a transition from accident investigation, via static systems modeling, toward dynamic systems modeling. Such a shift in systems modeling should coincide with a shift in paradigm in safety thinking in order to coordinate the integration of safety into these new systems modeling perspectives (see Figure 1).

Safety as a system state

Through this new conceptual thinking in complex and dynamic systems, safety can be considered a system state—stable or unstable, safe or unsafe. While safe and stable system states assess safety a noncritical value, unsafe and stable system states identify safety as a critical design and operational value, which has to be designed, managed, and controlled carefully to avert disaster. Providing transparency over the actual systems behavior becomes pivotal in such critical and unsafe system states. This transparency appeals to the previously mentioned transition in safety investigations to provide a timely transparency in the factual functioning of the system.

A combined transition in safety investigation and systems modeling has the potential to provide a generic and basic methodology and investigation notion for all kinds of investigations across industrial sectors and scientific domains. This transition serves to identify safety-critical knowledge deficiencies and establishes a working relation between forensic engineering and knowledge-based engineering design. This concept of safety investigations enables the transition from decomposing an event into isolated accident causation factors to a representation of the actual system state by identifying accident scenarios as the actual system state vector. In such a transition, two major changes have to be taken into account in order to establish the actual system state. A shift in focus occurs from the practical level of analysis

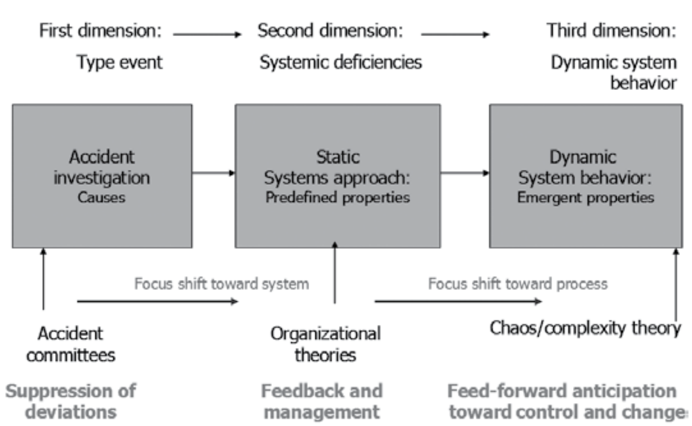

Figure 1. A third systems dimension.

to a methodological level, mobilizing new scientific concepts and theories and a merging between the socio-technological perspective and the socio-organizational perspective.

Safety-enhancing interventions can be categorized into two main classes, complying with a systems perspective—

- linear interventions and first-order solutions. Simple problems allow restricting the design space. This is valid only if the number of solutions is small, the number of design variables is small, their values have limited ranges, and optimizing within these values deals with sacrificing aspects among the limited set of variables. Such interventions reinforce the design space in the detailed design phase by reallocating factors, more stringently complying with rules and regulations, eliminating deviations, and being applied to simple, stand-alone systems.
- complex interventions and second-order solutions. Complex dynamic problems demand expansion of the design space. Such solutions focus on concepts and morphology; reallocating functions to components; reconfiguring and synthesizing sub-solutions, and involving actors, aspects, teamwork, communication, testing, and simulation. Such an expansion of the design space occurs in the functional design phase by developing conceptual alternatives and prototypes applicable to complex and embedded systems.

When first-order solutions have failed and do not prevent an event, a redesign of the system becomes necessary. To achieve such redesign, the event must be redefined in terms of engineering design methodology, identifying critical design aspects. In complex and dynamic systems, time is a critical aspect. A combined socio-organizational and socio-technical design strategy requires a systems design approach at the functional level to design system properties into a solution space.

Modeling, a challenging issue

Systems theory has seen rapid developments over the past two decades. Yet, the dynamics of socio-technical and socio-organizational systems and the interactions between system components and aspects are hard to model.

Historically, accident investigation has served either to provide proof in a judicial procedure to allocate blame and liability or to identify systemic and knowledge deficiencies in order to learn from mishap.

Distinguishing these two goals is pivotal to ease the drafting of recommendations for improving the safety performance of a system, process, or operator.

In conducting independent and blame-free investigations, a conceptual shift is made in the investigation process itself from finding the truth toward achieving or regaining trust in the safety performance of a system.

Truth finding serves the goal of allocating responsibilities and, consequently, accountabilities. Establishing an undisputed sequence of events by a credible, plausible, timely, and knowledgeable description of the event should create a starting point for understanding the failure phenomenon and sustainable change in a system. Such a shift from truth toward trust also changes the outcomes of an investigation (see Figure 2, page 22).

Instead of identifying the causal factors in order to establish the liable involvement of actors and their motives during the event, the operational performance of the system becomes relevant in the potential change toward a safer performance

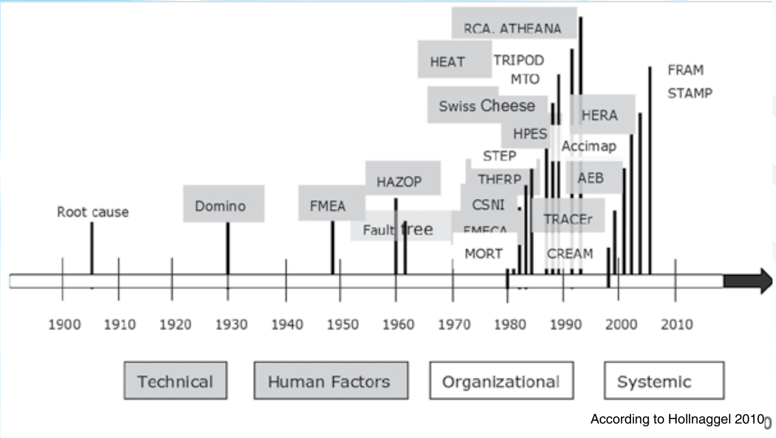

Figure 2. Organizational accident model development.

and toward the ability to learn from undesirable disruptions. Systemic deficiencies and knowledge deficiencies become the critical issue in system change and knowledge development. Consequently, increasing numbers of mixed accident causation and systemic models have been developed.

To enable such a change from event to system, two transitions in the investigation process are critical—

• A transition from descriptive variables and their causal relations as the answer to the what and how necessary and sufficient conditions were present for the event to occur toward explanatory variables that provide an answer to why the event could occur. This is the domain of forensic sciences—evidence-based and case-based learning.

• A transition from explanatory variables toward control, change, and design variables. Such a transition shifts the focus from influencing safety dimensions toward systemic dimensions and knowledge development. It adds a systems engineering perspective to identifying available solution space for safety enhancements. This is the domain of knowledge-based engineering, simulation, and dynamic modeling.

