ISASI FORUM
JANUARY-MARCH 2004
"AIR SAFETY THROUGH INVESTIGATION"

ISASI CODE OF ETHICS CANONS

INTEGRITY

Each Member should at all times conduct his activities in accordance with the high standards of integrity required of his profession.

PRINCIPLES

Each Member should respect and adhere to the principles on which ISASI was founded and developed, as illustrated by the Society's Bylaws.

OBJECTIVITY

Each Member should lend emphasis to objective determination of facts during investigations.

LOGIC

Each Member should develop all accident cause-effect relationships meaningful to air safety based upon logical application of facts.

ACCIDENT PREVENTION

Each Member should apply facts and analyses to develop findings and recommendations that will improve aviation safety.

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ABOUT THE COVER

The background on the development of ISASI's Code of Conduct *has a long history. Much of the work related to today's* Code *is owed to C.O. Miller, an ISASI member since 1968, but now deceased. The story of the* Code's *development begins on page 5 of this issue.*

ISASI FORUM

"Air Safety Through Investigation"

Volume 37, Number 1

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AIR SAFETY INVESTIGATORS
INCORPORATED AUGUST 31 1964

What Is ISASI Doing?

By Frank Del Gandio, President

What is ISASI doing for you, our member? What is ISASI doing for the aviation community? What is ISASI doing to improve aircraft accident investigations and aviation safety? During the recent annual seminar, ISASI 2003, those questions occurred to me and were reinforced when I was asked the same questions by a number of attendees. After some thought, I'd like to bring you up-to-date on a number of innovations and improvements.

The *Forum,* our in-house publication, was completely revamped and updated 6 years ago from a black-and-white, stapled collection of articles to a glossy, colored professional magazine. Today ISASI has a first-class informative and authoritative journal that is admired throughout the aviation community.

The growth and popularity of the annual ISASI seminar have been phenomenal. It seems that each year the seminar garners progressively higher attendance, and its technical presentations become more sharply focused to meet the needs of the air safety investigator to the fast-changing world of technology. Current technology and recent accidents are always highlighted. I realize that not all members are able to attend the seminars, and for that reason special emphasis on seminar presentations and speeches are featured in the *Forum*.

The advent of our Reachout seminar program has become a truly successful innovation. It was established to provide low-cost, subject-oriented accident investigation seminars in regions of the world with higher aircraft accident rates and where the training would have the greatest impact. The first ISASI Reachout was held in May 2001 in Prague, Czech Republic. Subsequent seminars were held in India, Sri Lanka, Tanzania, Chile, Lebanon, and Costa Rica. All were unqualified training successes in attendance and content. Another Reachout seminar was held in Mexico City in January.

The year 2002 saw the birth of the ISASI Rudy Kapustin Memorial Scholarship Fund, named for our departed friend to honor all those ISASI members who have flown west. The fund is administered by ISASI, and contributions are tax deductible. Each year two aviation college-level students are selected through a competitive process and awarded a grant to attend the annual seminar. Our first scholarship winners, Noelle Brunelle and Michiel Schuurman, attended ISASI 2003.

Another innovation is the now easily accessible ISASI website, www.isasi.org, with a limited public yet extensive "Members Only" information section. A concerted effort is currently under way to strengthen the website.

In response to rapidly escalating rental costs and difficulties in obtaining a business-like lease agreement, the ISASI Executive Council decided to explore purchasing a permanent home. This has proven to be a most forward-thinking decision. In March 2000, we were able to purchase an upper-floor condominium office for an excellent price. Not only did we gain a pleasant and permanent home office, we have saved more than $15,000 per year in housing costs. Additionally, by petitioning the county and state governments, we obtained relief from all personal property and real estate taxes, for a savings of about $1,200 annually.

In summary, the officers and members of the International Council are actively looking out for the interests of the Society and expanding its role in the aviation safety community. Be assured that we will continue to manage ISASI with you, our member, in mind during our 40th anniversary year. ◆

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ISASI Web: **http://www.isasi.org**
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Governmental Investigation Organizations

Australia-Accident Transportation Safety Board (ATSB)
http://www.atsb.gov
Canada—Transportation Safety Board (TSB)
http://www.bst.tsb.gc.ca
Denmark—Aircraft Accident Investigation Board (AAIB)
http://www.hcl.dk
Finland—Aircraft Accident Investigation Board (AAIBF)
http://www.onnettomuustutkinta.fi/2602.htm
France—Department of Transportation (BEA)
http://www.bea-fr.org/anglaise/index.htm
Germany—Federal Bureau of Aircraft Accident Investigation (BFU)
http://www.bfu-web.de
International Civil Aviation Organization (ICAO)
http://www.icao.int
New Zealand—Transport Accident Investigation Commission
http://www.taic.org.nz
Norway—Accident Investigation Board (HSLB)
http://www.aaib-n.org
Sweden—Accident Investigation Board (SHK)
http:///www.havkom.se/indes-eng.html
Taiwan—Aviation Safety Council (ASC)
http://www.asc.gov.tw
United Kingdom—Department of Transport
http://www.dft.gov.uk
USA—Federal Aviation Administration (FAA)
http://www.faa.gov
USA—National Transportation Safety Board (NTSB)
http://www.ntsb.gov ◆

Budgets Snare Investigator Training

By Ron Schleede, Vice-President

I pass on my sincere greetings and best wishes for the New Year.

During several discussions I have had in the past couple of years, particularly during ISASI 2003, with colleagues from around the world, it is evident that air safety investigators, both government and private sector, are feeling the worldwide budget crunch being experienced by the aviation industry. Although many government and industry organizations are cutting budgets that support investigator training, most organizations are able to find funds, even during tight times, to begin and complete accident investigations. However, the quality of the investigation is definitely in question if the investigators have not maintained proficiency through adequate training. I have witnessed this problem firsthand during my career and am also aware that this problem is prevalent at many other organizations around the world.

What would happen if we were investigating an accident involving an airline that was having financial difficulties—many currently are—and we found that pilot, cabin attendant, or maintenance training had been severely reduced because of financial distress? We would probably look long and hard at this factor in the accident causal sequence. We might even develop findings that cite corporate culture and management deficiencies as being involved in the accident causal sequence. For example, if a pilot involved in an operational accident had not had recurrent training, that fact would be a significant finding. Should air safety investigators and their managers be held to lesser standards?

What can ISASI and its members do to help?

I believe ISASI should form a working group, ideally with the assistance of representatives from organizations with success in maintaining an adequate budget for training its investigators. Of course, representatives from organizations that would like to rectify current funding difficulties should also participate. The working group could attempt to develop a logical strategy to aid investigation organizations to resolve this problem.

Based on the comments I have heard in the past couple of years, I know there are valid concerns about this matter. Now we need volunteers to work to resolve the concerns. If anyone is interested in assisting, please contact me directly. I certainly would be available for counsel and support for such an effort (ronschleede@aol.com). ◆

2003 Annual Seminar Proceedings Now Available

Active members in good standing and corporate members may acquire, on a no-fee basis, a copy of the *Proceedings of the 34th International Seminar*, held in Washington, D.C., Aug. 26-28, 2003, by downloading the information from the appropriate section of the ISASI web page at http://www.isasi.org. The seminar papers can be found in the "Members" section. Further, active members may purchase the *Proceedings* on a CD-ROM for the nominal fee of $15, which covers postage and handling. Non-ISASI members may acquire the CD-ROM for a US$75 fee. A limited number of paper copies of *Proceedings 2003* are available at a cost of US$150. Checks should accompany the request and be made payable to ISASI. Mail to ISASI, 107 E. Holly Ave., Suite 11, Sterling, VA USA 20164-5405.

The following papers were presented in Washington, D.C.:

- **SESSION I Keynote Address Human Spirit and Accomplishment Are Unlimited** *by Ellen G. Engleman, Chairman, NTSB, USA*
- **The Practical Use of the Root Cause Analysis System(RCA) Using Reason ®: A Building Block for Accident/Incident Investigations** *by Jean-Pierre Dagon, Director of Corporate Safety, AirTran Airways*
- **From the Wright Flyer to the Space Shuttle: A Historical Perspective of Aircraft Accident Investigation** *by Jeff Guzzetti, NTSB, USA, and Brian Nicklas, National Air and Space Museum, USA*
- **The Emergency and Abnormal Situations Project** *by Barbara K. Burian, R. Key Dismukes, and Immanuel Barshi, NASA Ames Research Center*

SESSION II

- **Accident Reconstruction—The Decision Process** *by John W. Purvis, Safety Services International*
- **CI611 and GE791 Wreckage Recovery Operations—Comparisons and Lessons Learned** *by David Lee, Steven Su, and Kay Yong, Aviation Safety Council, Taiwan, ROC*
- **Application of the 3-D Software Wreckage Reconstruction Technology at the Aircraft Accident Investigation** *by Wen-Lin, Guan, Victor Liang, Phil Tai, and Kay Yong, Aviation Safety Council Taiwan. Presented by Victor Liang.*
- **CVR Recordings of Explosions and Structural Failure Decompressions** *by Stuart Dyne, ISVR Consulting, Institute of Sound and Vibration Research, University of Southampton, UK*

SESSION III Keynote Address Learning for 'Kicking Tin' *by Marion C. Blakey, Administrator, FAA, USA*

- **Investigating Techniques Used for DHC-6 Twin Otter Accident, March 2001** *by Stéphane Corcos and Gérald Gaubert, BEA, France*
- **Investigation Enhancement Through Information Technology** *by Jay Graser, Galaxy Scientific Corporation*
- **Historical Review of Flight Attendant Participation in Accident Investigations** *by Candace K. Kolander, Association of Flight Attendants*
- **Accident Investigation Without the Accident** *by Michael R. Poole, Flightscape*

SESSION IV Keynote Address Growth of ATC System and Controllers Union *by John Carr, President, National Air Traffic Controllers Association, USA*

- **Crashworthiness Investigation: Enhanced Occupant Protection Through Crashworthiness Evaluation and Advances in Design—A View form the Wreckage** *by William D. Waldock, Embry-Riddle Aeronautical University*
- **Enhanced Occupant Protection Through Injury Pattern Analysis** *by William T. Gormley, Office of the Chief Medical Examiner, Commonwealth of Virginia*
- **Forensic Aspects of Occupant Protection: Victim Identification** *by Mary Cimrmancic, Transportation Safety Institute, Oklahoma City, Okla.*
- **Aircraft Accident Investigation—The Role of Aerospace and Preventive Medicine** *by Allen J. Parmet, Midwest Occupational Medicine, Kansas City, Mo.*
- **Expansion of the ICAO Universal Safety Oversight Audit Program to Include Annex 13—Aircraft Accident and Incident Investigation** *by Caj Frostell, Chief, Accident Investigation and Prevention, ICAO*

SESSION V

- **The CFIT and ALAR Challenge: Attacking the Killers in Aviation** *by Jim Burin, Flight Safety Foundation*
- **Flightdeck Image Recording on Commercial Aircraft** *by Pippa Moore, CAA, UK*
- **Flightdeck Image Recording on Commercial Aircraft** *by Mike Horne, AD Aerospace, Ltd., Manchester, UK*
- **An Analysis of the Relationship of Finding-Cause-Recommendation from Selected Recent NTSB Aircraft Accident Reports** *by Michael Huhn, Air Line Pilots Association. Presented by Chris Baum.*
- **Ramp Accidents and Incidents Involving U.S. Carriers, 1987-2002** *by Robert Matthews, FAA, USA*

SESSION VI Keynote Address Accident Investigation in Brazil *by Col. Marcus A. Araújo da Costa, Chief Aeronautical Accident Prevention and Investigation Center (CENIPA), Brazil*

- **Airline Safety Data: Where Are We and Where Are We Going?** *by Timothy J. Logan, Southwest Airlines*
- **Use of Computed Tomography Imaging in Accident Investigation** *by Scott A. Warren, NTSB, USA*
- **Investigating Survival Factors in Aircraft Accidents: Revisiting the Past to Look to the Future** *by Thomas A. Farrier, Air Transport Association of America, Inc.*
- **The Accident Database of the Cabin Safety Research Technical Group** *by Ray Cherry, R.G.W. Cherry & Associates Limited, UK*
- **Search & Recovery: The Art and Science** *by Steven Saint Amour, Phoenix International, Inc.*
- **National Transportation Safety Board Recommendations Relating to Inflight Fire Emergencies** *by Mark George, NTSB, USA*

ISASI Code of Conduct Genesis

By C.O. Miller

Charles O. Miller, "Chuck" or "C.O.," as he was more commonly known, embarked on his final flight west on Oct. 20, 2003, from a hospital in Massillon, Ohio. He died of pneumonia and respiratory failure. He became a member of the Society of Air Safety Investigators in 1968 and maintained continuous membership until his passing. Survivors include his wife of 53 years, Ilene Falls Miller of Wooster; five children, Sandra Miller Koeller of West Bend, Wisc.; Cheryl Miller Davis of Wooster; Deborah Miller Rylant of Santa Maria, Calif.; and Janice Miller Grimes and Kenneth Bartlett Miller, both of Herndon; and 13 grandchildren. While his reputation as an air safety advocate extraordinaire was known far and wide, the deep spirit of his dedication to making flight safe is no better known to any group than the air safety investigators of ISASI. This article, prepared from material he presented at the ISASI annual seminar of October1982, is published as a tribute to his allegiance to the Society, its purpose, and its members.—Editor

One of the indices of self-recognition as well as public recognition of the professional status of any group is that group's adherence to a specified doctrine of behavior. To this end, a *Code of Ethics and Conduct* was begun several years ago and has undergone numerous modifications through inputs from a wide cross-section of Society members. It is now completed and following is its developmental path explaining its rationale and intent.

The Society of Air Safety Investigators, forefather of ISASI, was incorporated in the District of Columbia on Aug. 31, 1964. On Oct. 11, 1978, SASI became ISASI and articles were developed to form the basis of agreement between the international society and member societies. Within those articles, the parties agreed *"to abstain from conduct deleterious to the interest of the Air Safety Investigators profession or which falls below the standards established by the* Code of Ethics *of the International Society of Air Safety Investigators."*

The *Constitution* of the Society also speaks to a *Code* under Article VI, Termination and Reinstatement of Membership: *"A member of the International Society shall be subject to suspension or expulsion…for unethical professional conduct or for willful conduct contrary to the* Code of Ethics *of the International Society…."*

It is obvious from the foregoing that current Society functioning, let alone the precepts on which the Society was founded, presupposes the existence of a doctrine related to both the ethics and conduct of Society members, and the willingness of the Society to discipline breaches thereof.

However, the *Code of Ethics* drafted by Stan Mohler and forwarded to the Council in 1976 languished in "deliberation" until Laurie Edwards amplified on the work done by Mohler and forwarded it to this author in March 1981. The material contained a remarkable number of detailed standards of conduct…a tribute to the astute thought processes of Stan and Laurie.

The only problem then…was the presence of too many good ideas. Thus, the main task remaining was to structure the information so as to simplify matter (albeit add one's own ideas, which is the prerogative of the people who agree to be committee chairmen).

In preparation for the rewrite of the *Code*, reviews were made of codes pertaining to other fields of endeavor, including the Code of Ethics for the (U.S.) Government Service, the Board of Certified Safety Professionals, the American Society of Mechanical Engineers, the American Society for Quality Control, and the American Bar Association.

The result was a decision to delineate "Ethics" from "Conduct" by keeping the Ethics broad, simple, and few in number. As mentioned in the preamble to the *Ethic and Code*, ethics are aspirational. They are goals toward which we all "should" strive. Being broad, they do not contain the kind of words that adequately reflect criteria against which a member's conduct could be judged for disciplinary reason, if it ever came to that. Statements of Conduct fulfill that need. They are the "shall" of member behavior.

About the Author

Chuck Miller, 79, was born in Cleveland, Ohio. A multisport varsity athlete and president of his high school's National Honor Society, he enlisted in the Navy's aviation cadet program on his 18th birthday. He subsequently became a Marine Corps night fighter pilot during World War II. His university-level education includes a B.S. in aeronautical engineering from MIT (1949), an M.S. in system management from USC (1967), and a J.D. from the Potomac School of Law (1980). He was a registered professional engineer-safety (California 1976).

• **Professional Experience**—Upon graduation from MIT, he became a flight test engineer with the Douglas Aircraft Company at Muroc (now Edwards) Air Force Base, assigned to the D-558-II "Skyrocket" research project. Fourteen months later, he became a test pilot with the Chance Vought Aircraft Corp. (CVA) developing guidance systems and "flying" the world's first operational cruise missile, "Regulus," from single and two-place aircraft, from the ground and from submarines. In late 1953, he became staff engineer, cockpit design and flight safety at CVA. Specific safety positions he subsequently occupied were special assistant to the director, Flight Safety Foundation (1962-63), lecturer and director of research at USC's Aerospace Safety Institute (1963-68), director of the Bureau of Aviation Safety of the National Transportation Safety Board (1968-74), president and principal consultant of System Safety, Inc. (1974-93). Consultant clients included government agencies in the United States and abroad, airlines, manufacturers, trade associations, attorneys, and congressional committees. He wrote approximately 125 professional papers and two books. He lectured frequently internationally and taught courses at George Washington University and Embry-Riddle Aeronautical University (ERAU) and USC.

