

FORUM

ISASI

Air Safety Through Investigation

JULY–SEPTEMBER 2014

Journal of the International Society of Air Safety Investigators



“I wish to congratulate ISASI on its landmark 50th anniversary celebration. ISASI has had a significant role in improving the science, technology, and procedures in aircraft accident and incident investigation, and ICAO will look forward to continued cooperation with your organization in fostering further improvements in aviation safety.”

— Raymond Benjamin, Secretary General, International Civil Aviation Organization

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The displayed 50th year anniversary logo was designed and produced courtesy of Safety Research Corporation of America (SRCA), founded by Robert Rendzio, who also serves as president of U.S. ISASI's Southeast Regional Chapter. The logo will be displayed throughout ISASI's anniversary year.

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Editor Esperison Martinez
Design Editor Jessica Ferry
Associate Editor Susan Fager

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Organization

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internationale

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организация
гражданской
авиации

منظمة الطيران
المدني الدولي

国际民用
航空组织

THE SECRETARY GENERAL

Ref.: E4/174 27 March 2014

Dear Mr. Del Gandio,

It gives me great pleasure to convey my congratulations to the International Society of Air Safety Investigators (ISASI) on its 50th anniversary. ICAO and ISASI have enjoyed a mutually beneficial relationship for 50 years.

As a professional society for aircraft accident and incident investigators and related safety professionals, ISASI has been a strong supporter of ICAO goals and objectives in improving aviation safety worldwide by enhancing the science and techniques of aircraft accident and incident investigation. ISASI has been instrumental in fostering cooperation among accident investigators from states worldwide. I have noted that ISASI participated as an International Observer Organization in the ICAO Accident Investigation and Prevention Divisional meetings held in the past 40 years (AIG/74, AIG/79, AIG/92, AIG/99, and AIG/08).

At these meetings, significant and far-reaching improvements were developed under the auspices of ICAO in respect of the standards and recommended practices (SARPS) in ICAO Annex 13—Aircraft Accident and Incident Investigation—as well as ICAO Annex 6—Flight Operations for the flight recorder carriage requirements. ISASI participation in ICAO activities was further strengthened in 2013, when ICAO granted ISASI International Observer Organization status in ICAO.

I would also like to congratulate ISASI for its continued success in convening its annual international seminars (inclusive of the 45th ISASI seminar to be held this year in Adelaide, Australia) that have enhanced the quality of accident investigations and improved aviation safety worldwide. The technical excellence of seminar presentations and worldwide networking opportunities you facilitate among investigators are invaluable to the participants.

ICAO, in turn, has actively participated in ISASI seminars, leading overarching discussions on recent and future developments in the field of accident and incident investigations. Similarly, ICAO has assisted in the deliberations of ISASI's Government Air Safety Investigators Group, which, among others, encourages a proactive approach to investigations through the exchange of information on research and mutual assistance in investigations.

The 2008 ICAO AIG Divisional Meeting formulated a recommendation: "That ICAO and its regional offices continue to cooperate in the organization of ISASI Reachout workshops." The ICAO endorsement of the workshops has facilitated the attendance of safety experts from numerous states. I also have noted that the ISASI Reachout workshops were instituted in cooperation with ICAO about 14 years ago and that, to date, 46 such workshops have provided accident and incident investigation training to several thousand aviation safety specialists around the world.

I am aware that significant improvements in flight recorders and their carriage requirements, as developed by the ICAO Flight Recorder Panel, took into due account the work of the ISASI Flight Recorder Working Group. Similarly, ICAO Circular 298, Training Guidelines for Aircraft Accident Investigators, was partially based on the ISASI investigator training guidelines.

In conclusion, I wish to congratulate ISASI on its landmark 50th anniversary celebration. ISASI has had a significant role in improving the science, technology, and procedures in aircraft accident and incident investigation, and ICAO will look forward to continued cooperation with your organization in fostering further improvements in aviation safety.

Yours sincerely,



Raymond Benjamin

999 University Street
Montréal, Quebec
Canada H3C 5H7

Tel.: 514-954-8041
Fax: 514-954-6077

E-mail: icaohq@icao.int
www.icao.int

About This 50th ANNIVERSARY Issue of *Forum*

By Frank Del Gandio, President

On August 31, we celebrate our 50th birthday and the 50th anniversary of the 1964 incorporation as the Society of Air Safety Investigators. Fourteen years later, on Oct. 11, 1978, our status as an international society took effect. We looked at a day of celebration for reaching our 50th milestone but determined that once the day was gone so, too, would be the short-lived celebration. We could not let this pass as an ordinary event because too many persons and events have helped shape today's ISASI.

So to create a more living and lasting memory, we decided that a 50th anniversary *Forum* would make an ideal celebration platform. You are holding the result of our efforts, which we hope will for our long-term members awaken memories and for our newer members create new knowledge.