The dynamics and interrelations in such a systems perspective play a very important role in such modeling, but have seen relatively little attention in the modeling process or are in a very early phase of theoretical development. This has raised interest in the dynamics in the accident process as a critical dimension in accident investigation methodology. Consequently, the dimension of time in the investigation process and in event analysis becomes critical as an input parameter for redesigning the system

The dimension of time

A study into time dimension in the investigation process reveals several steps where such modeling will be beneficial for enhanced understanding of the accident phenomenon and a systems response to the occurrence, such as

• analyzing human factors, with respect to the skill, rule, and knowledge level of decision-making at the individual and crew level.

• exploring the temporal and spatial state of the system and perceivable changes of systems states during the occurrence.

• recovery and resilience capacity with respect to a safe completion of the mission and early detection and analysis of safety performance indicators, events, and incidents as precursors to occurrences and accidents.

• incremental change in actual operational use versus intended and designed use of technical and organizational resources as a cause for potential drift into failure.

• validating and testing strategic points of no return as a precautionary principle in designing missions, routes, policy-making procedures, operating procedures, and operator task loads.

Based on a series of accident investigations, the dimension of time is explored on a case base level in all modes of transportation.

Operator level time restraints

With respect to analyzing human factors at the operator level, a systemic collection of data is required to analyze to what extent, and how, tasks can be prone to error and where interference of tasks may lead to incidents and accidents. These questions have been addressed in the design of road systems for several decades. A designer needs to know which rules or combination of rules should be avoided. More specifically, What errors may arise when drivers conform in their behavior with particular rules or designs?

The answers create a need for cognitive psychologists to translate their human error rules such as GEMS (Generic Error Modeling System) into production rules and error classifications. A simplification of reality discriminates three levels of task classification on one dimension against three levels of behavior on the other. The first axis corresponds to the hierarchy of rules; each category is roughly related to a time constant for the task duration (control = milliseconds, maneuvers = seconds, planning = minutes to hours). The second axis corresponds to the level of attention control, which is given to the (sub-) task.

To perform these tasks appropriately, the needed information and time should be available to process the information and decide accordingly. Otherwise, when decisions are notably incorrect, it's generally because operators have run out of time. Since skilled responses deal with milliseconds, rule-based responses deal with seconds; knowledge-based decisions take minutes or more. Once an error has been detected and corrected by a knowledge-based decision, the available response time may run short. In such a case, the temporal point of no return has long been passed once the error has been detected and the accident becomes inevitable.

Within each box of the matrix, the designer needs to look at the potential conflicts that the use of a set of rules could produce and selection of priorities between rules, while the time necessary to discover error and to recover from a wrong decision should be

	planning	maneuver	control
knowledge	Navigation in unknown areas	Recovery from unexpected movements	Novice operator
rule	Choices between familiar routes	Traffic rules	Driving unfamiliar vehicle
skill	Commuting	Negotiating through traffic	Routine vehicle control

Figure 3. Operator task complexity.

provided. What is currently missing from psychological theory is systematic information about human recovery—what types of error are most or least likely to be noticed by the operator or compensated by the other operator in order to prevent the situation to develop into a disaster (see Figure 3).

Temporal and spatial changes in the system

In December 2002, the vessel *Tricolor*, carrying 2,000 new cars, collided with the *Kariba* in the English Channel and sank, merely submerging below the high tide waterline. Two days later, the cargo vessel *Nicola* collided with the *Tricolor*. Two weeks later, the oil tanker *Vicky* ran into the wreckage. Before the wreckage was removed about one year later, and while the wreckage was under constant survey of wreck marking-buoys and standby vessels, more than 100 incidents and near misses had been reported by the authorities. Eventually, the International Association of Lighthouse Authorities (IALA) issued regulations to safeguard similar sites by setting emergency wreck-marking buoys and deploying a rapid intervention vessel in the area.

Sailing the English Channel is done under two main systems: sailing in a Traffic Separation System (TSS) and sailing under radar coverage. The general Safety of Life at Sea (SOLAS) conventions are in force. They deal with observation and communication and triggering actions to avoid potential collisions. These systems can be in a regular, complex, or chaotic state, defined by conditions such as traffic intensity, the weather, vision, sea swell, and the state of the vessels.

In addition, the *Tricolor* sank on a crossing between two shipping lanes, the Doverstrait TSS and Westhinder TSS, increasing the complexity of the situation compared to a collision in a shipping lane. Due to crossing maneuvers, increased traffic intensity, and increased need for traffic information between the vessels, the transition from a transparent traffic image in a TSS to a crossing is quite distinct.

Directly after the accident, every sailor was well aware of the situation, responding to the emergency situation and facilitating a quick stabilization of the situation. However, since the removal of the wreckage took about one year, the duration of increased complexity continued, requiring constant vigilance in safeguarding the accident site and providing additional information to the traffic. Since more than 100 incidents occurred, it is questionable whether the buffer in the system worked to deal with this sudden, unexpected, and lasting disturbance. An unstable system state occurred over a long time (see Figure 4).

A study into different accident investigation perspectives showed different insights, conclusions, and subsequent recommendations in the occurrence.

• The regular investigations as conducted by the authorities focus on the accident process itself: causes, consequences, probabilities, and scenarios. The fundamental prevention mechanism is buffering and damping, focusing in time on the moment of the collision itself. The IALA, as the responsible authority, issues recommendations focusing on the infrastructure: emergency wreck-marking buoys and rapid intervention vessels.

• In explaining the collision, the Normal Accident Theory (NAT) and High Reliability Organizations (HRO) theories focus on systems aspects, in particular technical aspects (NAT) and human factors/traffic processes (HRO). They represent a static, retrospective approach, applying feedback from past performance as their principal mechanism. Internal changes within the system should facilitate preventing similar accidents

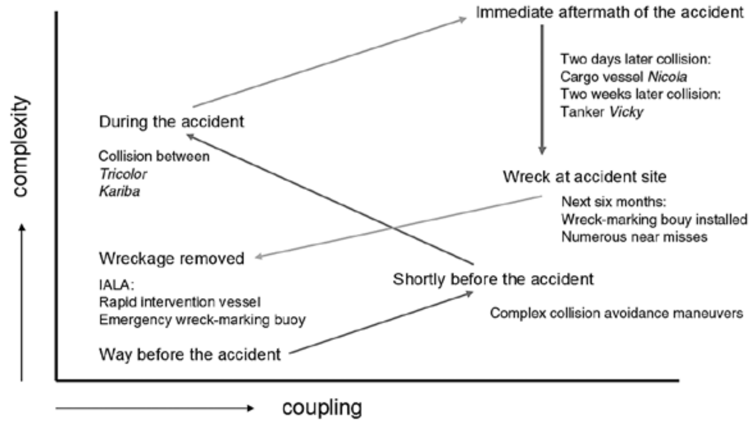

Figure 4. System state diagram.

• Applying a systems theory, taking into account chaos and complexity notions. Feedback and anticipation are principal mechanisms. By predicting the emerging system state, appropriate measures should be taken to reduce the probability and consequences of the occurrence. The goal of the analysis is to identify undesirable system states before they emerge in practice and become inevitable or highly likely. Recommendations for intervention focus on either reducing or dealing with complexity or redesigning the system to reduce complexity, dynamic interrelations, and coupling.