• **Career Highlights**—He was best known for his interdisciplinary and systems approach to accident prevention. For example, he was a principal developer of the advanced safety management course at USC in the mid-1960s, which later evolved into system safety courses taught there and elsewhere. He was granted the prestigious "Fellow" ranking by four major technical societies: the American Institute of Aeronautics (AIAA), the Human Factors Society (HFS), the International Society of Air Safety Investigators (ISASI), and the System Safety Society (SSS). He was retained by the Nuclear Regulatory Commission in its inquiry into the Three Mile Island accident. ◆

Examination of the *Code of Ethics and Conduct* reveals the logic developed that provides the items of Conduct as subsets of five Ethics whose key words are Integrity, Principles, Objectivity, Logic, and Accident Prevention. These categories are somewhat arbitrary and subject to challenges inherent in any classification system. The Ethic/Conduct hierarchy was deemed necessary, however, to ensure an organized approach to the 44 statements of conduct, which, if left standing by themselves, would cause undue reader confusion.

Code review

During earlier drafts of the document, liaison was maintained with Stan Mohler and Laurie Edwards. Coordination was accomplished with Gerry Bruggink, Les Kerfoot, and all members of the Executive Council. All ISASI national societies and chapters had the opportunity to comment, and reviews were done by Jerry Lederer and Ludi Benner, both well-respected members of the air safety profession. Of all the responses, only one expressed disapproval of the document in the total sense because it would be "impossible to comply."

Substantive comments tended to identify three issues that merit consideration:

- The overall degree of detail or complexity of the *Code* as presently constituted. Is it excessive?
- The degree to which the *Code* relates to accident prevention rather than to pure fact-finding tasks attendant to the investigative process.
- The possible conflict between provision of this *Code* and other obligations of members base upon their particular employment or other codes that they are obligated to follow.

The Executive Council determined after review of comments in hand by July 23, [1982], that they did not merit further

ISASI CODE OF CONDUCT

1. INTEGRITY Each Member should at all times conduct his activities in accordance with the high standards of integrity required of his profession. Each Member shall:

1.1 Not attempt, or assist others to attempt, to falsify, conceal, or destroy any facts or evidence which may relate to an accident.

1.2 Not make any misrepresentations of fact to obtain information that would otherwise be denied to him.

1.3 Be responsive to the feelings, sensibilities, and emotions of involved persons, and shall avoid actions which might aggravate what may already be a delicate situation.

1.4 Not divulge fragmentary or unsupported information concerning the accident to parties external to the investigation no matter how publicly important such parties may appear to be.

1.5 Avoid actions or comments which might be reasonably perceived during the fact-finding phase of the investigation as favoring one party or another.

1.6 Establish and adhere to the chain of authority with attendant responsibilities throughout the course of the investigation.

1.7 Not attempt to profit, nor accept profit, other than by normal processes of remuneration for professional services. *(Note: Fee-splitting in the absence of actual work performed or acceptance of contingency fees for investigative activity are not acceptable conduct.)*

1.8 Remain open-minded to the introduction of new evidence or opinions as to interpretation of facts as determined through analysis, and be willing to revise one's own findings accordingly.

1.9 Avoid any implication of professional impropriety by continuously applying the foregoing principles to one's own endeavors, and encouraging the application of these same principles to others associated with air safety investigation.

2. PRINCIPLES Each Member should respect and adhere to the principles on which ISASI was founded and developed, as illustrated by the Society's Bylaws. Each Member shall:

2.1 Promote accident investigation as a fundamental element in accident prevention.

2.2 Assist other Members to carry out their accident investigation tasks.

2.3 Not use membership status to effect personal gain or favor beyond signifying qualification to published membership criteria.

2.4 Not represent the Society or imply a position of the Society in public utterances on any issue unless prior written authority has been received from the Society President.

2.5 Seek advice of the International Council, via the Secretary, in the event a situation arises where contemplated conduct by the Member may violate the Bylaws or *Code of Ethics and Conduct* of the Society.

2.6 Submit evidence of violations of the ISASI Bylaws or this *Code* to the Society's Ethics and Conduct Committee in accordance with procedures approved by the International Council, and refrain from public discussion of the alleged violation until the Committee findings have become a matter of appropriate record.

2.7 Encourage uninhibited, informal interchange of views among Members; however, any sensitive information thus gained shall not be made public or transmitted to others without clear approval of the person from whom the information was gained.

2.8 Have an obligation to improve the professional image of the Society; however, Members shall:

2.8.1 Refrain from unfounded criticism of officers of the Society either publicly or privately unless the matter is investigated thoroughly and brought to the attention of the President with reasonable time being allocated to review the situation and act accordingly.

2.8.2 Refrain from public criticism of any fellow Member unless that individual has first been apprised of the alleged basis for that criticism and given an opportunity for rebuttal.

2.9 Encourage and participate in the education, training, and indoctrination of personnel likely to become involved actively in accident investigation.

2.10 Develop and implement a personal program for a continually improving level of professional knowledge applicable to air safety investigation.

2.11 Transfer promptly to the Treasurer of the Society any Socidelaying in getting the *Code* into circulation. In the past, the delays in processing the *Code* resulted from infinite piecemeal attempts to improve the *Code* language by a select few persons. Now, after two major rewrites, it was recognized that the *Code* may still merit changes, but not to the degree to warrant circulation delay. Further, it was envisioned that 100 percent agreement on all aspects of the *Code* would never be attained.

Final thought

One of the documents encountered in the course of this project was an unpublished paper examining "professionals" from a sociological and historical viewpoint. When discussing how professions formed, the paper noted in part: *"A person did not 'learn' a profession. He 'made' a profession. The profession was his free and open declaration of his acceptance of the duties of his calling.…He stood in front of his townspeople and publicly professed that because of the special knowledge now reposed in him, he had a special duty to discharge on their behalf. He professed a duty of truth, of professional judgment, as he might call it today, and a duty not to hide his substantial knowledge when they should require it."* (Carol Benson: *Ethical considerations for the System Safety Professional*).

Those thoughts would seem to have a bearing on anyone still reluctant to place an ISASI *Code of Ethics and Conduct* before the public. Furthermore, "duty" speaks to those members who are troubled over competing obligations as might be found in the *Code*. To resolve such a conflict, perhaps it is just a matter of how professional one cares to be. (The International Council went on to adopt the *Code of Ethics and Conduct*, with minor changes, as developed by C.O. Miller in collaboration with the others mentioned in the article. Following is ISASI's current *Code of Ethics and Conduct*, which has remained unchanged since its adoption in October 1983.—*Editor)*

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ety funds or property coming into the Member's possession unless specific use thereof has been authorized under the Bylaws.

3. OBJECTIVITY Each Member should lend emphasis to objective determination of facts during investigations. Each Member shall:

3.1 Ensure that all items presented as facts reflect honest perceptions or physical evidence that have been checked insofar as practicable for accuracy.

3.2 Ensure that each item of information leading to fact determination be documented or otherwise identified for a reasonable time for possible follow-up by others.

3.3 Use the best available expertise and equipment in determining the validity of information.

3.4 Pursue fact determination expeditiously.

3.5 Following all avenues of fact determination, which appear to have practical value towards achieving accident prevention action.

3.6 Avoid speculation except in the sense of presenting a hypothesis for testing during the fact-finding and analysis process.

3.7 Refrain from release of factual information publicly except to authorized persons, by authorized methods, and then only when it does not jeopardize the overall investigation.

3.8 Handle with discretion any information reflecting adversely on persons or organizations and, when the information is reasonably established, notify such persons or organizations of potential criticism before it becomes a matter of public record.

4. LOGIC Each Member should develop all accident cause-effect relationships meaningful to air safety based on logical application of facts. Each Member shall:

4.1 Begin sufficiently upstream in each sequence of events so as to ascertain practicable accident prevention information.

4.2 Continue downstream in a sequence of events sufficiently to include not only accident prevention information but also crash injury prevention, search, and survival information.

4.3 Ensure that all safety-meaningful facts, however small, are related to all sequences of events.

4.4 Delineate those major facts deemed not to be safety-related, explaining why they should not be considered as critical in the sequences of events.

4.5 Be particularly alert to value judgments based upon personal experiences which may influence the analysis; and where suspect, turn to colleagues for independent assessment of the facts.

4.6 Express the sequences in simple, clear terms which may be understood by persons not specializing in a particular discipline.

4.7 Include specialist material supporting the analysis either in an appendix or as references clearly identified as to source and availability.

4.8 Prepare illustrative material and select photographs so as not to present misleading significance of the data or facts thus portrayed.

4.9 List all documents examined or otherwise associated with the analysis and include an index thereof.

5. ACCIDENT PREVENTION Each Member should apply facts and analyses to develop findings and recommendations that will improve aviation safety. Each Member shall:

5.1 Identify from the investigation those cause-effect relationships about which something can be done reasonably to prevent similar accidents.

5.2 Document those aviation system shortcomings learned during an investigation which, while not causative in the accident in question, are hazards requiring further study and/or remedial action.

5.3 Communicate facts, analyses, and findings to those people or organizations which may use such information effectively; such communication to be constrained only by established policies and procedures of the employer of the Member.

5.4 Provide specific, practical recommendations for remedial action when supported by the findings of the accident having been investigated singly or as supported by other cases.

5.5 Communicate the above-noted information in writing, properly identified as a matter of record.

5.6 Encourage retention of relevant investigation evidence within the aviation system in such a manner as to form an effective baseline for further investigation of the given accident and/or facilitate analysis in connection with future accidents.

5.7 Demonstrate a respect for interpretation of facts by others when developing conclusions regarding a given accident and provide reasonable opportunity for such views to be made known during the course of the investigation.

Accident Reconstruction and Its Decision Process

The author examines current mockup practices of major portions of an airplane, suggests certain steps the investigator can take to ensure there is value in doing a reconstruction, and looks to the future for new ideas.

By John W. Purvis (MO3002), Partner, Safety Services Internationa

(This article was adapted, with permission, from the author's presentation entitled "Accident Reconstruction—The Decision Process," presented at the ISASI 2003 seminar in Washington D.C., USA, August 2003. The full presentation is available on the ISASI website at http://www.isasi.org.—Editor)

During my more than two decades of accident investigation experience, several issues have increasingly gnawed at the back of my mind. One of those is what I perceive as the seemingly haphazard industry process for deciding when to reconstruct wreckage as part of an accident investigation. In my quest for information, I approached many of the world's leading investigators and discovered, not to my surprise, that the decision process for reconstruction *is* very loose and poorly documented. Sometime mockups or reconstructions just seem to happen.

There seemed to be general agreement that the system could, and should, be improved.

But before we get into the details, let's define what we are talking about. In my mind the words *mockup* and *reconstruction* are one in the same, and I have used always used them interchangeably. The words denote part of the system of collecting physical wreckage from land or under water, sorting it, usually by airplane section, and after a period of investigation, laying it out in some organized fashion. However, this article is restricted to the mockup and its decision process—what happens after the parts are recovered. It will not include material about the actual recovery process of the physical wreckage, or even the initial sorting process.

So, why do a reconstruction in the first place? Clearly, a reconstruction is an excellent investigative tool when used properly. It can be the key for determining the existence of clues leading to the causes of the event. It can eliminate certain ideas as well. Some of the things you may be looking for can include

- structural inflight breakup—breakup patterns, sequence, loss of parts, etc.
- progress and effects of fire, smoke, and heat—fire or smoke patterns
- missile or gun projectile, meteor hits, space debris, etc.
- mid-air collision
- overpressure, such as from a bomb or other explosion
- chemical residue of an explosive device
- missing pieces
- interactions between different airplane systems

On the other hand, even if the causes of the accident have already been established, the mockup can play an important role in preventing a similar situation. For example, if you suspect there was a bomb in a cargo hold, the mockup may lead you to look at a breakup sequence and help you determine where to make changes to the airplane or its operating procedures to control venting so that the overpressure won't cause catastrophic structural damage. Or you could develop stronger cargo containers or other means to control the overpressure. Here are some technical issues that may support a need for reconstruction:

- Evidence from full body X-rays and autopsies, burns, and smoke inhalation

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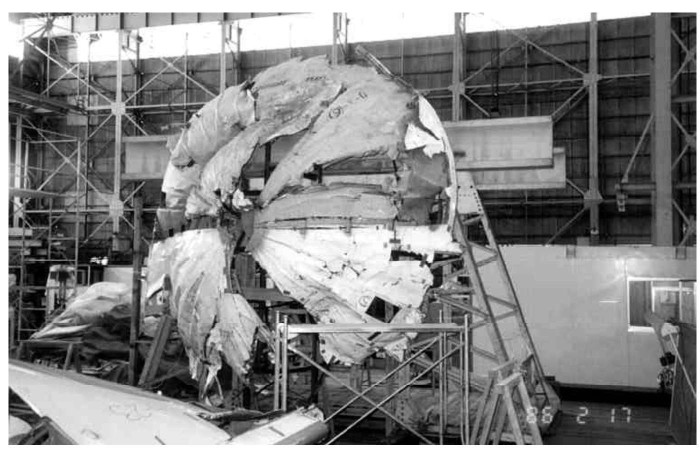
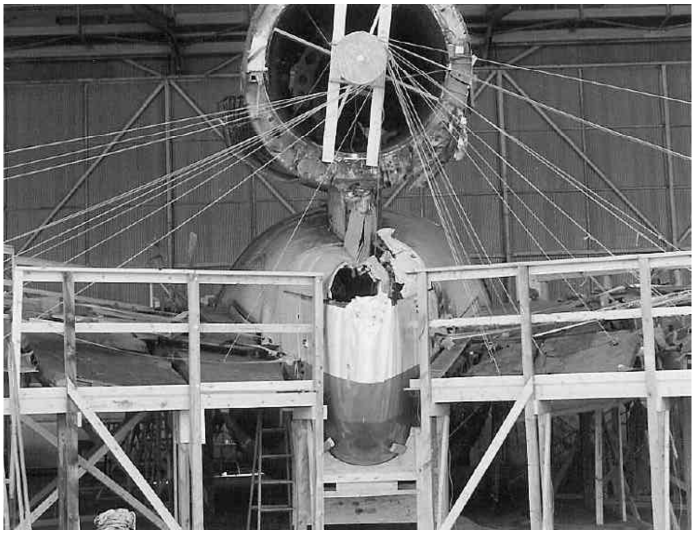


Aft pressure bulkhead 3-D mockup (JAL B-747, 1985).

- Search for explosives
- Evidence of fire and smoke on the structures and systems—the need to determine origin and progress patterns
- Parts found some distance from the wreckage sites
- Major missing parts
- Evidence from other systems analysis
- Evidence derived from a basic, simple layout

Mockup types

What kind of mockups are we talking about? There are several, each having increased complexity. The reconstruction can be as simple as a reassembly of just a few significant pieces of wreckage. This would typically be done on a hangar floor to examine a limited area of the airplane. It's a basic 2-D layout, done flat on the hangar floor, or even a simple 3-D construction. Graduating from there would be a more complex 2-D layout where more of the airplane is laid out on the floor. Finally, there is the complex 3-D mockup, either of a limited section or system of the airplane or a rebuild of an entire section. Let's examine these one by one.



Limited 3-D mockup applying to a specific area in question (UAL DC-10, Souix City).

Basic, simple layout—The decision process is likewise simple. The mockup might be done as, say, a structural group activity, with the group chairman making the decision. The cost of such a layout can be very low since it could be accomplished with existing personnel and in existing space. Some sort of a layout like this is done in most accidents. Potentially, this can be as basic as laying out a few pieces to visualize their relationships, to look for witness marks, or to examine burn or smoke patterns. In many cases, this may be all that is necessary to assist the investigator in determining probable cause. The simple layout is often the starting point for a more formal decision to go further. All mockups have the added benefit of providing a visual inventory of the wreckage recovered.

Comprehensive 2-D mockup—These are also commonly done and can be extensive but still quite cost effective. The tools to make a larger 2-D mockup can be a tape measure, masking tape, some chalk, a clean floor, and basic technical information. It can be indoors or outdoors. The need for a roof would be driven by the expected length of the investigation and the weather. For technical information, you'll need a diagram, probably from the manufacturer, of the area under study.

For example, in the Air Florida 737 accident in 1982, where the airplane ended up in the Potomac River near Washington, D.C., we had an entire hangar floor available and were able to lay out the parts of the airplane as they were recovered from the River. As this developed, we were able to visualize what we had, what was missing, and where the basic parts of the airplane had separated. Eventually, other information from the investigation such as the recorders began to supercede the need for a layout and this effort was halted. However, given the high profile of the accident and the unknown situation in the early days of the investigation, it was a prudent first step to take. The decision to proceed was made by the IIC after consulting with his group chairmen.

A reconstruction is an excellent investigative tool when used properly. It can be the key for determining the existence of clues leading to the causes of the event. It can eliminate certain ideas as well.

Once the tape measure and chalk have been used to mark the outline of the area to be mocked up, putting down masking tape will help with the visualization. Another trick would be to "scale up" the area being looked at. Scaling-up means providing additional space between the pieces by enlarging the space allotted for the layout by up to 20 percent. This allows you to walk between the pieces to visualize/examine them as well as facilitate moving the parts into position. It will also ensure that torn edges will not rub one another and damage the fracture surfaces or remove other evidence. Further, it will provide extra space for laying out the upper and lower surfaces in the same area, although for detailed layouts separate areas would be used for the two surfaces. A 2-D mockup can eventually be converted to a 3-D mockup, if needed.

3-D mockups—These can be the ultimate in physical reconstruction, depending on their extent. However, going to a 3-D mockup is not for the feint of heart, and it comes with political overtones. The costs rise astronomically because of the demands for space and manpower. The physical facilities will be in use longer because of the length of time the mockup will be under construction and preserved. Some large 3-D mockups may require the formation of a separate "reconstruction group" to staff and manage the process. Further, significant effort will be expended on a database to track the parts being hung on the frame. On a major reconstruction, the frame alone can cost tens of thousands of dollars. The overall cost for a major mockup can run into several millions of dollars.