We are very pleased to receive the congratulations from ICAO, which is noted on page 3 of this issue. You may recall that ICAO granted the society "observer" status in May 2013. Achieving that status was a five-year effort on the part of your governing International Council.

The article "*Creating the Code*" deals with the genesis of ISASI's *Code of Ethics and Conduct*. Our early leaders recognized that a mark of self- and public recognition of a professional status of any group is adherence to a specified doctrine of behavior. Thus came the development of our "Code," primarily by C.O. Miller. He joined ISASI in 1968, received the Lederer Award in 1988, and achieved Fellow status. He flew west in 2003. C.O. enjoyed a reputation as an air safety advocate extraordinaire.

Editor Marty Martinez keeps the memory of ISASI's president emeritus alive through his "Jerome F. Lederer: Gone But Not To Be Forgotten." The article reveals how and why the coveted ISASI Jerome F. Lederer Award came into existence as the society's highest peer recognition award. In the article "Father of Aviation," Jerry's life path is followed through his seven decades of devotion to aviation safety. He died at age 101, leaving behind a legacy that is best described in these words by an unknown author, "Aviation and manned space flight have seldom, if ever, had one person contribute so much for so long to the advancement and the consequent well-being of humanity."

Gary DiNunno, editor of the electronic news *ISASI Update*, in his article "ISASI: Becoming a Global Force For Air Safety" takes us through a journey of ISASI's past and into the present. He explores the times and tribulations of the society's early years and how the governing bodies met the needs of the times.

In "ISASI: 50 Years of Investigation," Ludi Benner looks back at the history of investigation during the society's existence to note the difference that ISASI members have made in the aviation industry. He used his extensive knowledge of past accident investigations, sought input from active investigators, and came up with a "not exhaustive" set of past investigations that produced new information that had some value for improving safety performance. Each investigation was selected on the basis of the magnitude of the changes each precipitated.

While ISASI is turning 50, accident investigation is turning 100. Robert Matthews traces the time line of aviation accident investigation to explain why the statement "Aviation Is Safer Than Ever" was true in the 1920s, the 30s, the 40s, today, and into the future. He carries us back to the start in 1915 when the UK's Royal Flying Corps created the first organization dedicated to accident investigation. From there he follows the historical path of the growth of investigative organizations—some you may know, and some you may not.

Closing the issue is Thomas Farrier's "Year 2050: 'SkyArc 71, Surveillance Lost.'" This fictional account, the first to ever appear in the *Forum*, is about the possible future of air safety investigations. It builds on present-day issues and emerging technologies. Told in the narrative short-story style, I am willing to bet it will capture you.

Finally, I send to each and every member, and every potential member, my heartiest expectations that the future challenges to ISASI as an international safety/accident investigator organization will be met as professionally and completely as those of the past 50 years. ♦



ISASI

Code of Ethics

Preamble

The purpose of the Society is “To promote the development and improvement of aviation or incident accident investigation.” Implicit therein is a requirement for a baseline of agreement between the Members and the Society as to what constitutes professional behavior of the Members. Indeed, under the Bylaws, the Member covenants to support provisions of the Bylaws as a prerequisite to membership in the Society. Therefore, as an Appendix to the Bylaws, this Code of Ethics (and the accompanying Code of Conduct) reflects behavior expected of ISASI Members. It has been prepared and adopted with the full realization that determination of the adherence or lack of adherence to these principles is a matter of judgment; judgment which can only be effected reasonably by peer review.

I. Integrity

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

II. Principles

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

III. Objectivity

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

IV. Logic

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

V. Accident Prevention

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



Creating the *Code*

By Charles O. Miller

(This article dealing with the genesis of the Code of Ethics and Conduct was prepared from material presented by Charles O. Miller, “Chuck” or “C.O.” as he was more commonly known, at the ISASI annual seminar in October 1982. Miller joined ISASI in 1968 and “flew west” in 2003. 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 reflected than in his creation of ISASI’s Code of Ethics and Conduct.—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 [prior to 1983] 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, includ-

ing 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.

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 based 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 delaying 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*)



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

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. Below is ISASI's combined current Code of Ethics and Conduct, which has remained unchanged since its adoption in October 1983. The stand-alone Code of Ethics is the opening page of this article.—Editor) ♦

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 Society 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.



Chuck Miller (1924–2003) 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 graduating 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. Later he supervised the company's reliability, maintainability, and human factors engineering in addition to being its chief flight safety engineering official (among the first in this capacity in the aerospace industry). Specific safety positions he subsequently occupied included 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), and 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 held numerous positions in these and other groups (e.g., charter member and second president of the System Safety Society, principal author of the Code of Ethics and Conduct for ISASI, and the first chairman of ERAU's Advisory Committee for its Center for Aerospace Safety Education (CASE). He was retained by the Nuclear Regulatory Commission in its inquiry into the Three Mile Island accident wherein he authored one of the commission's final report's main chapters dealing with safety management. He received other awards in addition to those fellow rankings noted above. These included election to the International Safety Academy at its inception in 1971, the Flight Safety Foundation Distinguished Service Award in 1971, Aviation Week and Space Technology's “Laurels for 1974” for his role in the Congress's increasing NTSB's independence from the Department of Transportation, the Space and Flight Equipment (SAFE) Society's 1992 Spruance Award for “outstanding contributions to safety through education,” and induction in 1993 into the Arizona Aviation Hall of Fame located at Tucson's Pima Air Museum.