A mission's safe completion

Damage to the system may go unnoticed for some time but may jeopardize a future safe performance, shortly afterward or even years later.

During the evening rush hour of Dec. 3, 2008, an Amsterdam metro train derailed in the tunnel section of line 54, a main transport artery in Amsterdam. There were no casualties, but there was significant damage. At first sight, the cause seemed to be obvious: a catcher on the front bogie had worked loose and had dropped on the railhead. When it struck a checkrail in a set of points, it deformed in such a way that it obstructed a wheel, causing it to derail. Failure to detect the lose bolts in the catcher's mounting bracket during routine maintenance was the most obvious cause of this derailment. It seemed like an open-and-shut case to the inspecting officers.

Yet there were doubts. Parts of the disintegrated front bogie were missing, including the bolts with which the catchers were mounted on the front bogie. The inspectorate began a full investigation. Two days later, the true cause was found, as was the missing evidence. Through forensic engineering and reverse process reconstruction, the investigators unraveled the derailment's sequence of events.

Approximately 1½ hour before the derailment, another driver had crashed into a buffer stop at Gaasperplas terminus with this same train, partly derailing it. Not only did he not report this accident, he tried to cover it up by re-railing his train. It was this unauthorized movement that caused considerable hidden damage to the front bogie, including to the catchers and the power transmission. Later, with the third driver running the train as route 54, the transmission in the front bogie broke apart causing severe vibration. The vibration caused the partly failed and

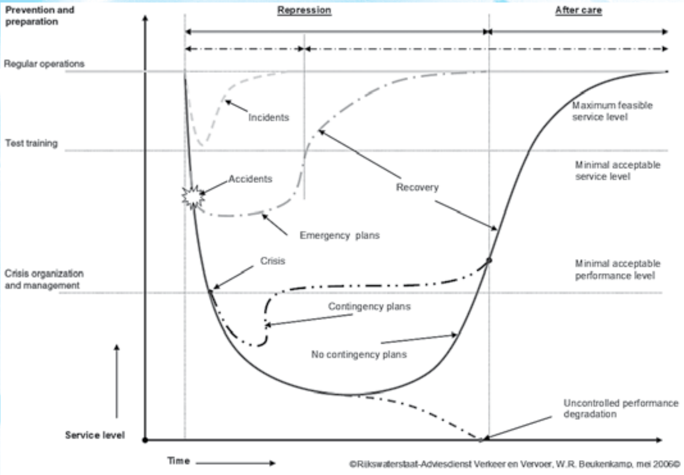

Figure 5. Recovery timeframe.

damaged catchers to drop and trigger the derailment. Thus, investigators found that the cause of the derailment in the tunnel was an event found three kilometers away, on a different part of the network, and with a different driver.

The most important lessons are that the accident cause was far more complex than it looked at first sight. In fact, it was a set of two accidents, with two different locations and three drivers involved, spread over nearly two hours' time. The second lesson was that it is difficult to determine the end of an investigation. Sometimes the factual crash site can be far larger than originally thought. The third lesson learned is that what looked like a technical problem turned out to be a severe case of misbehavior resulting from human error.

Safety performance indicators

In aviation, early detection of damage and deficiencies in the system are critical for enhancing and maintaining a safe performance. Such a safe performance is assessed during design and certification and submitted to a balanced and encompassing system of rules, regulations, standards, and procedures, setting the scene for a safe operational performance. Despite such an encompassing safety assessment, accidents occur.

In the airline industry, a number of accident case studies have gained iconic value in lessons learned from mishap and knowledge deficiencies in the actual behavior of aircraft during their operational life. After being exposed to a higher load than anticipated during design, an eventual exceeding of the ultimate load may occur, leading the aircraft into disaster. Such an exceeding may occur due to design knowledge deficiencies on material fatigue properties, such as with the de Havilland Comet; extended duration of the economic life beyond the design values, as with the Aloha Airways B-737 case; or due to stretching maintenance intervals, as with the Alaska 261 jackscrew lubrication intervals. Although a system may seemingly perform beyond expectations, the actual performance may deteriorate unnoticed under a minimal acceptable safety integrity level (see Figure 5).

Safety investigations provide indispensable feedback into the knowledge system that supports the aviation industry, providing several levels of defense in identifying recovery and resilience opportunities in the system. Such opportunities do not only manifest themselves during the sequence of an event, but may also be designed into the system to enable a graceful degradation during the event and safe termination of a mission.

Consequently, the time required to diagnose a malfunction during the flight and the time to develop an appropriate response should not fall outside the boundaries of a safe continuation of a nominal flight. Diagnosing multiple warnings, uncertainty about (partial) loss of critical systems, and lack of information on actual system states may require a timescale, expertise, and experience that exceed the available timeframe and capabilities for a nominal crew to continue a mission. The handling of the QF32 A380 loss of containment has demonstrated the time criticality and expert judgment abilities of such diagnostic processes. Such a discrepancy between applied load and allowable load should not be solved during operations because of the discrepancy in available time and necessary time to diagnose and solve a problem before it becomes critical.

During an aircraft's operational life cycle, a gradual transition takes place from technical uncertainties to operational uncertainties, dealing with adaptations based on feedback from operational experiences. During operations, a balancing of safety takes place against other operational aspects such as environment, noise, health, terrorism threat, and market changes, embedded in a context of operating conditions and company cultural values. Diagnosing events in such an operational context occurs from a socio-organizational perspective that focuses on a company's policy-making decision, efficiency of its business processes, and quality of its service provision. Throughout operations, tradeoffs are made dealing with efficiency-thoroughness considerations, organizational resilience, and recovery from critical situations.

Technological aspects are taken as a constant, covered by the design and certification framework, by training, and by proficiency checks of the crew. If the assumptions, conditions, and limitations of these frameworks are not taken into account by management, crew, and maintenance staff during their operational decision-making processes, a gradual drift into failure may occur, eventually creating mishap and disaster. An intermediate assessment of changes in operating conditions and practices should be evaluated for their safety consequences before changes are put in practice. The assessment task is similar to a technical recertification of an aircraft after major technical changes and adaptations.

Safety, a long-term strategic value

As the previous changes and adaptation can be considered internal to the aviation system, external changes also may have their consequences, creating emergent behavior of the aviation system. Expansion and major modifications on airport infrastructure, introducing new fleet aircraft, and changing the international network and reconfiguration of the aircraft/ATM system will affect the eventual safety performance level of the aviation system. In terms of chaos and complexity theory, such changes deal with systemic perturbations, disturbances, state transitions, and bifurcation points. Changes may bring the system to new, unprecedented states that are yet to be assessed as safe or stable.