On the positive side, a 3-D mockup has distinct advantages that no other investigative tool offers. It can show the presence or absence of causes, such as penetration or missile impact. It will create sightlines that could provide other clues. These may help reduce or eliminate outside pet theories. On the other hand, it may allow an insight that didn't exist before. It may eliminate or confirm potential criminal activity. It can give a good visualization of missing pieces. Three-dimensional relationships are easier to visualize, especially those involving fire or smoke patterns or curling and bending of parts.

Resources and costs

However, not all areas of the world are created equal. Some poorer States may not have the technical capabilities to accomplish a major reconstruction. More importantly, they may not have the financial resources to pay for such an unusual effort.

The decision process of where to stop and how much of the airplane you *really* need should be determined ahead of time by the right people involved in the investigation.

What is the answer to this costs and resources dilemma? Some years ago, I presented a paper entitled "Who Should Bear the Burden for Extraordinary Investigative Costs?" (ISASI seminar, Boston, *Proceedings* 1999, page 30). The same ideas that were outlined to assist with recovery costs could be applied to mockups, since they could also be considered extraordinary. These solutions might include worldwide insurance or a fund supported by governments or a service tax. Indeed, the NTSB has proposed to ICAO that means be found to help with costs of extraordinary investigations.

One fact stands out bold and clear: In my search for inputs from various experts, I found that large 3-D mockups often do not add much to the technical understanding, and it is difficult to keep them simple, safe, and uncluttered. My experts seem to think that an extensive mockup is rarely required for a technical investigation. Rather, 3-D mockups are important for show and tell. Such a mock is "sexy" from the media standpoint, and makes excellent fodder for the media and politicians. Moreover, it can create both public and political support for the investigative agency seeking recognition, budget, or manpower. Clearly, and appreciably—there can be good and valid reasons and demands, besides technical, that may sway a decision for a mockup.

Along with this, it seems that once a major mockup gets started, it is difficult to stop the momentum, even if the thrust of the investigation changes. The decision process of where to stop and how much of the airplane you *really* need should be determined ahead of time by the right people involved in the investigation. At the same time, there must be flexibility and understanding if the plan needs to be altered or reversed.

Quite often, the floor space occupied by a 3-D mockup could be more productive for other uses. Cost, space, and manpower are only part of the consideration. What will you do with this expensive edifice once the investigation is no longer necessary?

Below is a list of some accidents that involved 3-D reconstructions. It is far from a comprehensive list but rather presented as examples where large mockups were used.

- Swissair 111, MD-11 (forward fuselage)
- Air France, Concorde (fuel tanks and wings)
- TWA 800, 747 (center fuselage/center wing tank)
- United Sioux City, DC-10 (center engine/tail)
- Pan Am Lockerbie, 747 (center fuselage)
- ValuJet, DC-9 (cargo compartment)

Virtual mockups—As computer power grows and methods of digitizing objects improve, there is a growing interest in the virtual mockup, along the line of computer-aided design (CAD programs) currently used to design parts or manufacturing processes. Much of the software is still being developed, but investigators need to understand what is waiting in the wings. At this time, a virtual mockup is typically being done after the 3-D mockup is in place. It is good for cataloguing the rescued pieces and determining what may be missing. It provides another option for the investigator, but its cost and pros and cons are still to be determined.

Jig/frame for Swissair MD-11 3-D mockup (photo courtesy TSB Canada).

One of the possible downsides of this new technology is the ability to manipulate digitized data and the need for systems that ensure absolute data security.

During ISASI 2003, engineers from the Aviation Safety Council (ASC) of Taiwan presented an excellent paper. It explained the use of their impressive Three Dimensional Software Reconstruction and Presentation System (3D-SWRPS) in the CI611 747 accident. The ASC has done an amazing job —because of their effort the future is here, right now.

Eventually, it will be possible to jump directly to a virtual mockup, bypassing the need for a physical 2-D or 3-D mockup. Consider this: we take our digitizing devices to the accident site and digitize the wreckage through a photographic or laser process by taking multiple views of each piece of wreckage. These are then manipulated onto a 3-D view of each part and applied to a virtual frame. The technique will first become common with land-based accidents because the pieces can be easily accessed and digitized. Eventually, the technology may allow us to go under water using remotely operated vehicles, digitizing parts in place, thus eliminating the need of bringing them to the surface. Further it may be possible to do very close up digitizing of fracture surfaces, burn patterns, and other features and apply them to the frame separately.

Let's not fool ourselves. As mentioned previously, there are many non-technical reasons for building some form of mockup, especially a 3-D mockup. As investigators, we probably don't like to hear that the process can be driven by anything but the need for technical information, but it seems to be true. Politics and pressures from the public, families, and media all play roles in whether to build a mockup and how far to take it. There seems to be a desire on the part of the investigative agencies to show off their work. It has public relations value. The grand 3-D mockup has value in obtaining budget, and it could even play a role in personal image building.

While these are major driving reasons to do a 3-D mockup, investigative teams usually underestimate them. Yet, all of these may be valid reasons—if they are accepted by the investigative team as priorities during the planning stages. The time, cost, and manpower factors need to be understood and a determination made that there are no better ways to use affected resources. Here is a summary of some of the resources required:

- Additional parts may be needed
- Hangar space and roofing needs
- Money, and lots of it
- Labor
- Consider an "expanded" mockup—where you make the layout larger than the original design to allow room for interiors, visualization, analysis, and access
- Time
- Management support
- A safe physical frame (3D) designed for the job and with space for adding interiors, carpets, seats, systems, etc., if necessary
- Knowledgeable, professional help (say to build a good frame)
- Multiple mockups (2D or 3D) to cover separate systems or areas of the airplane
- Know where the mockup's final resting place will be—and have a design that allows it to be relocated

So, where are we? In the ideal world, the decision process would be technically based and made primarily by the technical team of investigators. Economics would not play a role. Politics and public pressures would be minimal. The decision to move ahead with a simple 2-D or 3-D mockup would prove to be wise and produce valuable results. (It would "solve" the accident.) The decision to halt the process would be acceptable at any point without retribution.

But we live in a real world. Mockups may not be as valuable as hoped, especially 3-D mockups, when considering the time, money, and effort spent to create them and the space they occupy. I was surprised to discover in my research that there are no well-thought-out, formal plans for the full process. Once a decision has been made to construct a mockup, it is difficult to stop or change direction. The extent of the reconstructions often exceeds technical needs. Finally, when the mockups are complete, they can take on lives of their own beyond the consideration of technical value. No one has thought about "what are we going to do with it?" It can become a monument, a museum piece, or an expensive white elephant looking for a home.

Decision process

The decision process for constructing a mockup is just a small part of the overall management of an investigation. Typically, project management oversight includes the resources and their allocation, the people and their assignments, budget, travel, and research. This should also include, as a distinct and separate item, the reconstruction decision process. In my search, I could not find any organization with an existing formal process setting out the ground rules and decision process leading to a "go" or "no go" of a reconstruction. Mostly, I found it was a "seat of the pants" decision process, handed down informally over the years and accomplished somewhat haphazardly in the heat of the battle. As mentioned earlier, sometimes mockups seem to—just happen.

Typically, project management oversight includes the resources and their allocation, the people and their assignments, budget, travel, and research. This should also include, as a distinct and separate item, the reconstruction decision process.

To improve the process, consider the following:

- It is a major decision; act accordingly
- Think about what you have, what you need (and what of that you can reasonably expect to get), and what you are trying to accomplish
- Consider delaying the mockup decision process while other facets of the investigation proceed; it may turn out you don't need one
- Involve all the interested parties in the decision process
- Attempt to minimize the effects of politics, cost, time, and space requirements or, at least, understand them
- Proceed up the chain, starting with a basic 2-D construction and do it in a logical, well-planned way
- Avoid making it an open-ended research project
- Have a plan and stick with it
- Have an end point in mind

The bottom line is the same: Have a process and follow it.

This article is a distillation of my thoughts garnered over 45 years of aviation experience and supplemented by generous inputs from numerous expert investigators from all over the world. But it is not the ultimate word on the reconstruction decision process; rather it is but one step in an attempt to get investigators to think about where they are going before launching off on an expensive and time-consuming project that ultimately may be unnecessary. We live in a rapidly changing world, which is progressing far more quickly than we can track individually. Thanks to venues like the ISASI annual seminar, we can learn from each other. ◆

Applying 3-D SWRPS Technology

Using a combination of the computer 3-D-graphic techniques and laser scanning, this newly developed Three-Dimensional-Software-Reconstruction and Presentation System can provide sub-centimeter accuracy in the wreckage reconstruction process and can be used to determine fracture behavior and propagation of stress of break up.

By Wen-Lin, Guan, Victor Liang , Phil Tai, and Kay Yong, Aviation Safety Council, ROC

(This article was adapted, with permission, from the authors' presentation entitled "Application of the 3-D Software Wreckage Reconstruction Technology at the Aircraft Accident Investigation," presented at the ISASI 2003 seminar in Washington, D.C., USA, August 2003. The full presentation is available on the ISASI website at http://www.isasi.org.—Editor)

Authors' comments: *Presented here is a methodology and application of a Three-Dimensional-Software-Reconstruction and Presentation System (3D-SWRPS). This system was developed to support the investigation of the China Airlines Flight CI611 inflight breakup accident that occurred on May 25, 2002. The accident aircraft was a B-747-200 carrying 19 crewmembers and 206 passengers. The accident occurred near Penghu Island in the Taiwan Strait. All 225 people on board the aircraft perished in this accident. The Aviation Safety Council (ASC), an independent government organization responsible for all civil aircraft accident and serious incident investigation in Taiwan, has been investigating the accident. At the time of this writing, this investigation is still ongoing and probable causes of this accident have not yet been determined.*

When an aircraft accident happens, investigation begins on scene: searching for and subsequent readout of the flight recorders, gathering relevant factual data, drafting analytical topics, finding out probable causes, and proposing safety recommendations, etc.

That work process is familiar to everyone in this field; however, for an inflight breakup accident such as Pan American Flight 103 (PA103, 747-100), Trans World Airlines Flight 800 (TWA800, 747-141), or Swissair Flight 111 (SR111, MD-11), wreckage reconstruction becomes an important means to help achieve factual evidence collection and subsequent analyses.

There are several relevant applications associated with wreckage reconstruction: finite element analysis (FEA), for the research of structure stress and metal fatigue; computational fluid dynamics (CFD), for verification of flow fields; evaluation of human-mechanics interface and flight controls by engineering flight simulators. For example, in hard landing investigations for a MD-11 and EMB-145, FEA was used to examine the stress of landing gears and support structures. After the Air France Concorde accident in 2000, academic researchers at the University of Leeds applied CFD to analyze the Concorde's phenomenon of combustible stabilization .

Thanks to the advanced technology, the application of 3-D surveying technology provides an even better way to promote the efficiency and cost savings of wreckage reconstruction. This so-called 3-D surveying technology aims the precise 3-D laser scanner at an object to measure its tangent planes, then aligns these planes with selected reference points of alignment to assemble them into complete a 3-D model.

About the principal author: *Michael Guan holds both M.S. and Ph.D. degrees from the Institute of Aeronautics and Astronautics of the Cheng-Kung University in Taiwan, ROC. He started his investigation career in July 1998. Since the establishment of the ASC, he is responsible for setting up the investigation lab in the ASC. Guan is currently the deputy chief of the lab. In his 5-year career with the ASC, he has participated in more than 20 investigations in flight recorders and airplane performance. Most of the accidents and serious incidents happened in Taiwan.*

The methodology and application of 3D-SWRPS can also be used for future accident investigation in the areas of three-dimensional site survey, in secluded mountain area, or inside an airport, to determine the distributional relationship of wreckage and terrain.

Investigation and wreckage reconstruction

Aviation accident investigation integrates the technologies of aerospace, avionics, human factor, flight operation, weather, underwater recovery, spatial remote sensing (global position system, geographic information system, remote sensing), etc. ICAO Annex 13 generally dictates the investigation procedures for the determination of causal factors, and for proposing safety recommendations for the prevention of similar occurrences from happening again.

The investigation of an aviation accident as a whole contains six phases: on-scene investigation, factual data collection, factual verification, analysis, findings, and safety recommendations. The size of the investigation team depends on the nature and severity of the occurrence. A typical investigation team should include groups of flight operations, flight recorders, air traffic control, weather, airport, maintenance, survival factors, human factors, systems, and logistics.

The most difficult accident investigation in terms of budget and logistic is an over water investigation, which requires underwater recovery of the recorders and wreckages. For an inflight breakup accident, wreckage reconstruction becomes very informational helpful in the determination of causal factors. In the past decade, aviation accident investigation agencies have aggressively sought an efficient method of wreckage reconstruction but without significant development. In the last 15 years there were six inflight breakup accidents: PA103, AA811, TWA800, SR111, Air France's Concorde, and China Airlines CI611. As summarized in Table 1, wreckage reconstructions were conducted for the determination of their probable causes.

	PA103	UAL811	TW800	SR111	F-BTSC	CAL611
Accident Date	1988.12.21	1989.02.24	1996.07.17	1998.09.02	2000.07.25	2002.05.25
Report No.	AAIB/2/90	NTSB/AAR-92/0 2	NTSB/AAR-00/0 3			
Possible Cause	In-Flight Breakup	In-Flight Breakup	In-Flight Breakup	In-Flight Fire	during takeoff In-Flight Fire	In-Flight Breakup
	High explosive Device	Explosive Decompression	Center Tank Explosion	fire in the ceiling area	Debris throw the lower wing tank	
Reconstruction Area	Full Fuselage and Tail plane	Foreword Fuselage with Cargo Door	Foreword Fuselage and Center Wing Tank	Cockpit and Foreword Fuselage	Wing Structure and Tanks	AFT Fuselage Sect 44, 46 and 48
3D Mockup	Yes	Yes	Yes	Yes	2D Layout	Yes
3D SWRPS	No	No	No	No	No	Yes
Finite Element Analysis	Yes		Yes	?	Yes	Yes

Table 1: Aircraft Wreckage Reconstruction for Inflight Breakup Investigations in Recent 15 Years.

Manufacturer	**OPTECH (ILRIS-3D)**	**RIEGL (LMS Z420)**
Range	30 m ~ 2000 m	~ 800 m
Accuracy	3 mm	5 mm
Speed	2000 points/sec	3000 points/sec
Spot spacing	At 100 m < 2.6 mm	?
Controller	PDA (serial, IR)	PC / Laptop
Weight	12.0 KG	14.5 kg
Eye Safety	Class I Laser	Class IIIR

Table 2: Comparison of Long-Range and Precision 3-D Laser Scanners.

But irrespective of whether an aircraft crashed on land or into the sea, after salvaging the wreckage, investigators need to identify and examine the wreckage pieces one by one. When the source of force and destructive direction of structure could not be determined, then reconstruction using the wreckage collected is a viable method.

In general, to evaluate probable causes, determination of the failure sequence is required. However, not all accidents need wreckage reconstruction. For example, in the case of Singapore Airlines Flight 006 (SQ006), which crashed on the runway at Chiang Kai-Shek International Airport in Taiwan on Oct. 31, 2000, its structure failure sequence could be determined by ground collision marks and wreckage distribution, and hence did not require reconstruction of the wreckages.

Wreckage reconstruction serves three purposes: first, to find out the source of structure failure; second, to judge the endurance of the condition of forces; and third, to study the propagation of stress or force between main structures. Several preparation considerations are required prior to the wreckage reconstruction: 1) Evaluation of the reconstruction site; 2) Identification and tagging of wreckages; 3) Partial or whole wreckage reconstruction; 4) 2-D wreckage layout or 3-D wreckage reconstruction; 5) Design of frame or mockup; 6) Wreckage cut up and crane operation; 7) Accessibility to the mockup; and 8) Safety concerns of personnel at work. etc.

The determination of whether to undertake a partial or whole wreckage reconstruction is an important issue. A decision should be made according to clues and factual information collected during the on-scene investigation phase. These clues can usually be radar tracks, flight recorder data, related testimonies, and characteristics of salvaged wreckages. Those characteristics include failure conditions at different sections of the fuselage, burning conditions, and fracture surfaces, etc.

For example, after the inflight breakup of TWA800, the primary radar data display indicated that wreckages followed the flightpath spread along the downwind side. In interviews, testimonies such as "fireball and descending" appeared. There were abnormality and high-energy sound waves recorded in the cockpit voice recorder. Therefore, wreckage reconstruction of TWA800 emphasized finding the source of explosion; hence, the reconstruction was focused on the fuselage and central fuel tanks sections.

Furthermore, after the inflight breakup of SR111, primary radar data indicated that wreckages followed the flightpath and spread along the downwind side. Before the cockpit voice recorder stopped recording, flight crews were discussing a "cabin smoke problem." Therefore, wreckage reconstruction of SR111 emphasized finding the source of spark and smoke; reconstruction sections were then focused on the fuselage, flight deck, and electrical wiring. In contrast to past aircraft wreckage hardware reconstruction, the TSB of Canada was the first to produce panoramic images of the flight deck, which provide wreckage inspection technology similar to "virtual reality." In conjunction with wreckage sketches, 3-D CAD models, and relevant power wiring diagrams, TSB was able to demonstrate evidence of wire burning during the breakup sequence. The 3-D CAD model used to establish SR111 wreckage reconstruction is an improved method from the traditional hardware reconstruction.