Jerry in attendance at the 2003 ISASI seminar.

Jerry Lederer: Gone But Not To Be Forgotten

*ISASI's president emeritus's vision
remains a guiding light to the society.*

By Esperison Martinez, Editor



Jerry was very instrumental in initiating the society's first international seminar. It was held Nov. 2–4, 1970, and immediately followed a Flight Safety Foundation seminar. In the welcoming address, Jerry noted that the seminar is “an experiment that we hope will go far. It was an idea promulgated... with the feeling that meetings such as this would have the effect of getting people to know one another before the accidents occur in strange lands. You'll have an opportunity to meet with people and discuss

problem areas with people whom you will meet later when accidents occur in countries other than your own. In addition, of course, we will be able to exchange ideas on new techniques as well as the old proven techniques on aircraft accident investigation.” That “feeling” remains a cornerstone of today's ISASI international seminars.

Jerry also noted, “Much of the progress in the development of safety resulted from lessons learned from accident investigation.... Lessons learned from these accidents are what has led to much of our progress. There's no reason to doubt that this will continue and that new techniques will be developed to aid the investigator to determine probable causes with less time and more accuracy than in the past, in spite of the incredible growth and complexity of the vehicles.” This thought was indeed visionary.

So perhaps it is not a surprise that during the Sept. 27, 1976, meeting, the SASI Board of Directors determined that the award they had established for “technical excellence in the field of aircraft accident investigation” would carry Jerry Lederer's name. Thus, the Jerome F. Lederer Award was created.



Jerry, center, congratulates Caj Frostell, right, after presenting the 2003 Lederer Award. Looking on is ISASI President Frank Del Gandio. The 2003 ISASI seminar, held in Washington, D.C., was Jerry's final ISASI appearance.



The design of the award has not changed over the years, except for the name of the recipient.

The highest honor the International Society of Air Safety Investigators (ISASI) bestows is its Jerome F. Lederer Award for “technical excellence in furthering aviation accident investigation.” Yet little is known of the genesis of the award, and memory dims about the man for whom it recognizes—a man of boundless energy and absolute dedication to safe flight.

The Society of Air Safety Investigators (SASI), later to become ISASI, received its Certificate of Incorporation from the District of Columbia on Aug. 31, 1964. Just six months later,

on Feb. 20, 1965, Jerry Lederer applied to SASI for membership. At the time, he was the director of the Cornell University Guggenheim Aviation Safety Center, the U.S. representative to the ICAO panel that evaluated the acceptance of the jet transport airplane into international civil aviation, and president of the Flight Safety Foundation.

Recorded on his membership application as previous employers is the U.S. Air Mail Service, 1926–1927; director, Safety Bureau, CAB, 1940–1942. And under the “Résumé of aircraft accident investigations,” he wrote, “All airline accidents from July 1, 1940, to November 1, 1942.” About his background he noted: “The first accident in which I participated was a Hamilton all-metal cargo plane operated by Ford Motor Company. It crashed at Hammond, Indiana, about November 1926. My first investigation as director of the Safety Bureau, CAB, was Capital Airlines DC-3 on Aug 30, 1940. I organized the first school for aircraft accident investigators under FSF sponsorship at Mitchell Field, Long Island, in 1949.”

Following incorporation, SASI began to take shape as an organization. Objectives, purpose, a constitution, and bylaw language was debated and created, as was SASI policy and membership qualifications. Among the orders set was the election of officers: president, vice president, and secretary-treasurer. Election was by letter ballot of eligible voting members. The term was set at two years. In 1968, Jerry became the first elected and second serving SASI president. At the time, he was serving as director of the Office of Manned Space Flight Safety at NASA.

Its first presentation was to be at the 1977 ISASI seminar. Upon being notified of the board's action, Jerry responded: "I regret I shall not be present to acknowledge the honor SASI is bestowing on me by announcing the Jerome F Lederer Award for excellence in aircraft accident investigation. The award is doubly unique; first, because it is given for the special discipline in accident investigation and, secondly, because it is named after a person who is still living. I appreciate this very much—much more now than I would in the hereafter. I thank you for this great honor, and promise to conduct myself [now and] in the hereafter in such a way as to enhance the award. May I say what a great privilege it has been to be associated with SASI and to congratulate you for an excellent seminar."