Such long-term changes, adaptations, and modifications are based on arguments and considerations that are not necessarily transferred in time across stakeholders, market segments, or world regions. Lessons learned from safety investigations may hold in stable systems, based on historical insights in their

(continued on page 30)

ISASI 2012 Plans Near Completion

ISASI 2012, the Society's 43rd annual international conference on air accident investigation, being held in Baltimore, Md., USA, August 27–31, is nearing completion of its entire program plan, according to Frank Del Gandio, chairman of the seminar and Society president

The conference's website is fully operational. Go to www.isasi.org to register for the seminar, make hotel reservations, get information on the partner airline for travel arrangements, and to find out about the sights and sounds of the city of Baltimore and conference program details (excluding technical papers, for which the selection process is still in progress). The January-March issue of *ISASI Forum* detailed the costs associated with conference activities and hotel registration. These costs are posted on the conference website, which can be accessed through ISASI's website.

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

Although the technical segment of the conference is set within a three-day span, conference activities occur Monday through Friday. Monday is slated for tutorial programming, and Friday is an optional full-day tour.

Anna Cushman of the FAA is giving the tutorial "When Animation Doesn't Tell the Real Story…Flight Data Recorders for Accident Investigation and Beyond," and Andy McMinn of the DOT Safety Institute is presenting "Basic Failure Analyses: Failure Mode Identification at the Accident Site." The NTSB's daylong tutorial "Manufacturer Assistance to Accident Investigation" will give insight into some of the tools and techniques aircraft manufacturers have available to support major investigations. The three manufacturers making presentations are Airbus, Boeing, and Honeywell. A discussion of their presentations, which center on the capabilities, benefits, and limitations of utilizing certain data systems, is available on the conference website.

Conference planners have arranged for discounted travel with Lufthansa German Airlines. The airline is offering special prices and conditions on its comprehensive global route network, which links major cities around the world. Lufthansa's offer applies to participants, visitors, exhibitors, and invited guests as well as to employees of the ISASI 2012 annual conference and their travel companions. To make a reservation, please go to www.lufthansa.com/event-booking_en and enter the access code USZAXT in the "Access to Event Booking" area. This will open an online booking platform that will automatically calculate the discount offered or provide you with an even better offer if another promotional fare is available. *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.

On the social side of the weeklong activities is a Tuesday evening festive dinner/dance boat cruise aboard the *Spirit of Baltimore* through the Baltimore Harbor and along the Patapsco River. Wednesday is a free night for the attendees to explore Baltimore after sunset. Thursday evening is reserved for the heavily attended awards night festivities at which the year's Jerome F. Lederer Award is presented.

Friday is an optional tour day. At an additional cost of $140 per person, the tour will include a visit to Annapolis, the capital of Maryland. Well known as a center of sailing and boating in the Mid-Atlantic states, the city's historical center is vibrant and its charming colonial heritage well-preserved. The tour will include a visit to City Dock, the Maryland state house, and the governor's mansion. A stop is also planned at the United States Naval Academy, its chapel, and crypt of John Paul Jones. Next is a visit to Preble Hall, home of the U.S. Naval Academy museum, featuring two floors of exhibits exploring the history of sea power and the development of the U.S. Navy. A typical Maryland crab feast is on the luncheon menu, followed by free time to stroll along Annapolis's cobbled streets and do a bit of shopping.

Companions of attendees will enjoy a well-planned companion's program. Full-day activities are scheduled for Tuesday and Wednesday of the conference week.

Tuesday features a tour of Baltimore. One of America's oldest cities, it is known for its rich ethnic and maritime heritage, sense of history, and fine food. First comes a narrated city tour en route to Mt. Vernon. Sites and landmarks include the Katyn Memorial, the Phoenix Shot Tower, the War Memorial Plaza and city hall, and the Battle Monument.

Then, the tour will visit the Walters Art Museum, internationally renowned for its collection from pre-dynastic Egypt to 20th-century Europe. Among its many treasures are Greek sculpture and Roman sarcophagi, medieval ivories, and Old Master paintings. Next up is the Garrett-Jacobs Mansion—a jewel in the crown of Baltimore's most distinctive historic homes. This is followed by a docent-led tour of the Basilica of the National Shrine of the Assumption of the Blessed Virgin Mary, the first Roman Catholic Cathedral in the United States. Luncheon is a bus ride away to the Sunshine Grill at Boordy Vineyards, followed by a private vineyard tour and an exclusive wine tasting.

On Wednesday, August 29, the tour travels to Towson, Md., to the Hampton national historic site, which showcases

LETTERS TO THE EDITOR

Robert MacIntosh's papers about whether cause is obsolete (*ISASI Forum* April-June 2010) and his call for new thinking in his latest *Forum* (January-March 2012) article reflect growing concerns about some aspects of present investigation practices. Publication of the papers supports ISASI's purpose "to promote the development and improvement of aviation accident and incident investigations, as well as enhance aircraft accident prevention activities." Finding improvements to promote requires an understanding of what present practices are and why they exist. Past improvements began with identification of concerns or questions about those practices, needs they do not meet, or challenges to them.

Aircraft investigation practices have a long history and are well-known and well-documented. The thinking behind why they exist is less well-understood and documented. The cause-oriented thinking reflected in a 1927 U.S. Air Services report of an "Inquiry into the Cause of Fatal Accidents" has not changed much. The reporting framework, while expanded with additional elements, has retained its fundamental taxonomic approach reflected in a 1928 report "Aircraft Accidents: Method of Analysis" by J.S. Ames, chairman, National Advisory Committee for Aeronautics. This thinking's continued use indicates it has apparently been reasonably satisfying for historic "investigation consumers" over the years. MacIntosh's concerns are "within the box" of that general body of thinking.

However, MacIntosh's papers, JHSAT's difficulties trying to find ways to improve helicopter safety from investigation reports, increasingly complex systems and interactions, differing perceptions of what an accident is, the diversity of investigation methodologies used, frequent controversies about findings, investigation inefficiencies, ambiguity about end-users and their needs, cumbersome lessons learning practices, lack of metrics for ensuring investigation and output quality recommendations' effectiveness, and criminalization of accidents, for example, indicate opportunities for improvement.

Leveson starts her recent book, *Engineering a Safer World* by challenging underlying assumptions about safety and suggesting alternatives. I believe we need to do the same for investigations. The adversarial-oriented causal investigation thinking and reporting, inherited in large measure from the judicial system, may or may not be the best thinking to serve future needs for actionable safety information for existing "investigation customers" and new end-users like complex systems engineering, software development, managerial, maintenance, equipment manufacturing, or ATC personnel. We won't know until we identify and compare alternative thinking.

That effort can start by posing questions that open dialogues about current thinking and assumptions and then developing alternatives. I could offer numerous examples. Undoubtedly, others can suggest questions and needs to explore and ideas to introduce into the discussion. But how can such dialogues get started? One way would be for ISASI to create a working group to explore improvements to meet 21st-century needs. That would seem to be an appropriate way to initiate and carry on dialogues about current and alternative thinking. I'd be happy to contribute.