From the experience of using the 3-D CAD model developed by TSB in SR111 investigation, the ASC went on to develop the 3-D Software Wreckage Reconstruction and Presentation System (3D-SWRPS).

Architectures of 3D-SWRPS

The 3D-SWRPS utilizes a combination of computer 3-D-graphic techniques, laser scanning of wreckages recovered, the structure frame of an identical B-747-200 aircraft, and a generic CATIA engineering model of the same type of aircraft. It provides sub-centimeter accuracy in the reconstruction process. It can also be used to determine fracture behavior and propagation of stress of the breakup. In addition, the 3D-SWRPS can combine radar return signal, wreckage salvage data, and ballistic simulation program to assist analyzing the breakup sequence.

3D-SWRPS can provide sub-centimeter accuracy scan quality, and can be used to determine fracture behavior and aircraft breakup propagation. Advantages of the 3D-SWRPS are a) no wreckage disposal problem; b) reusability, once developed, the methodology can be used for other accident investigation; c) only one-half of the cost as compared to hardware reconstruction; d) flexibility in combining with simulation program for better analysis support.

The 3D-SWRPS project uses a long-range and precise 3-D laser scanner. Table 2 (page 13) summarizes the functions of 3-D laser scanners OPTECH (model ILRIS) and RIEGL (model LMS Z420). Based on the reliable operational safety of a laser, it can achieve precision to 3 mm with maximum range of 2 km. In order to align the 3-D wreckage model onto the "reference model," two models were collected, a Boeing 747-200 CATIA model and a scanned model of a China Airlines B-747-200 cargo aircraft. The ASC selected the ILRIS to do the job. The 3-D scanning was done to the whole aircraft's inner and outer body.

Sections 44, 46, and 48 of the CI611 wreckage were 3-D scanned and modeled at Hangar II of Tao Yuan Air Force Base (TAFB), Taiwan. In total, 161 pieces of wreckage were digitized and modeled into 3D-SWRPS; among them, 50 wreckage pieces needed crane handling to be scanned. Wreckages less than 1 m in size or smaller cargo floor beam pieces were ignored. The 3-D scanning and modeling process took nearly 1 month.

3D-SWRPS represents a different processing method for the aircraft wreckage reconstruction as follows:

- 3-D object digitizing: Once each individual piece is scanned by the laser scanner, the piece is then digitized. It processes organized point clouds, as produced by most plane-of-light laser scanner and optical systems.
- Aligning multiple datasets: During the digitizing process, investigators need either to rotate the wreckage or move the 3-D laser scanner in order to measure all wreckage surfaces. As a result, the digitizing process produced several 3-D scans expressed in a different 3-dimensional coordinate system. This step consists of bringing these scans into the same coordinate.
- Merging multiple datasets: A 3-D-graphic virtual reconstruction allows investigators to automatically merge a set of aligned 3-D scans of wreckage into a reference model, which was obtained from the same type of aircraft and Boeing's CATIA model. This procedure reduces the noise in the original 3-D data by averaging overlapped measurements.
- Polygon editing and reduction: In order to control the computer's memory allocation, this step uses the polygon reduction tool to reduce the 3-D model's size.
- Manually edit surfaces: Especially with uneven surfaces that may cause data loss.
- Texture mapping: Investigators can create texture-mapped models from the digitized color 3-D data.
- Breakup animation: A major function of this module is to simulate the inflight breakup sequence by combining radar data, ballistic trajectory, wind profile data, and wreckage 3-D model data in time history.

The 3D-SWRPS consists of six stand-alone programs: ballistic trajectory, polywork, multigen creator, polytrans, rational reduction, and the recovery analysis and presentation system (RAPS). The U.S. NTSB developed the ballistic trajectory program. The TSB of Canada developed RAPS. The Investigation Laboratory of ASC Taiwan developed other programs and integrated the whole as 3D-SWRPS.

After all 161 pieces of wreckage were scanned and modeled, ASC investigators spent 3 months to aligning and attaching 62 pieces onto the reference model, based upon their frame station and stringer number of the original aircraft. The result gives the investigators the capability to interact with the 3D-SWRPS to view the inner and outer side of the fuselage in different angles, to further examine the fracture conditions of neighboring wreckage pieces, metal fatigue and stress propagation of structures. In addition, the 3-D wreckage model also links to the database of the Systems Group, where investigators could access wreckage attributes through a secured Intranet. These attributes include size, station, section, damage photos, 3-D model, etc.

Results and discussion

Cargo aircraft 3-D model—The reference model of a B-747-200 cargo aircraft includes nose, fuselage, horizontal and vertical tails, inner frame, duct, aft pressure bulkhead, and door frames. During a D-check of the cargo aircraft, the heat insulation blanket was removed. The ASC spent 30 hours scanning the inner portion of the model.

CI611 wreckage 3-D model—Scanning and modeling 161 pieces of wreckage took 2 months. Each piece requires three to eight scans depending on its shape. The basic element of a 3-D model is composed of polygons. According to the conditions of the crooked and fractured wreckage, each 3-D model consists of polygons ranging from 30 to 70,000 in numbers, and

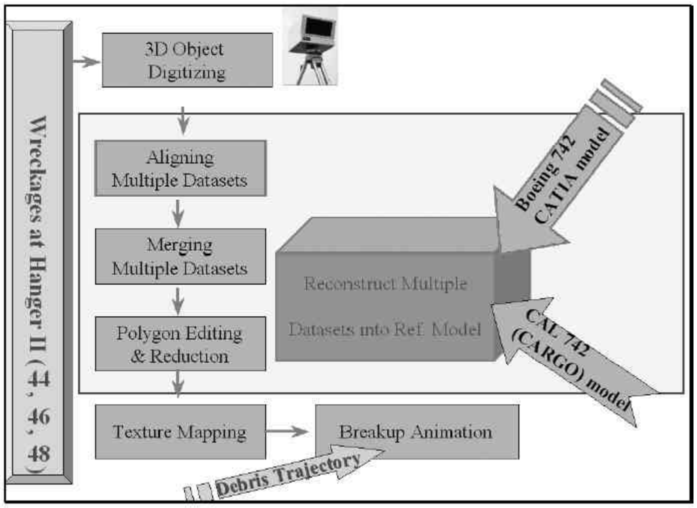


Figure 1. Crane operation photo of item 2136 and side view of 3-D model.

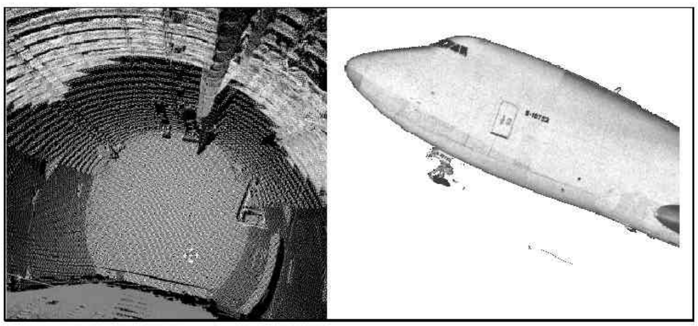


Figure 2. 3-D model of item 640 and reference frame model.

from 3 MB to 120 MB in file size. The data processing platform is a PC-based hi-level graphics workstation, equipped with a 1024 MB memory, AGP 4x graphics card, and 80 GB hard drive.

Figure 1 illustrates the crane operation and side view of item 2136. The reference number of stations and stringers are between 1960 and 2100, and between S-07L and S-11R, respectively.

The entire 3-D wreckage model is aligned with reference coordinates of stations and stringers. Wreckages with the least-deformed fracture surfaces were selected first as the reference point of alignment and aligning surfaces. The greatest difficulty in 3-D software reconstruction is the computer's memory allocation and the appropriate selection of reference point of alignment. An uneven selection of the reference point of alignment could cause gaps in the connecting surfaces of wreckages, or the alignment could not be done.

By using the reference coordinates of item 640, when manually aligning this piece onto the reference model of a B-747-200, it shows that the item belongs to section 46 of the right aft fuselage structure. Figure 2 indicates that the severe damage of the outer blend is located at stations 2060 and 2180, and a large "V"-shaped fracture existed at station 2180. Figure 2 also shows the inner view of item 640; the aft cargo-door frame is slightly deformed but intact with relevant frames of the fuselage. Figure 2 also illustrates significant fracture conditions between stations 1920 and 1980.

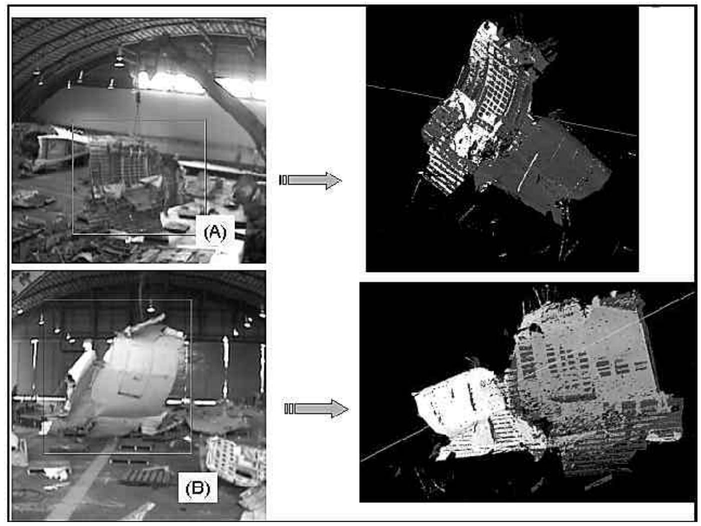


Figure 3. Comparison of 2-D layout and 3-D software reconstruction at section 46 and aft pressure bulkhead (upside-down view from the right).

In fact, it is very useful to adopt the 3D-SWRPS to evaluate or measure fracture behaviors. It could more easily measure the arc distance, including curve angles on the surface of wreckages, than to mark or compare the differences between the wreckage and reference model.

Totally, 1,442 pieces of wreckage were salvaged from the Taiwan Strait, which were then identified and placed at the Air Force base hangar for hardware reconstruction. After final tagging, sketching, and initial examination, all wreckages were arranged on the hangar floor according to their respective fuselage station and stringer numbers. Up to this point, there are 62 pieces of wreckage aligned on the reference CATIA model. Figure 3 shows the 2-D layout and 3-D software reconstruction at section 46 and the aft pressure bulkhead view from the outer right side.

A comparison

The use of 3D-SWRPS is generally better than 3-D hardware reconstruction. In fact, manpower, budget, and space required for 3D-SWRPS is much less than for 3-D hardware reconstruction. 3D-SWRPS has great advantages in reusability, ballistic trajectory analysis and simulation, and in conjunction with finite element analysis.

The cost of 3-D hardware reconstruction for CI611 was US$143,000, only for section 46. The cost of 3D-SWRPS for CI611 was US$91,500, including crane operation, rental of a 3-D scanner, and labor cost of two engineers. Use of 2-D wreckage layout together with 3-D software reconstruction might be the best choice if 3-D hardware reconstruction is not really that necessary from the investigation point of view.

3D-SWRPS can provide sub-centimeter accuracy scan quality, and can be used to determine fracture behavior and aircraft breakup propagation. Advantages of the 3D-SWRPS are a) no wreckage disposal problem; b) reusability, once developed, the methodology can be used for other accident investigation; c) only one-half of the cost as compared to hardware reconstruction; d) flexibility in combining with simulation program for better analysis support. ◆

Crashworthiness Investigation:

A View from the Wreckage

The author presents an examination of the history and beginnings of crashworthiness investigation, and how such investigations provide the opportunity to change design or procedure to improve survivability in aviation accidents.

By William D. Waldock (MO2906)

(This article was adapted, with permission, from the author's presentation entitled "Crashworthiness Investigation: Enhanced Occupant Protection Through Crashworthiness Evaluation and Advances in Design—A View from the Wreckage," presented at the ISASI 2003 seminar in Washington, D.C., USA, August 2003. The full presentation is available on the ISASI website at http://www.isasi.org.—Editor)

"Crashworthiness" is the technology and means by which we *mitigate* the effects of accidents. Nothing we do in crashworthiness will ever prevent an accident, only change the outcome. For some folks (including investigators), this requires a fundamental paradigm shift. Much of what we do in safety and accident investigation is focused on stopping the accident. To do crashworthiness, we must assume that we *will* have accidents. Only then can we learn and accomplish the things necessary to protect the occupants of aircraft in accidents we cannot stop.

A proper definition of accident survivability gives us background and a starting point. A survivable accident is one in which *the impact forces that reach the occupants remain within human tolerance,* ***and*** *occupiable space is maintained through the impact sequence,* ***and*** *the environment remains livable throughout the impact and beyond.* All three situations *must* exist for survival to be accomplished.

Accident investigation is like the discipline of history in many respects. We start from today and work backwards through time, gathering the data, evidence, and information necessary to understand how we got to where we are. There are some people who believe that crashworthiness is a somewhat new approach. In reality, we are building on the work of those who came before. I could spend hours telling you about folks like Dr. Jerry Snyder, Harry Robertson, Doc Turnbow, Vic Rothe, Chuck Miller, Richard Chandler, and many others. Many survivors of crashes owe their very lives to those folks.

In the field of crashworthiness *investigation*, two people stand out, for they started it all. Hugh DeHaven is literally the "father" of crashworthiness. Like so many folks in aviation safety, he started with a plane crash—his own. In 1916, while training to be a Royal Canadian Flying Corps pilot, he was involved in a mid-air collision in which everyone but him was killed. He was seriously injured in the crash and spent 6 months in the hospital. After that, since he couldn't fly anymore, he was assigned to investigate plane crashes. He was intrigued by several crashes in which the airplane was relatively intact, but in which the occupants were killed or seriously injured. This put him on the road to the study of *injurious mechanisms*. He was a graduate of the "first" formal training course for aircraft accident investigators, his certificate signed by Jerry Lederer himself. Through his work at Cornell, AvCIR, and beyond, he founded the belief system that we use today. His "packaging principles," first published in 1950, provide the basis for any crashworthy design.

They are

- "The package should not open up and spill its contents and should not collapse under expected conditions of force and thereby expose objects inside it to damage."
- "The packaging structures which shield the inner container must not be made of frail or brittle materials; they should resist force by yielding and absorbing energy applied to the outer container so as to cushion and distribute impact forces and thereby protect objects inside the inner container."
- "Articles contained in the package should be held and immobilized inside the outer structure by what packaging engineers call *interior packaging*. This interior packaging is an extremely important part of the overall design, for it prevents movement and resultant damage from impact against the inside of the package itself."
- "The means for holding an object inside a shipping container must transmit the forces applied to the container to the strongest parts of the contained objects."

If we assume that the "container" is an aircraft fuselage, and the "interior packaging" is the restraint system and tiedown chain, then we have an excellent perspective on impact crashworthiness, and can understand how to design systems to minimize injury.

DeHaven's assistant at Cornell was A. Howard Hasbrook. Like DeHaven, Hasbrook survived a near-fatal plane crash while crop-dusting in 1946. As Administrator of Field Research at the Crash Injury Research center, Hasbrook became convinced that investigation into "survivability factors" would allow changes in design and construction of aircraft to reduce the likelihood of injury or fatality.

In 1951, the Cornell University Medical College published the first guide (written by Hasbrook) for accident investigators to use in gathering the types of information necessary to do a

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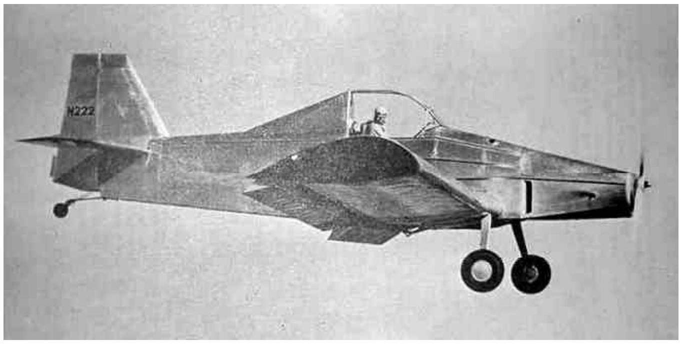

AG-1 concept.

crashworthiness evaluation of an aircraft accident. It specified procedures to use at an accident scene to preserve survivability aspects and identified the types of data necessary to the crashworthiness investigator. Most of it is as pertinent today as it was then. It identified the three basic pieces of evidence that *must* be gathered: angles, velocities, and distances—measurements that are often lacking in accident reports today. It also provided guidance to correlate the physical evidence gathered at the scene with injury patterns determined by autopsy or medical examination of survivors. Hasbrook conducted the first "crashworthiness" investigation on an airline plane crash in August 1952 of a Northeast Airlines Convair 240 accident at La Guardia. In 1954, DeHaven "retired" from the Aviation CIR program, and Howard Hasbrook became the Director.

Hasbrook's lifelong devotion to crash survival investigation continued through his tenure at AvCIR and later the FAA Aeromedical Branch. During his career, he wrote many articles and reports, mostly focused on how to improve survival in plane crashes. Though he was already at the FAA, Howard provided technical advice during creation of the first "crash survival investigator's school" through AvCIR in Phoenix. He remained an active pilot virtually till the end of his life, remembered as a spur pushing the need for survival investigation.