The Jerome F. Lederer Award has lost none of its luster or significance over the 37 years since its establishment. To date, 40 individuals or organizations have been recipients. The first presentation was made to Samuel M. Phillips at the eighth annual seminar held in Caracas, Venezuela. The most recent was a dual presentation to Frank Del Gandio and Myron Papadakis. And in October, yet another accident investigator will be honored by peers at the 45th annual accident investigation and prevention seminar being held in Adelaide, Australia.

Jerry "flew west" at age 101 on Feb 6, 2004. In the 10 years since his passing, many new members have joined ISASI. And for them, as well as for existing members whose memories may have begun to fade, the following article is reprinted from the April–June 2004 *ISASI Forum*, which was published in celebration of his life. ♦

Jerry Lederer:

"Father of Aviation Safety"

"Aviation and manned space flight have seldom, if ever, had one person contribute so much for so long to the advancement and the consequent well-being of humanity. Saving lives and conserving other resources is what accident prevention is all about. Jerry Lederer, upon making his final flight west at age 101, has created a textbook without an end in this area. Succeeding chapters will be written ad infinitum based upon his legacy."—Author Unknown

Prepared from news and magazine sources by Esperison Martinez, Editor

Known as the "Father of Aviation Safety" throughout the industry even before the U.S. Congress recognized him as such in 1997, Jerry himself never believed that to be true: "It's nice to be known as that, but I don't really think I am," he told Jeff Rud, reporter for the *Vancouver Times Colonist* newspaper in September 2001, while attending the ISASI annual seminar. "I think the Wright Brothers really deserve that honor," Jerry added to his comment. He pointed out that it was they "...who originated simple design concepts that included positioning the engine beside the pilot to lessen danger...and who invented the first flight data recorder..." wrote Rud.

That exchange personified Jerome F. Lederer's quiet, unassuming nature. Yet those who knew him, worked with him, talked with him recognized the depth of knowledge and selflessness that lay within the man whose small frame, cherubic features, and twinkling blue eyes belied his towering public stature.

Born on Sept. 26, 1902, the year before the Wright Brothers launched the world into powered flight, Jerry's flight safety career spans the entire aerospace safety spectrum and other areas of public interest as well. During his remarkable aviation career of more than seven decades, he has become, as one author wrote in 1970, "a veritable walking encyclopedia of aviation lore and safety facts and figures and a man of vision to challenge the seers of all times."

He lived with the growth of aviation

safety from the time the U.S. Post Office operated the nation's accident-plagued transcontinental air mail service and with the nation's early ill experiences of space flight safety to the present, when aviation is considered the safest form of public transportation.

"Jerry," as this most congenial of gentle men liked to be called, was graduated with honors from New York University's College of Engineering in 1924 with a bachelor's degree of science in mechanical engineering, securing his master's degree the next year. During his school year, he also was appointed assistant director of aeronautical engineering. "I erected and operated the first wind tunnel at New York University. It was a 4-foot, 40-mile-per-hour wind tunnel that we got from Curtiss Co. and I was paid \$12.00 a week," Jerry recalled during a recorded living history interview with Flight Safety Foundation (FSF) staff members.

U.S. Air Mail Service

In 1926, Jerry joined the U.S. Air Mail Service (1918–1927), at Maywood, Illinois, and became aeronautical engineer of the world's first system of scheduled air transportation, in which one of every six airline pilots died in crashes each year. It was here that his predilection for flight safety took hold. Bad-weather flying, coupled with technical problems, predominated as the cause of aircraft accidents that were taking the lives of so many pilots.

"We used the British de Havilland 4

biplane-powered airplane. When we lost all those Air Mail Service pilots in the early 1920s, the usual cause of death was a fire following a crash. We built a concrete ramp with a concrete wall at the end of it, put these ships under full power, and let them go down the ramp into the wall. Slow-motion pictures showed that when the airplane crashed, the fuel spilling out of the tanks—which were carried up front in the fuselage—would go onto the hot exhaust manifold and start the fire. I drew specifications for new parts and developed test methods for new ways of operating the plane. I put out my first bulletin when I was with the Air Mail Service. We had a lot of crackups, of course. We had a lot of spare wings but no spare fuselages. So my first safety bulletin addressed to the pilots said, ‘If you do crash, please crash the wings first. Go between two trees and take the wings off. We have plenty of wings, but no fuselages,’” he told FSF.

While with the Air Mail Service of “helmet-and-goggled pilots,” Jerry met Charles Lindbergh. The two men were working at Maywood, Illinois, where Lindbergh flew for an airline carrying U.S. mail. Their first meeting involved a discussion about a silk parachute Lindbergh had used during a bailout, which ended up in a field covered with grasshoppers. The parachute was full of great

big, brown holes. Unbeknownst at the time was the fact that grasshoppers exude a juice that burns through silk. The interests the two men shared in aviation developed into a life-long friendship. On the day before Lindbergh began his historic solo flight across the Atlantic, May 20, 1927, Jerry had this experience: “I went out to the field, and I looked the airplane over. I did not have too much hope that he would make it. He did not ask me to look at the airplane. I just went out because I was a friend of his and I wanted to see it, to look the situation over.” After the flight Lindbergh was called “Lucky Lindy.”