Ludwig Benner (LW2202), Chairman, Board of Fellows Committee

Mid-Atlantic life from before the American Revolution to after World War II. The site commemorates major phases of American social, cultural, and economic history across three centuries. A final stop will be a relaxing visit to Ladew Topiary Gardens, with its more than 100 larger-than-life topiary forms that serve as centerpieces to designated garden rooms. ◆

2012 Int'l Council Election Voting is Under Way

The 2012 ISASI International Council election voting period takes place June 1 to Aug. 1, 2012. The current Executive officers standing for reelection are President Frank Del Gandio, Vice President Paul Mayes, and Secretary Chris Baum. In addition, Ron Schleede, a past vice president, has been nominated for the office of ISASI vice president. He will run against the present incumbent Paul Mayes. Bob MacIntosh has accepted a nomination for the ISASI treasurer position. The current international councillor, Caj Frostell, and U.S. councillor, Toby Carroll, are also standing for reelection.

MacIntosh has been active in ISASI for more than 30 years, including participating as a seminar session chair, author, and speaker. He served with the U.S. National Transportation Safety Board as the chief advisor of international safety affairs from 2001 until his retirement in 2011. He was responsible for providing management expertise regarding U.S. government and industry technical participation in accident investigations on foreign soil, overseeing travel budget allocations, representing the U.S. at relevant ICAO meetings, and managing Safety Board activities included at the U.S. Interagency Group on International Aviation. He was responsible for coordinating the Safety Board's international air safety initiatives, presenting technical papers, and serving on committees associated with other international organizations, including the Flight Safety Foundation, ISASI, IATA, ECAC, and EASA. From 1988 to 2001, Bob was an investigator-in-charge and accident report writer with the NTSB Major Investigations Division. In that position, he led many high-profile domestic air safety investigations (Aloha, Sioux City, and the Los Angeles collision) and represented the U.S. NTSB in numerous international cases (Lauda, AirInter, LAPA, Concorde) as the U.S. accredited representative.

This year's election will again be conducted electronically via the Internet using VoteNet. The goals for implementing the electronic ballot are to make it

NEW MEMBERS

CORPORATE MEMBERS

Flight Data Systems, Australia
Darren Privitera
Justin Amore
Keilor Park
Military Air Accident Investigation Branch, UK
Michael Smith
Jeff Lindsay
Helicopters NZ Ltd.
Jeremy Feasey
Mathew Henderson
Air Accident Investigation Bureau of Mongolia
Narankhuu Khand
Battulga Baatarsuren
Papua New Guinea Accident Investigation Commission (PNG AIC)
David Inau

INDIVIDUAL MEMBERS

Adrian A.G., AbrahamSeremban, Malaysia
Heather M. Alexander, Wedgefield, SC, USA
Matthew W. Archer, Derby, KSU, SA
Megan S. Brandt, Destin, FL, USA
Rolf G. Brockmeyer, Gainesville, VA, USA
Michael D. Buran, Fort Worth, TX, USA
Thierry Chamard, Boisemont, France
Edward J. Coleman, Sandia Park, NM, USA
Keith Conradi, Aldershot, Hampshire, United Kingdom
Roger D. Cox, Annapolis, MD, USA
Stephane De Wolf, Brussels, Belgium
Mackenzie T. Dickson, Daytona Beach, FL, USA
Michael A. DiMatteo, Leesburg, VA, USA
Christopher A. Dore, Flemington VIC, Australia
Theresa M. Estes, Cocoa, FL, USA
Andrew J. Evans, Inverurie Scotland, United Kingdom
Christopher H. Ferguson, Newquay, United Kingdom
Patrick C.A. Forrester, Washington, DC, USA
Elmer “Alex” A. Gephart, Greenville, SC, USA
David S. Goodwill, Gig Harbor, WA, USA
Matthew P. Greenslade, Auckland, New Zealand
Pierre E. GuindiPonce, Inlet, FL, USA
Jim Kenny, Bonaire, GA, USA
Michael G. Kleihauer, Akron, IA, USA
Alexei Krochin, Daytona Beach, FL, USA
Toni C. Lacey, Lafayette, CO, USA
Jason Y. Liu, Daytona Beach, FL, USA
Kevin P. Lynch, Los Altos, CA, USA
Steve Magginetti, San Ramon, CA, USA
Shem P. Malmquist, Germantown, TN, USA
Alain Mazatan, Port Orange, FL, USA
Michael O. Minjares, Daytona Beach, FL, USA
Danni A. Nicholas, Mascot NSW, Australia
Ben O’Flanagan, Dee Why NSW, Australia
John Owens, Dublin, Ireland
Jeffrey D. Pooley, Riverside, CA, USA
Nathan W. Racine, Daytona Beach, FL, USA
Jincy Raj, Daytona Beach, FL, USA
Herrera Carlos G. Sacamanca, Bogota D.C., Columbia
Colleen M. Sadeski Cedartown, GA, USA
Randall J. Sauer, BelAire, KS, USA
James E. Schroeder, West Chester, PA, USA
John E. Shallcroft, Stithians, United Kingdom
Avi A. Shemesh, Daytona Beach, FL, USA
Leith Sherwin, East Perth, WA, Australia
Mark C. Stuntzner, Grand Prairie, TX, USA
Sri Suppiah, Brisbane, QLD, Australia
Robert J. Trevelyan, San Rafael, CA, USA
Stuart R. Walters, Worrigee, Australia
Donald C. West Jr., Daytona Beach, FL, USA
Jerome O. A. Williams, Daytona Beach, FL, USA
Brian S. Wood, O’Fallon, IL, USA
Kelly E. Woods, Moscow, TN, USA
Kenneth D. Young, Franklin, OH, USA ◆

easier, faster for members to vote, and to significantly reduce postage, labor, and materials costs. Members can log on to the ISASI website, www.isasi.org, and a link to VoteNet will appear on the home page beginning on June 1, 2012. Click on the link and follow the easy-to-follow instructions. There are three ballots 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 will be available only to the Ballot Certification Committee.

If any eligible member does not or cannot find access to the Internet to vote, he or she may contact Ann Schull or Troy Jackson, chairman of the Nominating Committee, at the international office and a paper ballot will be made available. Call (703) 430-9668; fax (703) 430-4970, or e-mail isasi@erols.com. Troy Jackson can be reached at troy.jackson@dot.gov.

The following ISASI members are eligible to vote: fellow members, full members, associate members, life fellow members, life full members, life associate members, life charter members, and charter members. U.S. members

ISASI Training Returns to Colombo, Sri Lanka

ISASI members Keith McGuire and Caj Frostell conducted a two-week accident investigation workshop for the Sri Lankan accident investigators and the civil aviation authority in January. The workshop was follow-up training to an ISASI Reachout workshop held in Colombo five years ago in aircraft accident investigation for Sri Lankan investigators who are available to be appointed to an accident investigation commission in the event of an accident.