Applying the lessons

In 1950, Fred Weick designed the AG-1 at Texas A & M. This was a crop-duster incorporating recommendations made by DeHaven and Hasbrook. The concept involved positioning the cockpit above and behind much of the mass in the airplane, with that structure being designed to progressively deform in a crash, thereby absorbing energy and attenuating the g-loads that reached the cockpit. It had a tri-axial steel roll cage around the pilot and tied him into the seat with a five-point harness that locked automatically using inertia reels. It was designed to provide a "40-g island of safety" for the pilot. The AG-1 evolved into the Piper Pawnee. Crop-dusters today still incorporate much of this technology (refined a bit) to protect the pilot in a crash. ASI's who have investigated AG accidents find that pilots in these crashes experience a much lower injury and fatality rate than those involved in accidents with other types of aircraft.

In the general aviation world, Beechcraft was the first manufacturer to use "crashworthiness" in design of its aircraft. The 1950s vintage Bonanzas and twin-Bonanzas had a long nose section, a reinforced keel and cockpit area, a wing designed to attenuate energy in a crash, seats that were attached with bolts to the spar trusses with belts attached to the seats, and a breakaway instrument panel and yoke designed to reduce head and upper body trauma. The company even incorporated shoulder harnesses in some models (not required in the rest of the GA fleet until those aircraft manufactured after 1978).

To a crashworthiness investigator, these ideas seem like mom and apple pie. Beechcraft began a public relations campaign to "sell" safety, based on DeHaven's and Hasbrook's work at CIR. The details are spelled out in a report authored by DeHaven in 1953, "Development of Crash-Survival Design in Personal, Executive, and Agricultural Aircraft." The folks at Beech were ahead of their time. Crashworthiness was a marketing flop. GA aircraft owners didn't want to pay for the extra systems in their aircraft. Aircraft should be made to fly, not to crash. They might even be trapped in a burning airplane by the shoulder harnesses. By 1960, Beechcraft abandoned its crashworthiness efforts and went back to building "standard" airplanes.

In 1959, the Cornell-Guggenheim Foundation became affiliated with the Flight Safety Foundation, and Flight Safety Foundation took over administration of what was now AvCIR (Aviation Crash Injury Research) in Phoenix, Ariz. The main focus of the program was now to develop and carry out test crashes using real aircraft to gather data on what actually happens in a crash. In a joint effort with NASA, the U.S. Army, and the FAA, 43 tests were completed, including the famous DC-7 and L1649 Connie crashes. Experiments gathered data on kinematic and impact-related issues, seat and restraint systems, fuel containment, and fire. Many of the pioneers of aviation safety were affiliated with the program over the years, including Jerry Lederer, C.O. Miller, Doc Turnbow, Harry Robertson, John Carroll, Joe Haley, Stan Desjardins, and, of course, Howard Hasbrook. Doc Turnbow and John Carroll started the first crash investigator's school (now the International Center for Safety Education run by SIMULA), and Doc continues to dazzle students with kinematic evaluation and application.

On the federal side of the house, Dr. Stan Mohler and Dr. John Swearingen ran the Civil Aeromedical Research Institute (CARI), which later became CAMI. They brought Hasbrook over to the FAA in 1959 and began investigating crashes to understand how people were injured or killed. In 1960, Dr. Jerry Snyder joined CARI and became chief of the Physical Anthropology Lab and the Protection and Survival Lab at Oklahoma City.

Dr. Snyder's many articles and reports are another excellent source of survivability information. In 1966, the name was changed to the Civil AeroMedical Institute (CAMI), and over the years the programs and research have continued to provide data and guidance relating to survivability and crashworthiness. Several facilities have provided critical crashworthiness data over the years. The FAA Technical Center in Atlantic City continues to research impact and fire survivability issues.

Airline crashworthiness investigation

Since Hasbrook first investigated an airline accident from the crashworthiness perspective in 1952, we've come a long way. Particularly over the last 25 years or so, "survival investigation" is an essential part of any "major" investigation. The NTSB has gotten very good at investigating crashworthiness issues in major airline crashes. The FAA has been gradually applying the lessons learned from these investigations and has improved the survivability of modern airline aircraft. Three examples are case in point:

The first involves Air Canada Flight 797, which experienced an inflight fire in 1983. The aircraft made an emergency landing at Cincinnati after 18 minutes, with the smoke and toxic gasses building up through the entire descent. Twenty-three of the 46 people on board died. Among the survival issues examined were the early stages of the fire in the lavatory during which it was not detected. As a direct result of this accident, the FAA mandated that smoke detectors be installed in airline lavatories. Another issue was the rapid involvement of the cabin furnishings and how significantly they contributed to the smoke and toxic gas build-up. The focus remained on the various plastics in airline cabins for the next few years. Ironically, the fire had not originated from someone throwing a lit cigarette into the trash bin, but was electric in origin. To this day, some folks still believe that it started with a cigarette.

The second accident happened in Manchester, England, in 1985. During the takeoff run, a combustor can exploded on the left engine of the 737, through a section of the can through the shroud and into the underside of the wing. It hit a cast aluminum inspection plate and shattered a 6-inch hole in the wing, resulting in a massive fuel leak. Due to somewhat unusual circumstances, the fire burned much hotter than Jet A normally does, resulting in a burnthrough and penetration of the aircraft sidewall skin in about 20 seconds. The cabin furnishings became involved very quickly and generated a tremendous amount of toxic gasses. Combined with major compromises to the evacuation, 55 people lost their lives, even though the crash/fire/rescue efforts and actions of the crew were magnificent. This accident caught quite a bit of attention and, in combination with the Air Canada accident and efforts of the FAA Tech Center, resulted in major changes to materials used in airline cabins. Experiments began to focus on fire suppression as well, including use of cabin water spray systems. Dr. Helen Muir and others in Britain began to experiment with smoke hoods and changes in seating configurations. The CFR community experimented with ways to introduce foams into a burning airliner cabin, culminating in the Snozzle device in use today.

The last example is the Continental DC-10 accident at LAX in 1978. The aircraft blew tires on the left main landing gear at V_1 and the crew rejected the takeoff. The aircraft overran the end of the runway and the left main gear collapsed. When the tires failed, they threw fragments into the underside of the left wing, opening several holes in that fuel tank. When the aircraft stopped, the pooling fuel ran toward the fuselage and ignited. The fire was concentrated mostly on the left side of the aircraft and center fuselage. Most of the emergency exits were unusable due to the fire. The two right forward exits deployed properly, but the slides were painted orange-yellow for visibility if used as life rafts. Fire never touched the forward slide, but due to the radiant heat uptake, the slide burst. Several passengers and a flight attendant had to exit through the copilot's side window. Some were injured by the rope or dropping the 8 feet or so after they were outside. A major change here was the requirement that slides be covered with a reflective outer layer, to reduce the radiant heat susceptibility and allow the slide to remain functional longer during an evacuation.

Left, S-tube seat. Right, pre-1988 general aviation seat.

These examples focus mainly on fire crashworthiness. Harry Robertson is perhaps the premiere fire safety investigator in the world. His designs for improving fire survivability are in use on military aircraft around the world today. They are even used in Indie cars to reduce the likelihood of fuel spill in a racecar crash. A current research project is under way to better understand how to minimize the possibility of fuel release in a crash and therefore reduce the likelihood of impact or post-impact fire. In the airline world, fire and its by-products pose the greatest threat to occupants during a crash, yet fire is involved in relatively few crashes.

Over the years, many improvements have been made in impact survivability as well. The seat/restraint systems are a major focus in airline crashes. The old standards for certification were grossly inadequate, requiring only that a passenger seat withstand 9 g's horizontally, 4.5 vertically, and 1.5 laterally. These seats were only required to be tested statically. Over the years, after many investigations in which passengers were injured or killed because seats failed or pulled out of the floor tracks, changes were made to require 16 g's horizontally, and be tested dynamically. We've gotten better, though we still have a ways to go. One problem remains involving old aircraft. Installing a 16-g seat in a 9-g track and floor just changes the weak point and moves where it fails. Plus, thanks to Col. Stapp and others, we know that a properly restrained human can withstand much higher g-loads in a crash than the seats. A focus for the future.

General aviation crashworthiness

In the report, "Survivability of Accidents Involving Part 121 U.S. Air Carrier Operations, 1983 Through 2000," the NTSB points out one of the recurring problems with analysis of general aviation crash survivability. It states, "The Safety Board examined only air carrier operations performed under … Part 121 because the majority of the Board's survival factors investigations are conducted in connection with accidents involving Part 121 carriers. Therefore, more survivability data are available for Part 121 operations than are available for Part 135 and Part 91 (general aviation) operations." Looking at a 10-year average, GA still experiences about 2,000 accidents per year. In about 25 percent of these, serious injuries and/or fatalities occur. In most cases, there is little to no data relative to the specific injuries themselves or what may have caused the injuries. Without good data, it is difficult, if not impossible, to determine what hurts people, nor make changes to prevent injuries in the future. Two case examples illustrate the points, as well as examine the issues with crashworthiness.

The first of these accidents happened in 1989. The aircraft was a Cessna 172N, built in 1977, being flown by a 120-hour private pilot. The flight was intended to show the pilot's girlfriend (passenger) what aviation was all about. The pilot had not flown in 63 days and had had problems with landings. On his first touch-and-go attempt, the pilot was rushed, rounding the base to final turn and touching down at a high vertical velocity. The aircraft bounced off and flew horizontally down the runway about a wingspan above the surface. Witnesses indicated that the flaps appeared down (40 deg) at the initial contact, then retracted near the mid point of the runway. The aircraft then nosed over and hit the runway. It slid out in the infield area, hit a taxiway sign, and flipped to the left, with the landing gear all failed. The pilot experienced multiple displaced fractures of his lumbar vertebrae and is permanently paralyzed from the waist down. The passenger suffered factures of the thoracic and lumbar vertebrae, but at a lesser severity and without displacement.

Examination of the wreckage revealed why the injuries were differing in severity. During impact, the nose gear failed rearward and positioned under the pilot's seat area. This caused a reduction in collapsible space (stopping distance) of about 6 inches. It also projected upward and bent his inboard seat rail up through the leading edge. This caused about a 15-deg lateralization to the left and a 50 percent increase in the g-loads he experienced, as compared to the passenger. Further, the brittle nature of the seat frame undoubtedly increased the g-spike that both occupants experienced. The result was the injury patterns experienced by the two occupants. Without the basic data (distances, angles, and velocities), it would have been difficult to understand why the injury patterns were what they were. The investigation also revealed the inherent lack of crashworthiness of most older GA aircraft.

The second accident is a good illustration of how important crashworthiness investigation can be. It involved a new Cessna 172S, which was designed according to the modified Part 23 requirements specifying 22-g seats and dynamic testing.

The aircraft had two occupants, an instructor and a student. They were attempting a touch-and-go landing when the aircraft encountered a severe lateral wind gust or microburst. The right wing came up suddenly and violently, rolling them over to the left. The instructor's attempt to correct was unsuccessful and the aircraft cartwheeled to the left off the runway. The left wing failed at the root, and the fuselage broke apart at the aft cabin bulkhead frame. The aircraft came to rest inverted. The IP extracted the unconscious student and both were medevaced to the hospital. The student had suffered serious injuries as a result of the left wing root intruding into the cabin area and his head striking the structure. The instructor had minor injuries only. Examination of the wreckage showed that the restraint systems performed normally. Even though this was a severe impact sequence, both occupants survived. Contrasting the damage to the aircraft with the previous case example, the new S-model experienced a much more severe impact, with a much more complex impact situation than the older aircraft. Yet the injuries to the occupants of the new aircraft were much less.

Seat/restraint issues

The older GA seats had little built-in crashworthiness. They were made of rigid, brittle materials and tended to fail in ways that increased injury severity. Further, the seat belt anchorages were attached to the floor, rather than to the seat. The ideal pull-off angle across the pelvis is 45 degrees. That angle can only be achieved if the belt anchorage is attached to the seat frame itself. The newer 22-g GA seats incorporate this feature as well as other changes, which were all learned through crashworthiness investigation. For example, in older aircraft the anchorages attached to the floor result in a change to the belt pull-off angle if the seat is positioned anywhere other than to accommodate a 50th percentile male mesomorph (5'9" tall with average arm leg torso proportions). When a tall person moves the seat all the way back, it results in an acute vertical lap belt pull-off angle. In a crash, this can dislocate the hips or break the femurs. A short person moves the seat all the way forward, resulting in a shallow pull-off angle, which may actually be positioned over the lower abdomen. In a crash, this person ruptures the spleen or intestines.

There are several seat systems that are intentionally designed to attenuate energy in a crash. The SIMULA Corporation manufactures several energy-attenuating seats for use in a variety of military aircraft. The S-tube seat was originally designed in the 70s for use in some general aviation aircraft. The retro-fit can be accomplished in the Cessna 182 and C206 models, and has been incorporated in the Mission Aviation fellowship aircraft for years. This particular seat was installed in a C206 that crashed in South America a few years ago. All the occupants survived an extreme crash, with minimal injury. It is one further example of how applying the lessons learned through crashworthiness investigation can be applied to change aircraft designs and systems to improve survivability.

What the crashworthiness engineer needs from the field investigator is the right data necessary to *do* a crashworthiness evaluation. For fire crashworthiness, we need evidence of fuel release points, fire origin and propagation, ignition sources, and fire effects. For impact analysis, we need angles…impact angles, attitude at impact, etc., velocities, impact airspeed, deceleration once on the surface, and a good description of the entire impact sequence and how non-linear decelerations might have happened. We also need distances. The vertical and horizontal ground scar measurements, as well as vertical and horizontal crush distances in front of and below the occupants. We also need good descriptions of deformations to the aircraft (photos work wonders) as they relate to the surrounding terrain. We also need good medical and pathologic information as to injuries and injury mechanisms as they relate to the victims. The old days of finding cause of death listed on the autopsy report as "airplane crash" just don't allow us to understand *why* the people got hurt or killed.

If we are truly going to improve survivability, crashworthiness investigation can provide the best data available to make those changes necessary. We *can* change the future, by learning from the past! ◆

Weakness of CVR Recordings

Learn why cockpit voice recorder (CVR) recordings are generally unable to discriminate between explosions and structural failure decompressions.

By Stuart Dyne (MO4779), Institute of Sound and Vibration Research, University of Southampton, UK

(This article was adapted, with permission, from the author's presentation entitled "CVR Recordings of Explosions and Structural Failure Decompressions," presented at the ISASI 2003 Seminar in Washington, D.C., USA, August 2003. The full presentation is available on the ISASI website at http://www.isasi.org.—Editor)

Rapid identification of the cause of failure is a high priority in the immediate aftermath of a major civil air craft accident. Attention is often focused on the two recorders, the cockpit voice recorder (CVR) and flight data recorder. In the event of sudden, catastrophic loss of an aircraft through explosions or structural failure decompressions, the recordings are seen as even more important. Yet these recorders are not designed to record such events with great fidelity, and the ability of accident investigators to interpret such recordings has been severely tested in several major accidents in the past 30 years. Comparisons between accident recordings have not been able to produce conclusive results.

The UK Air Accidents Investigation Branch report on the Pan Am Lockerbie accident in December 1998 identified a loud sound lasting 170 ms on the cockpit area microphone (CAM) track at the end of the recording. The sound occurred while the crew was copying their transatlantic clearance from Shanwick ATC. A very large volume of forensic material arising out of Lockerbie indicated that detonation of an improvised explosive device led directly to the destruction of the aircraft. While it is reasonably inferred that the "loud sound" is related in some way to the detonation of the explosive device, the official report into the accident conceded "analysis of the flight recorders…did not reveal positive evidence of the explosion event."

Moreover a safety recommendation arising out of the investigation was that "a method should be devised of recording positive and negative pressure pulses, preferably utilizing the aircraft's flight recorder systems." Since the publication of this report, a study into the CVR/CAM response to explosions and structural failure rapid decompressions has taken place and has been reported widely to working groups, such as ISASI WG50, EUROCAE ED-56, at conferences in 1993 and 1995, and to the ISASI seminar in 1995. More recently a loud sound at the end of the TWA 800 recording was subject to detailed and meticulous analysis by the NTSB but did not reveal the cause of the accident and was therefore of little diagnostic value. This aim of this paper is to explain why these recordings do not lead to useful forensic evidence and to consider what systems would be necessary to discriminate between explosions and structural failure decompressions and to locate the seat of the hull loss.

CAM/CVR recordings of explosions

Figure 1 shows the CVR and instrumentation signatures for an explosion event conducted on the ground in an ex-service BAe Trident aircraft. The plot shows the CAM channel of each of three tape-based CVR systems together with an accelerometer (vibration sensor) and a microphone (pressure sensor) installed close to the CAM for the trials. All sensors were in close proximity to each other in the cockpit and the explosion was approximately 9.4 m aft of the sensor position. Time zero is the time of detonation of the explosive device—obviously this reference would not be available on an accident recording but is helpful here in the determination of the cause of events within the recording.