Designer, fabricator, communicator

In June 1927, Jerry left the Air Mail Service and began a consulting career by forming his own company, Aerotech, in Davenport, Iowa, later that year. He did structural work on the world’s first cabin monoplane that had, in his words, “very odd wheels that looked like baby-

carriage wheels.” His work involved some 48 changes in the structure of the airplane before getting it certified by the Aeronautic Branch of the Department of Commerce. He began work that led to having the design of the two-place Monocoupe accepted for certification, then helped convert the Velie automobile manufacturing plant into an airplane plant manufacturing the Monocoupe. He would later design the four-place Monocoach for Velie.

His involvement in aircraft accident prevention began in earnest when he joined Aero Insurance Underwriters of New York in 1929. He became chief engineer in charge of loss prevention for one of the world’s largest insurance companies. “I was in charge of accident risk analysis. I would go over the losses, and I learned a lot about what was happening in aviation that should not happen. I started writing a newsletter to keep our insured operators out of trouble. We reduced accidents. The newsletters made such a big hit that we used to send them by the thousands to airlines [worldwide],” he told FSF interviewers. In his lifetime, he would write one book (*Safety in the Operation of Air Transport*, Norwich University, 1938) and hundreds of papers and articles that are now archived in the FSF Jerry Lederer Aviation Safety Library.

Jerry believed that risk management was a more useful term than safety. He often stated, “Risk management is a more-realistic term than safety; it implies that hazards are ever present, must be identified, analyzed, evaluated, and controlled or rationally accepted. Accepting the premise that no system is ever absolutely risk free or conversely that there are certain risks inherent in every system, it becomes an absolute necessity that management should know and understand the risks that it is assuming.” For more than a decade, he helped reduce losses through safety audits and other programs.

Aviation’s first safety chief

By 1940 Jerry had attained a full-fledged reputation in the flight safety arena and was selected to become the first director of the Safety Bureau of the Civil Aviation Board, serving until 1942. As director, he was responsible for the promulgation of all civil aviation safety regulations, violation investigation, and for directing all civil aviation accident investigations. During his tenure, Jerry laid the foundation and led the development of accident investigation procedures and regulatory standards. The principles and procedures he developed are essentially followed to this day by the United States National Transportation Safety Board (NTSB) and countless other government and military safety investigation groups. Indeed, the provisions eventually became a part



Jerry at age 25, just about the time he formed Aerotech in Davenport, Iowa.

of the U.S. contribution to standards, recommended practices, and guidance material in Annexes 1, 6, 8, and 13 of the International Civil Aviation Organization (ICAO) accident investigation and prevention manuals as well as other documentation.

The rapid growth in aviation and the increasing emphasis on national regulations placed a heavy burden of responsibility on the bureau. For example, the crash of a Douglas DC-3 over Lovettsville, Virginia, in August 1940 in which U.S. Sen. Ernest Lundeen of Minnesota died, along with 25 other persons, spotlighted the air safety bureau and its handling of the investigation. After only 1 month on the job, Jerry came under great pressure to ground the DC-3, owing to alleged stall characteristics of the aircraft. At that time, the DC-3 represented about 90 percent of the air traffic in the country. Jerry arranged to borrow two DC-3s from local air carriers, and the airplanes were sent to Langley Field, Virginia. Aerodynamics of the DC-3 was reevaluated as the CAB considered, and then rejected, the stall theory in the Lovettsville accident.

In recalling the incident for FSF, he noted that there was severe turbulence and lightening during the storm. Jimmy Doolittle, flying in the same storm in a light plane, reported the storm as the worst he had ever encountered. The CAB, in its final report, said that the probable cause of the accident was “the disabling of the pilots by a severe lightning discharge in the immediate neighborhood of the airplane, with resulting loss of control.” Changes in DC-3 pilot training later were implemented.

Jerry said, “When a senator gets killed, all hell breaks loose. I was investigated by both houses of Congress.... I got my gray hair at that time. The Senate Committee on Aviation was pretty mean.... I indicated that perhaps he [Sen. Lundeen] might have been sabotaged...so they ended the investigation. We developed the wheel-landing system tail high so that the airplane would not be flying near the stall, and the DC-3 came to be a pretty safe airplane. So I did not have to ground it....”

During his years at the CAB, Jerry was involved with many safety advances. Two in particular involve the evolution

of anti-collision lights and flight data recorders (FDRs). Jerry received a report from the Air Line Pilots Association (ALPA) of a developing nighttime hazard involving DC-3s and the faster military aircraft being developed. The report said that military pilots could not distinguish the stationary lights of the DC-3 from city lights when the DC-3 was being overtaken in flight.

Jerry recorded this recollection,



Jerry, left, and C.R. Smith, president and CEO of American Airlines, at a celebration of Flight Safety Foundation's 10th anniversary.