Ranjith De Silva, secretary of the Ministry of Civil Aviation, G.S. Withanage, additional secretary of the Ministry of Civil Aviation, and General Rohan Daluwatte, chairman of the Civil Aviation Authority of Sri Lanka, opened the January training period. The training in Colombo was handled by H.M.C. Nimalsiri, director general of the CAA, D.M.P. Dissanayake, senior director of the CAA, and Samudra Chandrartne, program assistant for aircraft accident investigation.

The 56 participants included representatives from the CAA, the airport authority, the Sri Lanka Air Force, five aviation industry operators, three representatives from Nepal, and one person from Bangladesh.

Caj Frostell, the ISASI international councillor, noted that ISASI co-sponsored the workshop. He said, “It was an excellent opportunity to promote ISASI and the Asian Society of ISASI, as well as the safety activities by ISASI.” ◆

Preparing to open the training session are, left to right, Keith McGuire, General Rohan Daluwatte, G.S. Withanage, Ranjith De Silva, and Caj Frostell.

will vote for president, vice president, secretary, treasurer, and U.S. councillor, and International members will vote for president, vice president, secretary, treasurer, and international councillor. Society members will vote for president, vice president, secretary, and treasurer.

The following members are not eligible to vote: affiliate members, corporate members (status only), honorary members, and student members. ◆

ESASI Elects New Officers

The European Society has conducted its election process for the next two-year period. New officers of the ESASI Committee assumed office in April. The Society enlarged its group of elected official by adding two positions, which aid greatly with general administration and annual seminar organization.

David King, incumbent president, and Anne Evens, incumbent councillor, did not stand for reelection. Elected to serve are

- ESASI President, Keith Conradi, UK chief inspector of Air Accidents,
- European Councillor, Olivier Ferrante, European Commission (Ex-BEA France),
- ESASI Secretary, John Dunne, consultant (reelected),
- ESASI Treasurer, Rex Parkinson, chief inspector air accidents, Qatar, (reelected),
- ESASI Membership Secretary, Steve Hull, aviation director, RTI, and
- ESASI Committee Member, Matthew Greaves, Safety and Accident Investigation Center, Cranfield University. ◆

Reachout Seeks Training Venues

The ISASI Reachout program is actively seeking requests from any air operator or agency that has a need for fundamental safety management and investigation training and mentoring. The program has a comprehensive list of willing volunteers who span the globe.

The process relies on any intending "host(s)" to specify the particular areas of expertise that are sought for the location. This enables the Reachout Committee to then match the necessary skills with the available volunteers. The host organization(s) is expected to provide a basic training venue that permits interactive learning for the attendees.

Reachout is proud to congratulate Committee member Wing Commander Syed Naseem Ahmed of Pakistan on his recent success in being awarded an Endeavour Executive Scholarship by the Australian Government. This coveted award allows him to further study and enhance aviation safety research in Australia and Pakistan for the benefit of all aviators during 2012. ◆

San Francisco Chapter Hosts Honorable Mark Rosekind

The San Francisco Chapter's first quarterly meeting in 2012 on February 24 hosted the Honorable Mark Rosekind, NTSB Board member. The well-attended meeting was held at the Oakland Aviation Museum, located at the Oakland International Airport.

Rosekind began with a concise explanation of the NTSB workings for the benefit of new and visiting non-ISASI members. He followed that with a fascinating and very educational tutorial on human fatigue and fatigue management.

By popular demand, Rosekind answered questions well beyond the scheduled one-hour meeting. Reluctantly, Chapter President Kevin Darcy had to end the lively question-and-answer session as the Museum was closing for the day. The captivating presentation prompted several attendees to apply for ISASI membership.

Rosekind's presentation materials for the meeting can be found at www.ntsb.gov/doclib/speeches/rosekind/Rosekind_120224.pdf. ◆

Asia Pacific Cabin Safety Working Group Meets

The Asia Pacific Cabin Safety Working Group had its second meeting of the year, this time hosted by Virgin Australia and Aviation Australia at their training facility at Brisbane Airport. Over the two days, approximately 50 representatives from airlines, the regulatory authorities, the military, and the aviation industry heard presentations on a range

2011 Annual Seminar Papers Now Available

Technical Papers Presented at ISASI 2011. (Available papers are posted on the ISASI website, www.isasi.org.)

TUESDAY, SEPTEMBER 13

Impact Modelling—Cases and Cautions
Robert Carter—UK, Principal Inspector of Air Accidents, AAIB

Major Investigations, New Thinking Ahead
Bob MacIntosh—USA, Chief Advisor, International Safety Affairs NTSB

Using "ASTERIX" in Accident Investigation
Michiel Schuurman—The Netherlands, Senior Investigator Aviation, Dutch Safety Board, and Paul Farrell, Ireland, Inspector of Accidents, AAIU

Who Is Onboard in GA and Air Taxi Accidents?
Bob Matthews—USA, Office of Accident Investigation, FAA

Preventing the Loss of Control Accident
Patrick Veillette—USA, Ph.D.

Analysis of Fuel Tank Fire and Explosion
N. Albert Moussa—USA, BlazeTech Corp.

WEDNESDAY, SEPTEMBER 14

Teamwork in the Cause of Aviation Safety
Sébastien David and Léopold Sartorius—France, Safety Investigators, BEA

Long-Distance Investigations
Thorkell Agustsson—Iceland, Chief Inspector, Air Accidents, AAIB

Smaller Nations and Annex 13
Syed Naseem Ahmed—Pakistan, Aviation Consultant

Timeliness, An Investigators Challenge
John Stoop—The Netherlands, Lund University, Sweden, and Delft University of Technology, the Netherlands

Flight Path Analysis
Major Adam Cybanski—Canada, Directorate of Flight Safety, Canadian Forces

Post-Turbulence Structural Integrity Evaluation
Ray Chang, C. Edward Lan, and Wen-Lin Guan—Republic of China

Building Partnerships in Unmanned Aviation Systems
Tom Farrier—USA, Chair, ISASI UAS WG

Regulatory Runway Incursion Awareness Systems
Robert Joslin—USA, Chief Scientific and Technical Advisor, Flight Deck Technology Integration, FAA

Helicopter Design for Maintainability
Andrés Serrano, Brazil; Guilherme Conceição Rocha, KONATUS; and Donizeti de Andrade, Italy

THURSDAY, SEPTEMBER 15

B-787 Safety Presentation
Thomas Dodt—USA, Chief Engineer, Air Safety Investigation, Boeing Commercial Airplanes

Human Errors and Criminal Guilt
Yukiko Kakimoto—Japan, Institute of Human Factors

Pilots' Cognitive Processes for Making Inflight Decisions Under Stress
Wen-Chin Li—Head of 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

Human Factors Standardized Procedures
Helena Reidemar—USA, First Officer, Major Airline

"Back to Basics" Still Work?
Mont Smith—USA, Director Safety, ATA

Update on the AF 447 Investigation
BEA—France

An Investigation media/communications Strategy
Ian Sangston—Australia, General Manager ASI, ATSB

Media in a High-Profile Accident
Thierry Thoreau—France, Director, Flight Safety, Airbus SAS ◆

of issues relating to cabin safety.