Several features are striking about this Figure 1. First, the three CAM signatures have some similar features but are certainly not identical. The features that they share include a response commencing before 0.01s with a low amplitude and low frequency range (the graph is fairly smooth). All of them change character at around 0.025s increasing in amplitude

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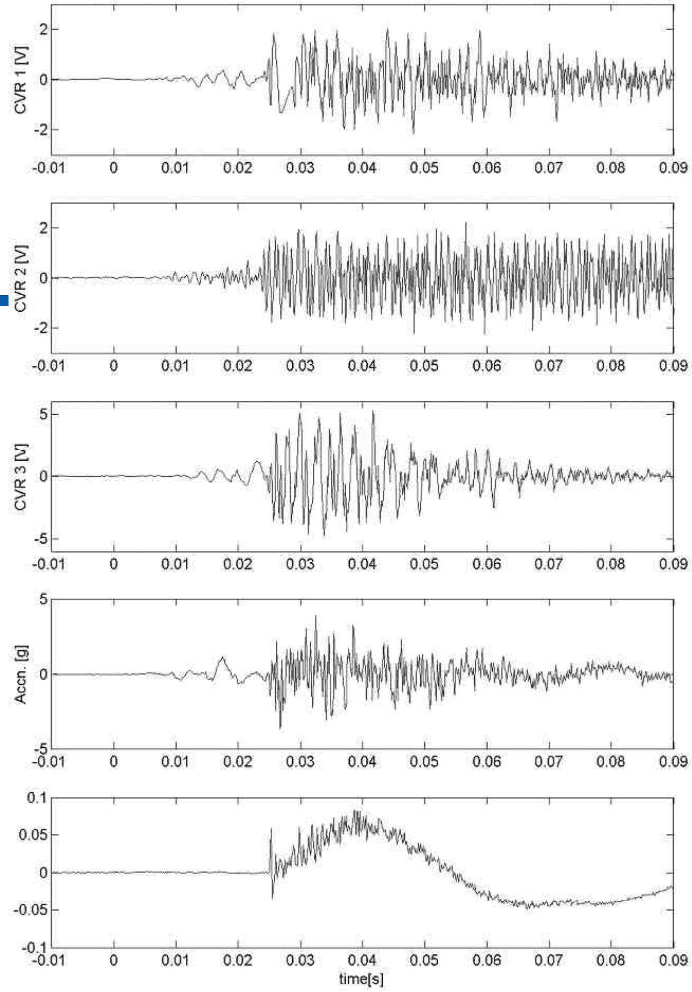


Figure 1: CVR and instrumentation signatures for an explosive device.

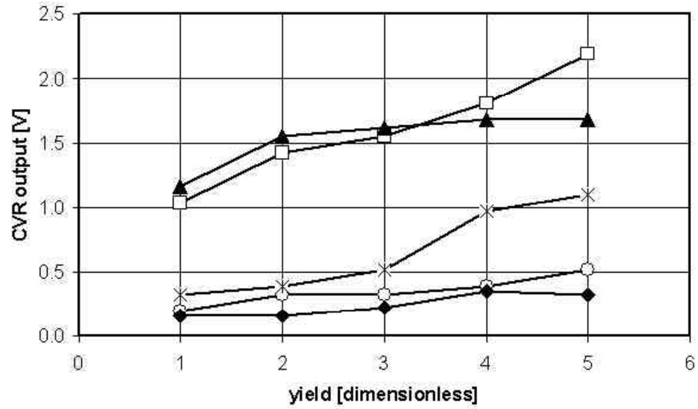


Figure 2: Variation in CVR output with explosion yield for t1<t<t2 for five different CVR/CAM systems. Each symbol represents one CVR type.

and frequency range (the graph becomes more spiky). Interestingly, the vibration record is similar although the vibration response amplitude falls soon after 0.035s whereas the record for CVR system 1 remains at a high level until 0.06s and high for the whole of the record for CVR 2, suggesting a possible saturation of the tape dynamic range. The pressure record differs from the others in that it only commences at 0.025s.

Similar results have been obtained from very many trials with explosive devices at many locations on several aircraft, and the following explanation of the records described above may be inferred. First the blast wave from the explosion source impinges on the structure and a shock wave is then transmitted through the structure at a speed of 4,000 to 5,000 m/s. The CAM is sensitive to vibration and responds to the arrival of the structure-borne shock wave. Meanwhile the air-blast wave travels through the fuselage and eventually arrives in the cockpit. The speed of this wave is dependent upon the yield of the explosion but can be taken as the speed of sound in air of 340 m/s where distances are relatively large and yields are quite small. On arrival in the cockpit, the blast produces both a pressure response from the CAM and produces further local vibration (as seen by the accelerometer) to which the CAM is also sensitive. The instrumentation microphone (bottom graph of Figure 1) responds only when the pressure wave arrives at the CAM and is designed to have very low vibration sensitivity.

Vibration sensitivity

Interestingly, the CAM is quite sensitive to vibration. This phenomenon has been exploited in the past with helicopter gearbox investigations, yet the CAM is intentionally vibration isolated from the structure. The reason is simply that the vibration levels of a few g's are themselves quite high, not that the CAM or vibration isolation is poorly designed.

The results of all these trials appeared to show that locating the seat of an explosion event should be rather straightforward. One simply took the difference in arrival times of the structure-borne and airborne shock waves and computed distance from this difference using values for the two propagation velocities. Formulae for this were given in my paper *Analysis of CVR Transient Signatures* and take into account the possible delay caused by the propagation of an air-blast wave across the fuselage for a device not attached to the outer skin, so providing lower and upper bounds for the distance from the cockpit to the seat of the explosion.

However, accident recordings did not appear to show these two events with any distinction, so determination of axial location using direct application of this method was not possible. Moreover some trials with larger explosion yields also did not show the two events; the explosion response simply arrived and then decayed with time without distinct change in bandwidth or amplitude after the start. Analysis of the influence of explosion yield on the response components helps to explain why this is so.

Explosion yield

Trials were conducted on a Boeing 747 aircraft using small-yield explosions. The response was measured with five widely used commercial aircraft CVR systems including four tape-based

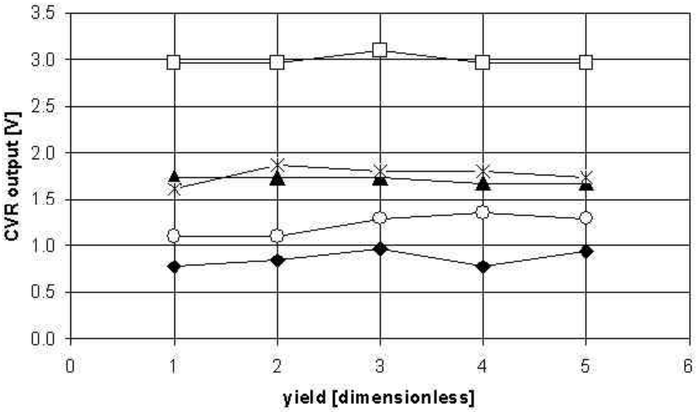


Figure 3: Variation in CVR output with explosion yield for t>t2 for five different CVR/CAM systems.

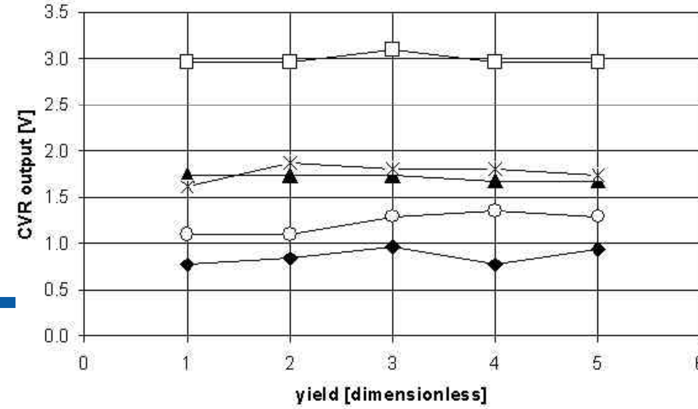


Figure 4: CAM time history for a high-yield explosion on a Boeing 727 aircraft.

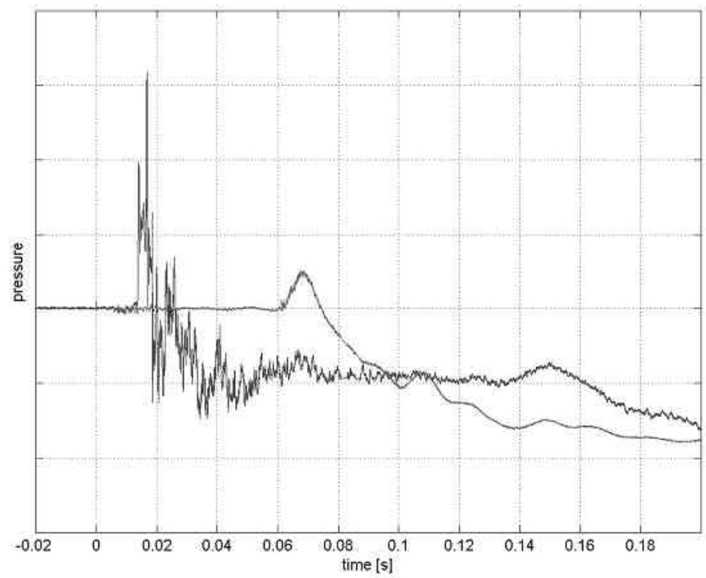


Figure 5: Recordings from pressure transducers placed on either side of an explosion in a pressurized fuselage.

systems and one solid-state recorder. For one series of firings, the same-source location was used each time but the mass of explosive was increased linearly from one unit to five units. The results, sets of time series, resembled the time series given in Figure 1 so are not reproduced here. Instead, in Figure 2, peak-to-peak values for the two components in each of the recordings are shown. Suppose we denote the time of arrival of the structure borne wave by t1 and the time of arrival of the airborne wave by t2. Figure 2 shows the CVR/CAM response amplitude for $t1<t<t2$, i.e., the response due exclusively to the structure-borne shock. The figure shows that an increase in yield generally produces a greater CVR/CAM output.

Figure 3 shows the results for $t>t2$, i.e., the response after the arrival of the airborne blast wave including both sound and vibration. Observe that the amplitude of this response is not only greater than for the phase $t1<t<t2$ but is independent of the explosion yield. This implies that the physical parameter variation is greater than the dynamic range of the recorder or that the sensors are overloaded and that the recording is saturated and probably highly distorted.

Figure 4 shows a CAM time history for a high-yield explosion on a pressurized Boeing 727 aircraft. The charge was approximately 8.1 m aft of the cockpit; the explosion ruptured the skin of the aircraft. Clearly the CAM does not show a transition at t2. The time taken for sound to travel from the seat of the explosion to the cockpit is approximately 0.024s, and the response clearly begins significantly before this. We infer that the response begins ostensibly at t1 but the magnitude already exceeds the dynamic range of the CAM/CVR so no change in signal magnitude is visible at t2. The record is therefore unable to show the axial location of the charge as was the case for smaller, non-destructive tests.

The yields of all the explosions analyzed in Figures 2 and 3 are below the yield that might be expected from a terrorist device. If results from increased yield were produced, the response for $t1<t<t2$ for all recorder types would exceed the dynamic range and the recordings would be saturated as was the case in Figure 4. There would then be no discrimination between the two phases of the response recording and the section for $t>t2$ would be indistinguishable from $t<t2$. It is, therefore, not possible to use the method described above to locate the source for accident recordings.

One extensive study by F.W. Slingerland has attempted to locate the seat of an explosion using the spectrogram of the CVR recording. The basis of the method is that the structural shock transmission is dispersive, i.e., different frequencies propagate at different velocities. However, the nature of the explosion source and complex multiple transmission paths severely limit the applicability of the theoretical basis. Operationally, the method required placement of a series of curves on an accident recording spectrogram with the intention that their curvature would indicate distance from the source to the CAM. Investigators found this aspect particularly problematic as several sets of curves could be drawn on any given spectrogram leading to ambiguous results.

In one part of the study, spectrograms of several accidents were analyzed in a blind test but were not able to confirm the validity of the approach. A recommendation arising from a review at the end of the study was that the method should not be used in accident investigation (Wayne Jackson (ed.), *CVR Explosion Analysis Technique*: *Development and Evaluation*, TP 13929E, Transport Canada, May 2002).

The interval t1<t<t2 is due to structure-borne vibration, which is likely to be produced at very high levels under both structural failure and explosion-generated conditions. In the case of an explosion, t2 is the arrival time of the blast wave at the CAM and in the case of a structural failure t2 is the arrival of the decompression wave at the CAM. Decompression waves travel at the speed of sound as with blast waves but are obviously of opposite polarity.

Their propagation velocity and arrival at the CAM has been observed in various decompression trials. For both explosions and decompressions, the CVR records are not high-fidelity recordings of vibration as (i) the CAM is not designed as a vibration sensor but merely exhibits vibration sensitivity (which may be frequency dependent, non-linear, and directionally dependent) and (ii) because the limited dynamic range of the recording medium and sensor are both (considerably) exceeded. Thus, the CVR/CAM combination is unable to locate the source of a decompression and seems to be unable to discriminate between explosions and structural failure decompressions.

Pressure transducers

Among the instrumentation deployed in some trials were arrays of pressure transducers. These are effectively very low sensitivity microphones with corresponding low-vibration sensitivity. Figure 5 shows the output of two transducers placed on either side (axially) of an explosion in a pressurized fuselage. Several features in these time histories are noteworthy. First both records commence with a pressure rise. The magnitude of an air-blast pressure rise is a function of explosion yield and distance from the charge and is widely tabulated by G.F. Kinney and K.J. Graham in their 1962 paper *Explosive Shocks in Air*, Springer-Verlag; and by the Department of the Army's *Fundamentals of Protective Design for Conventional Weapons*, Technical Manual TM 5-855-1, 1986.

The pressure rises occur at different times because the transducers are at different distances from the explosion source. The transducer closest to the charge shows the earliest and greatest pressure rise. The time delay between the two pressure rises can be used to determine the axial location of the device to within 0.5 m. Secondly, both transducers show a pressure fall to a value significantly below the original ambient conditions. This is due to the breach of the pressurized fuselage. The rate of depressurization indicates the size of the hole through which cabin pressure is venting. The precise form of the pressure curve (a series of pressure drops between short periods of relatively constant pressure producing a step-like appearance) has been explained by reference to one-dimensional flow models.

Interpretation of the results in Figure 5 indicates that recordings of pressure from either side of an event appear to offer everything the investigator would seek namely: the location of the source (from the difference in arrival times), the presence of any explosion (indicated by an initial pressure rise), and any decompression (indicated by a pressure fall).

Although this single result suggests that pressure-transducer-based systems may be widely applicable, trials are needed to consider the effect of baggage in the immediate vicinity of the explosive device, and of baggage and other barriers between the source and sensors. While vibration has the advantage that it is inevitably transmitted to all parts of the aircraft, it is ostensibly more difficult to analyze vibration records to locate sources. The likelihood of discriminating between explosions and structural failure decompressions from vibration records alone is not fully researched and certainly appears more difficult than the interpretation of pressure records.

Summary

We have seen that CVR/CAM records exhibit vibration sensitivity and that vibration is transmitted from the seat of an explosion/structural failure to the CAM. However, the level of vibration produced in accidents is so high that the dynamic range of the CAM/CVR is likely to be exceeded thereby masking the arrival of the explosion blast wave or decompression rarefaction wave in the cockpit.

It is appropriate to review all CVR recordings (of established provenance) of known explosions and structural failure decompressions. Such a review could confirm (or refute) the assertion that no transition at candidate values of t2 is visible. That is, the accident recordings correspond exclusively to vibration and not to pressure/sound. If so, accident investigators should be relieved to learn that the inability to obtain useful forensic information from the CVR in these cases is not a failing on their part but simply an equipment limitation.

The industry needs to consider if explosion/structural failure decompression sensors are required. If so, there is a need to invest in research to determine the most suitable sensor(s) and appropriate means of recording, possibly exploiting the flexibility now available through solid-state recording media.

Preliminary research suggests that pressure-based systems may be ideal in sudden catastrophic loss incidents, but trials are needed to consider the effect of baggage and other barriers between the source and sensor(s). ◆

(Adapted from minutes and notes of the International Council meeting recorded by Keith Hagy, Secretary.—Editor)

Council Sets 2004 Budget

The ISASI International Council on Aug. 24, 2003, in a general meeting that preceded the ISASI 2003 seminar in Washington, D.C., adopted a near balanced budget for year 2004, adopted a proposal for a new web communications policy for management of the ISASI website, and adopted stringent new Policies and Procedures governing the production and operation of the annual seminar, among other matters, including adoption of two new Positions dealing with unlawful interference and family assistance.

Following the "Call to Order" by President Frank Del Gandio, the Council executives gave their reports.

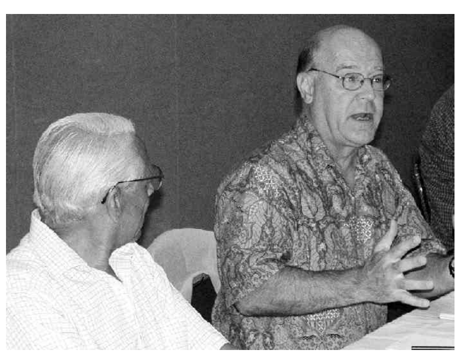
President Frank Del Gandio asked for and received Council approval to refinance the mortgage on the ISASI office condo to lower the mortgage interest rate and monthly payment. He further reported on the salary increase of the ISASI office manager to account for inflation and the increase in the cost of living in the Washington, D.C., area.

Vice-President Ron Schleede informed the Council that his attention in the upcoming months would be focused on his role of working with the various ISASI working groups and committees.

Treasurer Tom McCarthy gave an overview of his written report provided to the Council. He noted completion of the 2002 audit and tax return, which showed a year-end net assets/fund balance of $42,365 for that year. In a 2002 profit-and-loss budget comparison, his written report noted that ISASI did not receive any funds from ISASI 2002, held in Taiwan, due to a misunderstanding of the hosting group's financial obligations to ISASI. The result was a total loss of $16,000 in budgeted and actual costs for the 2002 budget year. The Council discussed the situation that resulted in seminar profits inadvertently being assigned to the Taiwan government and directed continued discussion to attempt to achieve an equitable distribution of the seminar proceeds. Nevertheless, the Treasurer reported ISASI to be in sound financial shape. The proposed 2004 budget of $168,850 is within $140 of being balanced. Following a detailed briefing of the budget's income and expense ratios, the Council unanimously approved it. McCarthy also reported the awarding of the first two ISASI Memorial Rudy Kapustin Scholarship Fund scholarships.