“Because ALPA believed we should do something about it, I started a project to test flashing lights. Some people in the Civil Aeronautics Administration did not think much of the idea and were fighting me.... We went ahead anyway. American Airlines loaned us a DC-3. We had several different kinds of flashing lights made and put on the airplane, on the tail, and also on the navigation lights. The way we judged the best intervals of the light/no light was to stand on the roofs of our houses at night and make notes while the airplane circled...that was how anti-collision lights evolved.”

Today's FDRs began with very primitive FDRs being installed on DC-3s owned by TWA and United. Jerry and his staff found the instruments very useful in their investigations and

determined that FDRs should be in all transport airplanes by regulation. The decision was unpopular with ALPA and air carriers. “ALPA said that this was just nothing but a mechanical spy that would tell lies about the pilot. I put through the regulation anyway. A few weeks later a pilot was accused of flying too low.... We proved by the FDR that he was flying at the correct altitude. He was a member of ALPA and that persuaded them to go along with the FDR. The airlines were a little harder. After I put the regulation through, World War II began and the airlines said the war effort...stood in the way of buying FDRs. The CAB rescinded the regulation,” Jerry recorded.

The war years were an especially busy time for Jerry, as they were for so many others. In 1942, he was tapped by the U.S. Air Transport Command to serve as director of training within the Airline War Training Institute. In this position he had oversight responsibility for the training of more than 10,000 pilots and navigators and 35,000 aircraft technicians. Under his guidance, the command produced 15 textbooks in 15 weeks, including one on survival in the event of a crash in a jungle, in the ocean, or elsewhere. It was urgent to produce this textbook immediately because an aircraft carrier could not embark on its mission until the book was published.

He was later appointed to the United States Strategic Bombing Survey in Europe to evaluate the effectiveness of this strategy. Of this experience he said, “We learned that bombing of a factory was not always very productive because bombs could not damage the steel machinery very much, but would damage the brick walls and make the Germans in the area very angry. So they would all pitch in and build a factory again very quickly. The bombing of the oil industry in Germany was effective, because that reduced the amount of fuel going to the air force. We bombed the German transportation centers, their canals, railroads, and bridges and kept them from putting their war materiel together.”

Breaking new ground

Following the war, Jerry found a way to achieve his passion for sharing safety information: he established Aircraft Engineering for Safety (AES). It disseminated

inated safety information across commercial and national boundaries. The event leading to the formation of AES in 1947 was the crash of a TWA Lockheed Constellation resulting from an inflight fire that killed all occupants except one pilot.

As a result of the investigation and public hearings into the crash, several flight safety experts recognized the usefulness of the Aero Insurance Underwriters safety bulletins, which Jerry had published. It was suggested that similar efforts would also be valuable to the entire aviation industry. “When word got around that I was starting up, some people said that I should not get into this stuff, that I would be sitting on a keg of dynamite, that it would ruin my career and that safety was not a saleable object—shows you how safety was a hard sell in those days. You mentioned safety and you scared people away. That is the big thing that I had to overcome—by diplomacy, mostly, and by not putting out things that would scare people,” said Jerry.

AES merged with a group that was studying cockpit layouts from a human factors point of view. The merged group took the name Flight Safety Foundation (FSF). The first seminar drew only eight people, but the number grew to 50 at the second seminar and kept growing. The present-day FSF is rooted in the recognition that sharing safety information is vital to the health of the industry. Jerry’s work has made the FSF a leader in influencing the formation of airline safety cultures and in implementing worldwide accident prevention programs.

While at the foundation in 1948, he organized the first U.S. aircraft accident investigation course by a private organization, using former CAB colleagues as instructors. More recently, the FSF formed the industry task force for the prevention of controlled flight into terrain (CFIT) and approach and landing accidents. The FSF has been instrumental in assisting and continues to assist ICAO with the promulgation of standards and recommended practices and other prevention materials to combat CFIT.

Jerry directed the FSF for 20 years and developed most of the programs for which it is noted, such as the worldwide exchange of prevention information, research projects, and safety seminars. These activities continue today. The FSF



Jerry, right, is sworn in as director of safety (1970) at NASA by Dr. George Mueller.

has established an extensive library in his name.

National roles

From 1950 to 1967, concurrent with his FSF leadership, Lederer was director of the Cornell University Guggenheim Aviation Safety Center, whose mission paralleled that of the foundation. The center frequently highlighted significant areas for further research. In 1956, he was appointed to U.S. President Dwight D. Eisenhower’s seven-person Aviation Facilities Investigation Group, which paved the way for the organization of the FAA and modernized the air traffic control system. And in 1965, Jerry represented the United States in supporting the ICAO Jet Transport Implementation Panel formed to evaluate the acceptance of the introduction of jet transport aircraft in international civil aviation.

Two years later, in 1967, following the tragic space capsule fire at Cape Kennedy in which three astronauts lost their lives, Jerry was invited to organize and become director of the new Office of Manned Space Flight Safety at NASA. At that time, he was 65 and had just retired from the FSF, having already earned the unofficial title “Mr. Aviation Safety” among his peers.