Mike Walker from the ATSB went through the investigation results of the Airbus A330 upset off the western Australian coast and explained in detail the results of passenger surveys and cabin issues. Brett Molesworth from the UNSW reported on his research into noise-cancelling headsets used inflight by many passengers. The attendees also had the opportunity to tour the extensive cabin training facilities of Aviation Australia and the aviation rescue firefighting station at Brisbane Airport. Thanks went to Dave Lattimore and James Redgrove for organizing another successful meeting. ◆

Michael Huerta Nominated to Head FAA

President Obama has nominated Acting FAA Administrator Michael Huerta to take the position of FAA administrator for a five-year term. Huerta was elevated to the post from deputy administrator in December after former FAA boss Randy Babbitt resigned the post. Huerta must be confirmed by the Senate before getting the job, but analysts don't seem to view that as an issue.

Before joining the FAA, Huerta held senior positions at Affiliated Computer Services from 2002–2009, rising to the position of president of the Transportation Solutions Group. ACS is now a Xerox company specializing in business processes and information technology.

Huerta was commissioner of New York City's Department of Ports, International Trade and Commerce from 1986–89. He then served as the executive director of the Port of San Francisco from 1989–1993. From 1993–98, he held senior positions in the U.S. Department of Transportation in Washington, D.C., serving under Secretary Federico Peña and Secretary Rodney E. Slater.

He holds a bachelor's degree in political science from the University of California-Riverside and a master's degree in international relations from the Woodrow Wilson School of Public and International Affairs at Princeton University. ◆

UAS Working Group Sets Team Concept

Tom Farrier, ISASI's Unmanned Aircraft Systems (UAS) Working Group (WG) chairman, reports that the tasks specified in the UASWG's Terms of Reference have been arranged to allow Group members to identify themselves with one or more of four teams within the Working Group:

- **Description Team:** Description of UAS, including similarities to and differences from manned aircraft. (Identification of needed investigative capabilities and training driven by differences will flow from this work product.)
- **Annex 13 Team:** Annex 13 gap analysis for areas in which UAS-specific content is needed.
- **Data Team:** Requirements for UAS-specific data over and above that currently collected in the course of investigations.
- **Liaise Team:** Liaison with other ISASI WGs on UAS matters that cross functional or interest boundaries.

The UAS WG is scheduled to hold its second in-person meeting at the ISASI annual seminar in Baltimore, Md. ◆

Human Factors Standardization in Safety Applications

(continued from page 19)

set up human factors programs.

This new approach requires a seismic shift in the source of awareness as human factors technology draws from a variety of sciences, psychology, biology, sociology, engineering, and even anthropology. Through these sciences and the research already conducted, a new approach can be formulated, inherent and systematic weaknesses can be identified, and human-centered training and designs for actual operational usage in real-world contexts can be implemented.

Collecting anecdotal evidence of the pilot's role in risk mitigation to identify hidden vulnerabilities should be conducted, retaining the human capabilities and lessons learned.

The Advanced Qualification Program (AQP) used at many airlines needs to be revisited. The program has simply become a means to justify reducing training programs. Although AQP provides a measure of progress, the subjective evaluations by instructors not properly educated in human factors disciplines do a disservice to line pilots. Standardization programs for the AQP evaluators/instructors lack the necessarily prescriptive protocols required to produce truly accurate results.

Safety is a continuous process and not a destination. In order to realize a measure of success in this arena, a new approach of developing procedures through greater responsiveness to safety data and the human performance at the center of the process is necessary. ◆

Timeliness: An Investigator's Challenge

(continued from page 24)

functioning. It is a question of strategic importance, however, to deal with newly designed and modified systems that introduce major innovations of a technological and an organizational nature.

A study into the long-term effects and sustainable impact of the safety recommendations after the B-747 ELAL crash at Schiphol Airport in 1992 demonstrate a decay in safety awareness, deteriorating the coherence and persistent focus on safety. Even at the level of institutional arrangements, lessons seem to become forgotten, while safety is degraded from a strategic and social value to an operational constraint. Governance, policy-making arenas, and external conditions may create a shift in safety thinking, awareness, and acceptance at a societal level, thus affecting all sectors of society. Safety investigations may contribute to the disclosure of such societal influences on the aviation system, providing a timely transparency in the factual functioning of the aviation system at a societal level.

Conclusions

Conclusions to be drawn from this exploration of time as a dimension in safety investigations include

• In dealing with dynamic and complex interacting systems, the dimension of time in the analysis of events as well as systems is indispensable as a sequencing tool in event recomposition, in the analysis of establishing causal relations, and in assessing changes and adaptations that occur throughout the systems life cycle.

• Based on case study experiences, the dimension of time can be applied to any level of the system, varying from the operator level to management and governance as well as to technical, behavioral, and organizational aspects.

• The dimension of time creates a series of feedback loops between the various lifecycle phases, systems levels, and system states, facilitating exchange of information about the factual functioning of each of the systems aspects, elements, and components among all actors.

• In a dynamic environment, lessons learned are not necessarily sustained. Time may erode them to become lessons forgotten, if feedback from this learning is not contained in the system's memory as a shared knowledge repository, accessible to all actors, stakeholders, and participants.

• Time is a systems dimension that is particularly of interest for investigators. It may provide investigators with a timely transparency of the factual functioning of the system. ◆

COMMITTEE CHAIRMEN

Audit, Dr. Michael K. Hynes (hynesdrm@aviationonly.com)
Award, Gale E. Braden (galebraden@cox.net)
Ballot Certification, Tom McCarthy (tomflyss@aol.com)
Board of Fellows, Ludi Benner (luben@patriot.net)
Bylaws, Darren T. Gaines (darren.t.gaines@faa.gov)
Code of Ethics, Jeff Edwards (vtailjeff@aol.com)
Membership, Tom McCarthy (tomflyss@aol.com)
Nominating, Troy Jackson (troy.jackson@dot.gov)
Reachout, John Guselli (jguselli@bigpond.net.au)
Seminar, Barbara Dunn (avsafe@shaw.ca)

WORKING GROUP CHAIRMEN

Air Traffic Services, Scott Dunham (Chair) (dunhams@ntsb.gov)
Ladislav Mika (Co-Chair) (mika@mdcr.cz)
Cabin Safety, Joann E. Matley (jaymat02@aol.com)
Corporate Affairs, Erin Carroll (erin.carroll@wnco.com)
Flight Recorder, Michael R. Poole (mike.poole@flightscape.com)
General Aviation, Jamea A. Viola (jamesviola@gmail.com)
Government Air Safety, Marcus Costa (mcosta@icao.int)
Human Factors, Richard Stone (rstone2@msn.com)
Investigators Training & Education, Graham R. Braithwaite (g.r.braithwaite@cranfield.ac.uk)
Military Air Safety Investigator, Bret Tesson (bret.w.tesson@boeing.com)
Unmanned Aerial Systems, Tom Farrier (farrierT@earthlink.net)