Secretary Keith Hagy reported that his efforts since the May Council meeting were focused on working with the ISASI web master to develop an ISASI web communications plan. He and Corey Stephens provided an overview of the plan developed with assistance from Ron Schleede and Kevin Darcy. The Council recognized the necessity of developing a web communications plan considering the growth of the ISASI website and the demands placed on the ISASI web master. After some discussion, the Council approved the web communications plan and asked that it be included in the *ISASI Policy Manual*. The Council also approved the establishment of a Web Committee to be chaired by Corey Stephens. Other members of the Committee include Keith Hagy, Ron Schleede, Curt Lewis, Kevin Darcy, Jim Stewart, and Marty Martinez. He also reported the start of an inventory to the contents of the ISASI library in preparation for packing and shipping the material to the ERAU Prescott Campus.

Executive Advisor Dick Stone announced the selectees for the scholarship awarded by the ISASI Rudy Kapustin Memorial Fund as Noelle Brundelle, Embry-Riddle Aeronautical University, and Michiel Schuurman, Delft University of Technology, the Netherlands. He also reported the addition of the University of New South Whales to the listing of facilities from which student scholarship applications will be accepted.



Caj Frostell, right, makes his report as Max Saint Germain listens.

Councillors/National Societies

Australian Councillor Lindsay Naylor was unable to attend due to health reasons but submitted a written report in which he noted a very successful Australasian regional air safety seminar in May/June 2003. He further reported on the ongoing work being done relative to hosting ISASI 2004. Larry Doherty served as Naylor's proxy and presented details regarding ISASI 2004 to be held in Gold Coast Australia August 30 through September 2.

Canadian Councillor Barbara Dunn reported that CSASI was in sound financial condition and that her involvement with the Southern California Safety Institute was producing new members for CSASI and ISASI. A number of Council members mentioned that in their involvement with other organizations they also took the opportunity to provide an ISASI overview and that those discussions routinely resulted in signing up new members. All Council members were asked to take the opportunity to highlight ISASI in any of the venues of opportunity and to use various ISASI publications to increase ISASI visibility in the aviation community. Councillor Dunn further reported that the CSASI Vice-President had accepted a 6-month assignment for ICAO in Nepal. CSASI continues to get requests for and is providing bloodborne pathogen training tapes. In addition, the Society is in the final development stages of its website.

New Zealand Councillor Ron Chippindale thanked Air New Zealand, which was assisting with transportation to the meeting and annual seminar. He reported

- NZSASI membership was steady at 47 and that the annual dues rate would remain at NZ$100.
- There would be no Australasian seminar this year since it was scheduled for 2004, which clashed with the ISASI 2004 seminar in the same region of the world.
- NZSASI would be sponsoring member

attendance at the 2004 ISASI seminar,
- He and NZSASI had been active with the MOT in a review of the accident investigation process in New Zealand.
- He had been successful in recruiting new student members during his lectures to Massey University.
- NZSASI was conducting its annual "aviation safety" essay contest.

International Council members in session.

He further reported that NZSASI purchased a tourism video on New Zealand at the request of ASASI to advise ISASI seminar attendees of the opportunity to stop and spend time in New Zealand if they attended the 2004 ISASI seminar in Australia.

United States Councillor Curt Lewis reported that he had published the ISASI 2004 seminar notice and agenda in his flight safety update e-mail notice, as well as the ISASI individual and corporate membership applications. The U.S. Society newsletter was published in July 2003. Since the last Council meeting, two new corporate members joined the U.S. Society.

International Councillor Caj Frostell spoke to the importance of Reachout to ISASI relative to spreading the "safety" word and increasing ISASI's visibility in the international aviation community. He, too, is distributing *ISASI Forum* and ISASI membership applications at SCSI meetings and at the Singapore Aviation Academy. Frostell also stated that he had been working IFALPA accreditation of the SCSI Prague course and the Singapore Aviation Academy course. He has received confirmation from Singapore that such accreditation was recently obtained.

Committee reports

Awards—Gale Braden provided a written report with regard to details of the voting of the 12-member Awards Committee for the selection of the person to receive the Jerome F. Lederer award.

Membership—Tom McCarthy reported that the current ISASI membership status stood at 1,385 individual members of which 131 were delinquent in dues. There are 110 corporate members of which 9 were delinquent in dues. He and President Del Gandio reminded all Council members to review the list of delinquent members and asked that they contact the delinquent members personally and seek renewal of membership.

Seminar—Kevin Darcy reported that the hotel envisioned for the possible 2006 seminar bid in San Juan had withdrawn its room rate guarantee. The Council discussed possible venues for the 2006 seminar and asked Darcy to contact the hotel to see if it would honor the previous rate. If so, the Council would consider San Juan if a formal bid was made along with those additional venues.

Based on discussion regarding seminar procedures and the role of the Seminar Committee in managing future ISASI seminars, the Council determined that all future seminars would be hosted and managed by the local ISASI chapter, ISASI society, or the ISASI Seminar Committee. In the cases of seminars managed by local chapters or societies, it is expected that the ISASI Seminar Committee will take on a more active role of providing oversight to ensure that ISASI seminar policies and guidelines are followed. In seminar locations where no local chapter or society exists then the Seminar Committee will manage the seminar. It was also decided that the ISASI headquarters office would collect seminar sponsorship donations.

Reachout—Jim Stewart in a written report said he had received a request for a Reachout from West Africa that would consist of 2 days of safety management system training and 2 days of accident investigation training. Other locations discussed for 2004 included Mexico, China, South Africa, Jamaica, and Costa Rica. Frank Del Gandio took the opportunity to acknowledge Jim Stewart and Caj Frostell for all of their hard work advancing Reachout.

Working groups

Positions—Ken Smart was unable to attend the Council meeting but had submitted two new "Positions" for Council consideration. The subject of the first was "unlawful interference" and the second was with regard to "family assistance" following an accident. After some discussion, the Council approved the Positions as drafted by Smart. *(The positions are reprinted below from the July-September 2003 issue of the* Forum, *page 24.—Editor)*

Unlawful Interference

Unlawful interference is defined as any unlawful act that has been or may have been committed during the operation of an aircraft. When it is suspected that unlawful interference has taken place, then the police and judicial authorities should be notified. Any aviation safety issues should continue to be investigated and through the normal processes while maintaining liaison with the police and judicial authorities.

Family Assistance

The accident investigating authority should make every effort to ensure that survivors and bereaved families are kept informed of the progress of investigations from the earliest stage to a level appropriate to the circumstances of the investigation and in accordance with their wishes. The basic principle should be to treat survivors with respect and sensitivity and in a way that we would all wish to be treated if we were subjected to the same tragic circumstances. Where possible the IIC and members of the investigation team should be directly involved in this process.

New business

Barbara Dunn presented the most recent version of the *ISASI International Seminar Policy and Procedures Manual.* A year in the drafting, Council members had earlier provided input, which had been incorporated into the discussed version. The Council approved the manual as revised and to include the discussion at this Council meeting regarding the increased role of the ISASI Seminar Committee in future ISASI seminars.

Richard Stone, in addressing the seminar financial responsibilities, proposed an expense form as a way to track and approve Council member expenses at future Council meetings. The Council agreed with the form's content and approved its use. ◆

ISASI 2004 Registration Opens

The Australian Society of Air Safety Investigators has declared registration for ISASI 2004 as open. The 35th annual seminar, which the Society is sponsoring, will take place Aug. 30-Sept. 2, 2004, and carry the theme "Investigate, Communicate, Educate." It will be held in the ANA Hotel Gold Coast, Queensland, Australia.

Registration for the seminar, tutorial, and hotel may be completed through the ISASI 2004 seminar website at www.asasi.org/isasi2004.htm. Registration can be done on line or by fax or mail. Alternatively, the registration from printed adjacent to this article may be completed and mailed to the indicated address. Registration costs will include breakfasts and social functions and (for companions) the day tours. Tutorial registrations and an optional Friday "wind down" tour will be optional extras.

Lindsay Naylor, seminar Chairman, said: "When considering if there is a 'best time' to register for ISASI 2004, remember that registrations will be in Australian dollars only. The Australian dollar has risen in value against most major foreign currencies by around 35 percent in the past 12 months, and economists are predicting further rises through 2004, even though the dollar is currently at a '6-year high.' If these rises should continue in coming months, the costs in your equivalent local currency value will increase. Hence, unless you are a gambler, the odds say you should register early."

Seminar registration costs in Australian dollars are

Full seminar and related functions

	By July 10	*After July 10*
Member	$625	$700
Student Member	$500	$550
Non-member	$750	$800
Single-day attendance		
Student members	$100	$100
All Others	$250	$250
Tutorials		
Interviewing	$85	$100
Communicating	$85	$100
Companion program	$350	$400
Post-seminar function	$100	$125

[As of Jan. 13, 2004, the exchange rate in U.S. dollars was 1 Australian dollar = US77cents. Exchange rates may be found at http//www.expedia.com/pub/agent.dll.—Editor]

The ANA Hotel Gold Coast is a five-star property located in the heart of Queensland's Gold Coast. It is a very popular international and domestic tourist holiday area. Thanks to a generous offer by the hotel, the accommodations rate for delegates will be A$154 (single/ twin/ double, deluxe ocean view room) including tax. That represents a very reasonable tariff for a hotel of this standard. For those who wish to arrive early or remain after the seminar, the same rate is available. Registration forms are available on the ISASI 2004 website. According to the hotel, "A block booking of hotel rooms for seminar delegates is being held only until June 30, 2004. After that date, availability of rooms is not guaranteed." The hotel may be contacted at P.O. Box 93, Surfers Paradise, Qld 4217 Australia; telephone reservations: +61 (0)7 5579 1060; Fax +61 (0)7 5592 2908.

Technical and social programming for the seminar is being completed. Tutorial planning is done and calls for two sessions to be conducted: (1) interviewing and (2) communicating and educating. More information on the technical program will be published in subsequent issues of this publication. Social activities include a cocktail reception on Monday evening, an off-site dinner on Tuesday evening, and the Awards Banquet on Thursday evening. The companion program will include a full-day tour and a half-day tour. A Friday activity is also being planned as a seminar "wind down."

About Australia

The ISASI website has this to say about the seminar location: "Those international visitors to Australia intending to participate in the ISASI seminar will probably enter Australia through either Sydney or Brisbane International Airports. Those arriving in Brisbane will be able to use a Gold Coast shuttle bus that departs from the airport at regular intervals, and will drop guests at Gold Coast hotels (including the ANA Gold Coast). Cost of return shuttle per person is likely to be around A$35. An airport rail and bus option is also available.

"For travelers arriving in Sydney (or one of the other Australian international airports), you can either drive up the coast (and allow 1-2 days from Sydney for this) or take one of the domestic flights to Coolangatta Airport (Gold Coast). From there, a shuttle or taxi will take you to the hotel.

"Local weather: September/October/November-Spring, mean temperature: 20.6° C (70° F), max. temperature: 25.3° C (78° F), min. temperature: 16.0° C (61° F); precipitation: averages 50 mm (2") a month—rains once every 3-4 weeks. For current Gold Coast weather information, visit the Australian Bureau of Meteorology.

"Brief facts: Australia is a very large continent, with a climate and geography that varies from snow-capped mountains to tropical rainforests to arid deserts. International visitors are reminded that if driving inland, there can be large distances between towns (fuel, food, water, etc.). If driving, drive on the left side of the road and adhere to local speed limits, which vary between states

INVESTIGATE, COMMUNICATE, EDUCATE—2004

August 30–September 2 • A professional training seminar presented by ISASI

Name: ______________________ ISASI No. ______________________

Organization: ______________________

Address: ______________________

Tel. (Hm): ____________ Tel. (Bus): ____________ Tel. (Cell) ____________

E-mail Address: ______________________

Name & title on badge: ______________________

Companion's name on badge: ______________________

Please check appropriate box *(Please note, all fees are shown in Australian dollars):*

	Registration by July 10		*Registration after July 10*	
Full Seminar & Function				
Member	❑ $625		❑ $700	
ISASI Student Member	❑ $500		❑ $550	
Non-member	❑ $750		❑ $800	
Single Day				
Tuesday	❑ $250	❑ Student $100	❑ $250	❑ Student $100
Wednesday	❑ $250	❑ Student $100	❑ $250	❑ Student $100
Thursday	❑ $250	❑ Student $100	❑ $250	❑ Student $100
Tutorials				
Interviewing	❑ $85		❑ $100	
Communicating and Educating	❑ $85		❑ $100	
Companion Program	❑ $350		❑ $400	
Post-Seminar Function	❑ $100		❑ $125	
Subtotal:	____________		____________	
Total Amount Due:	____________		____________	

Special Meal Requests (Vegetarian, Halal, Vegan, Kosher, etc.): ______________________

Credit Card Type (Visa, MasterCard, Bankcard): ______________________

Credit Card Number: ______________________ Expiration Date: ____________

If paying by credit card, fax to: **Lindsay Naylor** +61 2 6255 4413 *or* **Paul Mayes** +64 9 256 3911

If paying by money mrder or check, please send to: ASASI, P.O. BOX 588, Civic Square, ACT 2608 Australia

For assistance, contact: **Lindsay Naylor** +61 2 6241 2514 E-mail: lnaylor@spitfire.com.au

Cancellations made before July 10, 2004, will incur a $10 processing fee.

Cancellations made between July 11–August 10, 2004, will incur a $75 administration fee.

There will be no refunds for cancellations after August 10, 2004.

and are enforced by local police. The wearing of seatbelts is mandatory for all vehicle occupants in all states. The maximum blood alcohol limit while driving, in all states, is 0.05 percent.

"The electrical supply in Australia is 240 volts AC at 50 Hz. A two- or three-pin plug is used. Most large hotels provide 220/110 volt outlets for shavers/dryers, etc., and data comm ports. Australia uses the metric system, thus all speeds, distances, and temperatures are given in metric units. Australia uses three time zones (EST, CST, and WST). Some states also move to daylight saving. However, Queensland does not and remains on EST (UTC +10 hours). See the Time and Date page for the current Queensland date and time. "If bringing a mobile (cell) phone, it will need to be able to access the 900/1,800 Mhz GSM system or the 800 Mhz CDMA system and have roaming rights between your own phone company and one of the Australian phone companies.

"The Australian currency is the Australian dollar. See the forex calculator for exchange rates. Foreign currency will generally not be accepted in shops, restaurants, etc. However, nearly all shops, restaurants, etc., accept popular credit cards." If anyone has any queries on any aspect of the seminar, please contact Lindsay Naylor at lnaylor@spitfire.com.au. ◆

Election Nominations Due April 1

The ISASI Nomination Committee has issued a Call for Nominations for the Executive Officer and Councillor positions that will be open to election for the years 2005-2006. The nomination deadline is April 1, 2004. The positions to be filled are president, vice-president, secretary, treasurer, U.S. councillor, and international councillor.

Each potential candidate whose name is submitted to the Nominating Committee must have consented to the submission. The nominator must submit a short biographical sketch of the nominee. Nominees must be at least a full member to be eligible for office within ISASI. Nominations should be sent to the ISASI office, attention Nominating Committee. ◆

Awards Committee Seeks Lederer Nominations

The ISASI Awards Committee is seeking nominations for the 2004 Jerome F. Lederer Award. For consideration this year, nominations must be received by the end of May, according to Committee Chairman Gale Braden

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

The nomination process allows any member of ISASI to submit a nomination. The nominee may be an individual, a group of individuals, or an organization. The nominee is not required to be an ISASI member. The nomination may be for a single event, a series of events, or a lifetime of achievement. The nomination letter for the Lederer Award should be limited to a single page.

The ISASI Awards Committee, made up of 12 ISASI members, considers such traits as duration and persistence, standing among peers, manner and techniques of operating, and achievements. Once nominated, a nominee is considered for the next 3 years and then dropped. After an intervening year, the candidate may be nominated for another 3-year period.

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

Nominations should be mailed or e-mailed to the ISASI office, 107 Holly Ave., Suite 11, Sterling, VA 20164-5405 USA; e-mail address: isasi@erols.com; or directly to the Awards Committee Chairman, Gale Braden, 2413 Brixton Road, Edmond, OK 73034 USA; e-mail geb@ilinkusa.net ◆

Kapustin Scholarship Issues Application Call

The ISASI Rudolf Kapustin Memorial Fund has issued its call for scholarship applications to universities and colleges whose students are eligible to participate in the program, according to the Fund's administrators, Richard Stone, ISASI Executive Advisor, and Ron Schleede, ISASI Vice-President. The deadline for applications is April 1, 2004.