He told interviewers, “I did not know what I was getting into, and probably would not have taken the position if I had known this would be the most complicated thing I could ever imagine. For example, the idea of getting to the moon by stages and then taking off from the moon and meeting another stage in flight to come back to Earth was very foreign to me. If I had had anything to say, I would have said this was impossible, but it was done.” Neil Armstrong and Jerry became good friends during the *Apollo* program. In recalling his time with Jerry, the astronaut said, “Jerry was a realist. He recognized that flight without risk was flight without progress. But he spent a lifetime working on minimizing that risk.”

In 1970, having been awarded the NASA Exceptional Service Medal for his work in the *Apollo* program, he became director of safety for all NASA activities, responsible for the concept and execution of safety programs throughout the entire organization. He knew the daunting task of managing the risk associated with the complex NASA technology. His background of analyzing risk in the aircraft insurance field influenced his thinking and the terms he used to com-

(Continued on page 37)

Tracing ISASI's growth from an idea to a recognized and respected international aviation accident investigators' organization.

ISASI: Becoming a Global Force For Air Safety

By Gary DiNunno
Editor, *ISASI Update*

Good things can come from a simple discussion among like-minded people. Inventions are designed. Programs are begun. Organizations are formed. So it was in 1964, when Joe Fluet, then chief of the Investigative Division at the Civil Aeronautics Board, and Truman "Lucky" Finch started talking about air safety investigators and the advantages of cooperation through a professional organization.

Finch, in an e-mail on Aug. 1, 2010, to the ISASI office, wrote that in the winter of 1963–64, he and Joe Fluet talked about creating an organization "devoted strictly to promoting aviation safety with no side issues involved." Joe said, "That's a great idea. Get started on that." Finch said he selected the organization's name. "After considering Association of Air Safety Investigators (AASI) or Air Safety Investigator Association (ASIA)," he wrote, "I determined that the membership should be pledged to or dedicated to aviation safety rather than associated with aviation safety and the name society would be more appropriate. Society of Air Safety Investigators (SASI) was selected. Joe agreed."

In designing the ISASI logo, Finch said, "I wanted to emphasize safety, thus the large golden S surrounding the entire blue sky with aircraft entering and exiting the sky. The aircraft represent the past, the present, and the future. Additionally, they represent general aviation and commercial aviation." He noted that Joe concurred with the design.

The discussion spread to a handful of air safety inspectors. On March 25, 1964, Fluet sent a memo to Bobby R. Allen, the director of the Bureau of Safety, outlining a desire to develop a professional society with the objective to promote aviation safety, joining together individuals who have worked as air safety investigators at the CAB "for an appreciable time" or have retired, and providing the opportunity for members to meet on a "social level and promote fellowship." Fluet added that members may be required to meet certain criteria—perhaps five years of service as an air safety investigator and a board would approve membership applications. Barely more than a week later, Allen wrote that the bureau was in general agreement with the proposed organization. With that approval, a small group of both Washington, D.C.-based and field office staff drafted a proposed constitution and bylaws.

Finch added that Charlie King, an attorney in the CAB, volunteered to do all the legal work to set up the new organization. "We proposed the original bylaws and what they should reflect, and King composed them."

"In the spring of 1964," Finch said, "SASI was approved as an organization." He added that "Joe Fluet appointed himself president, and I was assigned to be the secretary-treasurer. Joe assigned the member-

ship numbers giving himself Charter Member 001, Bobby Allen Charter Member 002, and assigned me Charter Member 003. The original dues were \$10. Two of the original Honorary Members were Alan Boyd, chairman, Civil Aeronautics Board, and Najaeb Halaby, administrator, Federal Aviation Administration. Bill Hendricks, who became an air safety investigator at the CAB in 1961 and joined SASI in 1967, says, "When there were early discussions about this new 'club'—we called it Joe Fluet's tree house—there was skepticism. We wondered what was this all about?" On Aug. 31, 1964, the Society of Air Safety Investigators was incorporated as a nonprofit group in Washington, D.C.

The next step was to recruit members. News quickly spread about this new organization for air safety investigators by word of mouth and press coverage. Letters sent to SASI indicate that *The New York Times*, on March 14, 1965, said U.S. "air detectives" have incorporated under the name of Society of Air Safety Investigators. *Aviation Daily* announced the formation of SASI on March 9, 1965. A column, "On Wings," in *The Washington Star*, on March 24, 1965, noted the formation of SASI, listed the officers, said membership was open to eligible citizens of all countries, and provided the address to send applications. The *Air Force Times* announced SASI's incorporation in March. The April issue of *American Aviation* noted that Joe Fluet had been named as SASI president. The May issue of *FAA Aviation News* covered SASI's formation.