CORPORATE MEMBERS

AAIU Ministry of Transport Bulgaria
Accident Investigation Board, Finland
Accident Investigation Board/Norway
Accident Investigation & Prevention Bureau
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Aeronautical & Maritime Research Laboratory
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Air Line Pilots Association
Air New Zealand, Ltd.
Airbus S.A.S.
Airclaims Limited
Aircraft Accident Investigation Bureau—Switzerland
Aircraft Mechanics Fraternal Association
Airservices Australia
AirTran Airways
Airways New Zealand
Alaska Airlines
Alitalia Airlines—Flight Safety Dept.
Allianz Aviation Managers, LLC, USA
All Nippon Airways Company Limited
Allied Pilots Association
American Eagle Airlines
American Underwater Search & Survey, Ltd.
AmSafe Aviation
Aramco Associated Company
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Atlantic Southeast Airlines—Delta Connection
Australian and International Pilots Association (AIPA), Australia Australian Transport Safety Bureau
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Aviation Safety Investigations, UK
Avions de Transp ort Regional (ATR)
AVISURE, Australia
BEA-Bureau D'Enquetes et D'Analyses
Board of Accident Investigation—Sweden
Boeing Commercial Airplanes
Bombardier Aerospace
Bundesstelle fur Flugunfalluntersuchung—BFU
CAE-Flightscape, Inc.
Cathay Pacific Airways Limited
Cavok Group, Inc.
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Directorate of Aircraft Accident Investigations—Namibia
Directorate of Flight Safety (Canadian Forces)
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Dutch Airline Pilots Association
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EL AL Israel Airlines
Embraer-Empresa Brasileira de Aeronautica S.A.
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EVA Airways Corporation
Exponent, Inc.
Federal Aviation Administration
FedEx Express
Finnair Oyj
Finnish Military Aviation Authority
Flight Attendant Training Institute at Melville College
Flight Data Services Ltd., United Kingdom
Flight Safety Foundation
Flight Safety Foundation—Taiwan
Galaxy Scientific Corporation
General Aviation Manufacturers Association
GE Transportation/Aircraft Engines
Global Aerospace, Inc.
Gulf Flight Safety Committee, Azaiba, Oman
Hall & Associates, LLC
Hellenic Air Accident Investigation & Aviation Safety Board
Honeywell
Hong Kong Airline Pilots Association
Hong Kong Civil Aviation Department
IFALPA
Independent Pilots Association
Int'l Assoc. of Mach. & Aerospace Workers
Interstate Aviation Committee
Irish Air Corps
Irish Aviation Authority
Japan Airlines Domestic Co., LTD
Japanese Aviation Insurance Pool
Japan Transport Safety Board
Jeppesen
JetBlue Airways
Jones Day
KLM Royal Dutch Airlines
Korea Air Force Safety Ctr.
Korea Aviation & Railway Accident Investigation Board
Kreindler & Kreindler, LLP
L-3 Communications Aviation Recorders
Learjet, Inc.
Lockheed Martin Corporation
Lufthansa German Airlines
MyTravel Airways
National Aerospace Laboratory, NLR
National Air Traffic Controllers Assn.
National Business Aviation Association
National Transportation Safety Board
NAV Canada
Nigerian Ministry of Aviation and Accident Investigation Bureau
Northwest Airlines
Nova Aerospace, Australia Parker Aerospace
Phoenix International, Inc.
Pratt & Whitney
PT Merpati Nusantara l Airlines
Qantas Airways Limited
Qatar Airways
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Singapore Airlines, Ltd.
SNECMA Moteurs
South African Airways
South African Civil Aviation Authority
Southern California Safety Institute
Southwest Airlines Company
Southwest Airlines Pilots' Association
Spanish Airline Pilots' Association
Star Navigation Systems Group, Ltd.
State of Israel
Transport Canada
Transportation Safety Board of Canada
U.K. Civil Aviation Authority
UND Aerospace
University of NSW Aviation
University of Southern California
Volvo Aero Corporation
WestJet ◆

ISASI
107 E. Holly Ave., Suite 11
Sterling, VA 20164-5405 USA
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Who's Who

Lockheed Martin Aeronautics Company

(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)

Lockheed Martin Aeronautics Company is a world leader in the design, research and development, systems integration, production, and support of advanced military aircraft and related technologies. Its customers include the military services of the United States and Allied nations throughout the world.

The company's products include the F-35 Lighting II Joint Strike Fighter, F-22 Raptor, F-16 Multi-mission Fighter, C-130J Super Hercules, C-5 transport, P-3 maritime patrol aircraft, U-2 reconnaissance aircraft, and advanced development programs.

The company's major sites are in Fort Worth, Tex., which is the aeronautics headquarters and the home of the F-35 and F-16 programs; Marietta, Ga., the home of the C-130 and F-22 programs; and Palmdale, Calif., the center for advanced development programs. The company has about 28,000 employees.

Lockheed Martin Aeronautics, with $13.2 billion in 2010 sales, is a business area of Lockheed Martin Corporation. Headquartered in Bethesda, Md., Lockheed Martin employs about 126,000 people worldwide and is principally engaged in the research, design, development, manufacture, integration, and sustainment of advanced technology systems, products, and services.

Lockheed Martin products play a critical role in the security of the United States and Allied nations. For example, the F-16, C-130, U-2, and C-5 have been flown extensively in recent combat operations.

Flight safety initiatives

Lockheed Martin, in conjunction with U.S. Air Force and NASA researchers and test personnel, recently completed flight tests at Edwards Air Force Base in California to evaluate the automatic ground-collision avoidance system on an F-16. This new gear combines global positioning system data with digital terrain data maps to help pilots better reference the ground below. It also enables the aircraft to automatically execute avoidance maneuvers without pilot intervention if the aircraft ventures dangerously close to the ground.

The System Initiated Deep Stall Auto Recovery System (SIDSARS) continually monitors the state of the aircraft to determine if the aircraft has entered a deep stall condition. If this condition is determined to exist, SIDSARS automatically initiates a recovery maneuver and returns the aircraft to controlled flight.

Pilot Activated Recovery System (PARS) provides positive recovery of the aircraft in the event of pilot spatial disorientation. Pilot activation of PARS via single-switch depression returns the aircraft to a wings-level attitude, positive rate of climb, and nominal cruise speed via auto throttle.

Flight safety support

Lockheed Martin Aeronautics Flight Safety provides on-site and in-house aircraft mishap investigative support, inflight emergency assistance, comprehensive aircraft-specific mishap investigation manuals, state-of-the-art nonvolatile memory retrieval and analysis, and mishap video analysis and animation. Flight safety personnel have varied backgrounds, but most include military experience as pilots, aircrew, or maintenance technicians. ◆