The goal of the Fund is to encourage and assist college-level students interested in the field of aviation safety and aircraft occurrence investigation. All members of ISASI enrolled as a full-time student in an ISASI-recognized education program concentrated on aviation safety and/or aircraft occurrence investigation are eligible for the scholarship. A student who has once received the annual ISASI Rudolf Kapustin Memorial will not be eligible to apply for it again. One or more students will be selected in this process

NEW MEMBERS

Busby, E., MO4987, Ocean View, DE, USA
Chappell, AO4978, Hendra, Queensland Australia
Dawson, F., MO4988, Lantau
Dee, E., AO4974, Lumby, B.C.
Foster, W., MO4972, Caledon East, ON, Canada
Fournier, W., AO4990, Monterey, CA, USA
French, R., AO4992, Langley, B.C.
Harris, M., ST4983, Daytona Beach, FL, USA
Hayes, L., MO4981, Camarillo, CA, USA
Hutsell, G., MO4973, Madison, AL, USA
Kovoor, ST4971, Auckland, New Zealand
Ledoux, MO4989, Saint Hippolyte, Quebec, Canada
Matthews, ST4984, APO, AE 09601
McNair, J., MO4986, Orleans, Ottawa, ON, Canada
Montgomery, O., MO4993, Bowie, MD, USA
Parham, S., FO4980, Vero Beach, FL, USA
Parker, B., AO4976, Costa Mesa, CA, USA
Peters, E., MO4979, Potomac, MD, USA
Pouliezos, S., MO4994, Hilioupolis, Greece
Smith, H., MO4991, Mont Tremblant, Quebec, Canada
Swanson, T., MO4995, Amherst, NH, USA
Tank, MO4982, Prescott, AZ, USA
van Gelder, N., MO4985, Oud-Turnhout, Belgiu
Villegas, II, M., MO4977, North Las Vegas, NV, USA
West, E., MO4970, McLean, VA, USA

to attend the ISASI annual seminar. This year the seminar will be held at the ANA Hotel Gold Coast in Queensland, Australia, on August 30-September 2.

Continued funding for the Memorial Fund is through donations, which in the United States are tax deductible. An award of $1,500 is made to each student who wins the competitive writing requirement, meets the application requirements, and who registers to attend the ISASI annual seminar. The award will be used to cover costs for the seminar registration fees, travel, and lodging/meals expenses. Any expenses above and beyond the amount of the award will be borne by the recipient. Last year, two awards were presented. They went to Noelle Brundelle, Embry-Riddle Aeronautical University, and Michiel Schuurman, Delft University of Technology, the Netherlands.

The Fund is administered by an appointed committee and oversight of expenditures is done by the ISASI Treasurer. The Committee ensures that the education program is at an ISASI-recognized school and applicable to the aims of the Society, assesses the applications, and determines the most suitable candidate(s). Donors and recipients will be advised if donations are made in honor of a particular individual.

Application requirements

- A full-time student in an aviation safety/investigation/system safety course of minimum duration of 1 year. The student must be a member of ISASI.
- The student is to submit a 1,000 (+/-10 percent) word paper in English addressing "The Challenges For Air Safety Investigators."
- The paper is to be the student's own work and must be countersigned by the student's tutor/academic supervisor as authentic, original work.
- The papers will be judged on their content, original thinking, logic, and clarity of expression.
- The student must complete the application available at the university or at ISASI headquarters and submit it to ISASI with their paper by April 1, 2004.
- Completed applications should be forwarded to ISASI, 107 Holly Ave., Suite 11, Sterling, VA 20164-5405 USA. E-mail address: isasi@erols.com; Telephone: 703-430-9668.
- Applicants will be notified of ISASI's decision about the award by May 1, 2004.
- The judges' decision is final.

Universities and colleges whose students are eligible to participate in this scholarship program are
Auburn University, USA
Bridgewater College, USA
Central Missouri University, USA
Concordia University, Montreal, Canada
Dowling College, USA
Embry-Riddle University, Daytona Beach, USA
Embry-Riddle University, Prescott, USA
Florida Institute of Technology, USA
Hankuk Aviation University, Korea
Inter American University, Puerto Rico
Kent State, USA
Massey University, Auckland, NZ
Ohio University, USA
Parks College, USA
Pontificia University, Brazil
Purdue University, USA
San Jose State, USA
Southern Illinois University, USA
Western Michigan University, USA
University of New South Wales, Queensland, Australia ◆

Reachout Resumes Workshop Schedule

Following a 6-month breathing space, the ISASI Reachout program has begun its second round of workshops. The next workshop was scheduled for Mexico City January 26-30 and included a workshop on accident investigation and safety management. Hosts for the workshop were the Mexican Air Line Pilots Association (ASPA), and ISASI was again supported by ICAO. The Air Line Pilots Association and Continental Airlines were corporate sponsors, and ASPA also provided considerable sponsorship. The 5-day workshop included four ISASI instructors—Caj Frostell and Ron Schleede for accident investigation and Jim Stewart and Dick Stone for safety management.

TRAINING COURSE CALENDAR 2004

UNIVERSITY OF SOUTHERN CALIFORNIA
- **Aviation Safety Program Management**
Mar. 22-Apr. 2, Jun. 21-Jul. 2, Sept. 20, Oct. 1, Dec. 6-17
- **Human Factors in Aviation Safety**
Mar. 1-5, May 17-21, Sept. 13-17, Nov. 8-12
- **Safety Management for Aviation Maintenance**
May 10-14, Nov. 1-5
- **Software Safety**
Apr. 26-29, Nov. 15-18
- **Gas Turbine Accident Investigation**
May 3-7, Nov. 15-19
- **Accident/Incident Response Preparedness**
Feb. 23-35, Oct. 18-20
- **Photography in Accident Investigations**
Feb. 26-27, Oct. 21-22
- **Helicopter Accident Investigation**
Apr. 5-9, Oct. 25-29
- **Aircraft Accident Investigation**
Mar. 8-19, Jun. 7-18, Oct. 4-15
- **Incident Investigation/Analysis**
Aug. 30-Sept. 2

For further information contact:
University of Southern California/Aviation Safety Programs
Tele: 310-342-1345
Website: www.usc.edu/dept/engineering/AV.html

SOUTHERN CALIFORNIA SAFETY INSTITUTE
A=Albuquerque, NM
T=Torrance, CA
O=Ottawa, Canada
V=Vancouver, British Columbia
PR=Prague, the Czech Republic
- **Aircraft Accident Investigation (A)**
May 30-Jun. 11, Oct. 11-22
- **Human Factors for Accident Investigators (A)**
Mar. 8-12, Jun. 14-18, Oct. 25-29
- **Investigation Management (A)**
Mar. 15-19, Jun. 21-25, Nov. 1-5
- **Gas Turbine Accident Investigation (A)**
Mar. 22-26, Nov. 8-12
- **Aircraft Performance and Structures Investigation (A)**
Nov. 17-21 (03)
- **Operational Risk Management (T)**
Mar. 1-5
- **Ramp and Maintenance Safety (T)**
TBD
- **Fire and Explosives Investigation (A)**
TBD
- **Helicopter Accident Investigation (A)**
Mar. 29-Apr 2
- **Safety Management Systems (T)**
Sept. 13-24
- **Human Factors in Safety Management Systems (T)**
Sept. 27-Oct. 1
- **European Edition of the Cabin Safety Symposium (PR)**
Mar. 23-25
- **Basic Accident Prevention and Investigation (PR)**
Apr. 19-30

For further information contact:
Eduardo Treto, Registrar
SCSI, 3521 Lomita Blvd, Ste 103
Torrance, CA 90505-5016, USA
Tele: 1-800-545-3766 or 310-517-8844,
Fax: 310-540-0532
E-mail: registrar@scsi-inccom
Website: wwwscsi-inccom

TRANSPORTATION SAFETY INSTITUTE & FAA
- **Aircraft Accident Investigation**
Mar. 9-17, May 3-11, Jun. 8-16, Jul. 13-21, Jul. 27-Aug. 4, Aug. 18-26,
- **Accident Investigation Recurrent Tng.**
Mar. 2-4, Apr. 20-22, Aug. 10-12, Sept. 14-16
- **Human Factors in Accident Investigation**
Feb. 10-12, Apr. 13-15, Jun. 29-Jul. 1, Aug. 31-Sept. 2
- **Rotorcraft Accident Investigation**
Feb. 18-27, Mar. 23-Apr 1, Apr. 20-29, May 18-27
- **Aircraft Cabin Safety Investigation**
May 4-5, Aug. 19-20
- **Aviation Safety Officer**
May 18-20
- **Amateur Build Aircraft Accident Investigation**
Jun. 8-10, Jul. 27-29
- **Turbine Engine Accident Investigation**
May 18-20

For further information contact:
Pat Brown, Transport Safety Institute
Tele: 405-954-7206
Website: www.tsi.dot.gov

Plans are under way for a mid-May Reachout to be held in Beijing. The workshop will be hosted by the ICAO Cooperative Development of Operational Safety and Continuing Airworthiness Program (COS-CAP) and will follow the very successful program that COS-CAP hosted in India and Sri Lanka last year. The India and Sri Lanka workshops were considered one of the highest quality workshops to be delivered in the area. The organizers and Jim Stewart, Chairman of ISASI Reachout, credited the instructors, Caj Frostell, Elaine Parker, and Keith McGuire, for that success and for the return invitation. "Taking ISASI Reachout to Beijing has been high on our priority list since the Reachout program was formed," said Stewart. "The support and visibility we are receiving through ICAO has opened the door on a number of possible Reachout sites."

Barbara Dunn, Canadian Councillor and Society President, has been asked to head up a second Reachout program in India, following an invitation by the ICAO COS-CAP program. "The hosts asked for a cabin safety workshop," Stewart reported, "as well as a maintenance workshop." The Reachout Chairman is still looking for someone to participate in a maintenance workshop, and asks anyone with a maintenance background and experience instructing to please come forward and contact him.

"We have a tentative workshop scheduled for Cairo, Egypt, in the near future," said Stewart, "but the dates are yet to be confirmed." The workshop scheduled to be held in Burkina Faso was to have been the first non-English Reachout; it has been delayed and will be rescheduled.

The ISASI International Council believes the program has successfully reached its target audience. The program has expanded its subject matter to deal with accident investigation, safety management, ATS safety management, and, with the recent request for a cabin safety workshop, is in the process of adding a fourth area. Reachout's working group members are actively seeking additional hosts.

Tom McCarthy, ISASI Treasurer, acts as the gatekeeper for sponsorship funding and both he and the Reachout Chairman have to agree before commitments are made to support a particular workshop with sponsorship funds. "Right after the Mexico City workshop," McCarthy said, "Jim Stewart and I will be planning a major fundraising campaign to rebuild the Reachout account and allow us to continue with this important ISASI program." ISASI Reachout's continued success and its ability to offer a no-cost workshop experience to participants is dependent on ISASI's corporate sponsors.

If you are interested in joining the Reachout team as a corporate sponsor, please contact Jim Stewart, Chairman of ISASI Reachout, at stewartj@alpa.org or through the ISASI home office. ◆

PNRC Receives Session on Interviewing Techniques

At the November 2003 technical meeting, the Pacific Northwest Regional Chapter received a presentation by Dick Wood on the principles of interviewing witnesses. The meeting was well attended by both members and guests. Wood has worked extensively with witness interviews while in the Air Force, as an instructor at USC, and as a consultant. He presented several interesting aspects critical to interviewing that will improve the quality of an investigation. He encouraged the group to separate witnesses into those who are reporting what they did from those who are reporting what they saw. He also illustrated the importance of using model aircraft in the interview process and how to go from general questions to specific questions without the use of leading questions. The meeting was held at the Boeing Longacres facility in Renton.

The PNRC will be continuing its technical meetings on alternate months throughout 2004. Meetings are currently scheduled for March 10, May 12, July 14, September 8, and November 10. Guests from other regions or individuals interested in aviation safety are always invited to attend any of the Chapter meetings. Details on the exact times and locations for these presentations can be obtained directly from Chapter President Kevin Darcy at kdarcy@safeserv.com or from Leo Rydzewski at leo.j.rydzewski@boeing.com. ◆

MARC Recounts Seminar Success

The Mid-Atlantic Regional Chapter President Ron Schleede exclaimed the Chapter's delight with the success of ISASI 2003 held in Washington, D.C., in August. He said, "To all who missed ISASI 2003, you missed a great seminar! MARC and our Committee thank all who attended and helped. I am sure the support for ISASI 2004 will be tremendous and it will be a great show! My wife, Kathie, and I plan to be there."

Because of the success of ISASI 2003, and primarily because of the tremendous support of corporate members, ISASI and MARC will benefit financially, enabling the Society to continue its work that could not be accomplished without such support. Schleede said, "We hope to use part of the funds to make MARC more active and useful to our members, and to support the ISASI Rudolf Kapustin Memorial Fund. Rudy kept MARC running for many years and he would be pleased to know his work is continuing through the funding of scholarships for new investigators."

MARC plans to hold its annual dinner/meeting on Thursday, May 6, 2004, which will be held in conjunction with the ISASI International Council meeting. The venue for that event is not yet established. ◆

ATSWG Assesses Group Performance

The year 2003 has disappeared from our radar screen almost as quickly as it arrived. Like any useful endeavor, our working group performance can be measured by the simple question, Did we make a difference? We think we can say "yes."

Our objective was to aim at our "top ten" ATS safety issues in 2003. This objective proved a little too ambitious, but we managed to meet some of them in part.

The issues of TCAS/ACAS interface were broadly highlighted by Secretary Bert Ruitenberg in a number of high-profile forums. The lessons learned from the tragedy at Überlingen have been largely disseminated at the operational and management levels of many ATM service providers. Aspects of human performance, systems integration, and privatization were combined to add a new dimension to ATS investigations.

Equally, our group managed to tread the boards of the world stage thanks to the efforts of past ATS WG Chairman Darren Gaines. Gaines represented ISASI at ICAO Regional Safety Seminars on runway safety and safety management in Singapore and Cairo. In conjunction with representatives from ICAO, IFATCA, FAA, Eurocontrol, Airservices Australia, UK CAA, and Nav Canada, Gaines was able to present a working level view of the issues and offer strategies to militate against the problems. This level of representation is indicative of the collective status enjoyed by the ATSWG. We believe that it will continue to develop and become an even greater safety tool for our industry. ◆

Lewis Elected to BCSP V.P. Position

C.L. (Curt) Lewis, ISASI U.S. Councillor and President of the U.S. Society, was recently elected to fill the 2004 Vice-President position of the Board of Certified Safety Professionals. The term of office is 1 year. Henry Smahlik, BCSP's current Vice-President, was elected to fill the President position.

Lewis is currently Manager of System Safety for American Airlines in Fort Worth, Tex., as well as President of the ISASI Ft. Worth Chapter. He also fills a Director-At-Large position on the BCSP Board and has served since 1999. ◆

AirTran Airways' First 'Guiding Principle'

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

At AirTran Airways, safety is not only a word, but also a culture that is instilled in each crewmember from his or her first day of working at the airline. During the orientation process, crewmembers learn to incorporate safety into everything they do, whether they are out on the tarmac or in the terminal assisting a customer.

After the events of Sept. 11, 2001, AirTran Airways proved itself as a leader in the industry by being the first airline to complete the installation of cockpit door reinforcements 1 month before the deadlines set by the Federal Aviation Administration.

Furthermore, on Jan. 9, 2002, AirTran Airways responded quickly to crewmember's demands for enforced cabin safety by being the first U.S. airline to offer Close Quarter Defense (CQD) training for the carrier's flight attendants. The free and voluntary classes taught self-defense techniques specifically geared toward linear defense in the cabin and aisle and received an overwhelming response from flight attendants, as well as interest from other airlines who soon followed in the airline's footsteps.

Pilots also have benefited from AirTran Airways' participation in voluntary safety programs, including Flight Operational Quality Assurance (FOQA) and AirTran's Safety Collaborative Program (ASCP), a customized version of the FAA's Aviation Safety Action Program (ASAP). During initial, upgrade, and recurrent training, pilots are taught the benefits of ASCP, a program that promotes a non-jeopardy environment where concerns can be expressed without fear of reprisal provided certain conditions are met.

Although AirTran Airways works hard to prevent incidents from occurring in the first place, investments in safety software technology, such as AQD (Aviation Quality Database) and TRAX, have proven to be boons in tracking and preventing potential incidents and events.

AQD is a safety database that tracks incidents, events, and findings and produces an analysis report for the airline's internal evaluation program. TRAX was implemented systemwide as a tool for maintenance and engineering to track such things as fleet reliability, quality assurance and control, maintenance discrepancies, aircraft performance and modifications, and vendor performance and inventory.

In addition, AirTran Airways became one of the first in the industry to use an interactive safety software program meant to assist it in determining the underlying cause of operational issues, particularly in the Reliability, Quality Assurance, and Safety Departments. The Reason 6.0? Root Cause Analysis and Lessons Learned System by Decision Systems, Inc., maximizes the safety and reliability of services by monitoring and studying inventory or mechanical issues before they can escalate into larger problems that could affect operations.

"AirTran Airways is a strong proponent of using technological advances to enhance the reliability, safety, maintenance, operations, and security issues that constantly challenge our industry," said J.P. Dagon, AirTran Airways' Director of Corporate Safety. Dagon heads up the Safety Department that oversees operational and occupational safety issues and includes an independent internal evaluation program.

Safety in the workplace also is an important focus for the airline. Last year, AirTran Airways joined the OSHA Airline Alliance to create standards and procedures to improve occupational safety at airlines and airports.

The past few years marked many enhancements in AirTran Airways' focus on safety for its customers, but none more so than this past October, when the airline's last McDonnell Douglas DC-9 aircraft were retired and replaced by Boeing 717s.

"AirTran Airways is 100 percent committed to the safety and security of our crewmembers and passengers, and the corporate initiatives we have adopted in the past few years are proof of our dedication," said Dagon. ◆

AIR SAFETY INVESTIGATORS
INCORPORATED AUGUST 31, 1964

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