A deadline for charter members and charter corporate members was set for June 30, 1965. By that date, 139 members, two corporate members (United Airlines and the Air Line Pilots Association), and two honorary members had joined SASI. By the end of that year, 21 more members signed up. The society had three categories of membership. A full member was an air safety investigator with five years' experience and participation in at least 10 aircraft accident investigations or three years' experience and 50 aircraft accident investigations. An associate member needed three years' experience and five investigations or one year experience and 15 investigations. An honorary member was an individual who had made an outstanding contribution to air safety investigation with the recommendation of the membership committee and approval of SASI officers. The initiation fee for members and associate members was \$30, and the annual dues were \$10.

In the fall of 1965, Fluet and a five-person Board of Directors tried to get the society off the ground, but a series of air carrier accidents took priority, requiring four CAB investigation teams well into 1966. SASI officials decided to create a program committee and appointed a program director to initiate appropriate society programs and offer "cohesive communications." Sam Parsons, named program director, began a regular membership bul-

letin, the *PDQ* in 1966. In the first issue, he wrote, "What does PDQ mean? No, it isn't pretty d--n quick. It simply stands for Program Director's Communiqué."

He noted that the new society "has a tremendous potential. Visualize, if you will, the air-safety think power" of which it is capable. The membership, he explained, "consists of old-timers to current investigators who have proven themselves...in the field or in accident prevention research." SASI members, Parsons continued, "have made and are making recommendations on a daily basis for the prevention of aircraft accidents. They have and are acquiring experience unmatched anywhere in the world in the business of aircraft accident investigation and the promotion of air safety. Put that brain power to work, and you have something going that will have no equal."

Also in 1966, SASI added requirements for corporate membership. Corporate annual dues were set at \$250, and the corporate representative had to meet the same qualifications as individual SASI members when possible. Parsons noted in the bulletin that SASI encourages local and regional chapters of the society and offers to furnish guidelines for members to establish them. The society took action to create regional chapters in each of the 10 CAB field offices, one in Europe, and one in the CAB headquarters.

In August 1966, SASI held a general meeting in Washington, D.C., for all members. Its main purpose was to "stimulate member interest in the activities of the society." A panel discussion led by the SASI directors covered issues about SASI's creation and structure. In late 1966, SASI membership stood at 180, with 67 based in Washington, D.C., 5 in Europe, and the remainder scattered throughout major U.S. cities with CAB regional offices. In December, SASI announced the intention to reduce member dues "until we develop some programs that would justify the expenditure of more funds." The change required the Board of Directors to propose an amendment to the SASI Constitution.

SASI had an election year in 1967. The incumbent officers won another term. The SASI National Capital Chapter conducted luncheon meetings every two months that included a speaker from the aviation industry. Recordings of

the luncheon speaker were made available to the regional chapters for their meetings. The Washington, D.C., chapter also held a business meeting every other month at noon where "interested parties can discuss and debate issues of their choice."

In a letter to members in appreciation for reelecting the incumbent officers, President Fluet declared, "as air safety investigators, we are bound together by common objectives. Our thesis is air safety through accident prevention. The tools of our trade are technical competence, perseverance, and a strong sense of responsibility toward the public." Fluet added, "As air safety investigators, we are unmatched anywhere in the world in our ability to walk into the remotest area where an aircraft might fall and determine exactly what happened, why it happened, and how to prevent it from happening again."

President Fluet announced several changes to help SASI reach short-term goals: 1. The Board of Directors was expanded from five to nine members. 2. The Membership Committee was reorganized to enable more efficient processing of applications and to launch a recruiting campaign with the goal of attaining 500 SASI members. 3. Regional chapters were to be established on a "firm footing." 4. Work was begun to make the next annual meeting "both memorable and constructive."

The new Board of Directors met in May 1967 and proposed several changes to the SASI Constitution. Annual dues were reduced to \$3 for members and associate members, to \$100 for corporate members, and to \$25 for institutional members. The definition of an associate member was amended to, in effect, make anyone "who conducts an aircraft accident investigation, either alone or as part of a team, or who is just starting out in the business" eligible for consideration. A special SASI meeting was called for in June to ratify the amendments. The Membership Committee was authorized to establish an annual award for recruitment. The Allied Pilots Association, L-3 Aviation recorders, and Honeywell Aerospace became corporate members in 1967.

Sam Parsons reported in an August 1967 *PDQ* about recent discussions to provide members a platform or forum in which to present their views—a periodical "that will give the membership a

chance to discuss, debate, propose, educate, and exchange information among members to further the objectives of the society." SASI proposed, therefore, to publish such a periodical on a quarterly basis, beginning in January 1968, with the title *SASI Forum*. Parsons became the voluntary editor.

In a speech to SASI members on January 11, 1968, at the Army Navy Club in Washington, D.C., Jerome Lederer, then with the Office of Manned Space Flight, suggested the society might have to change its name to the Society of Aerospace Safety Inspectors. He observed that the first accident in space had yet to occur, but undoubtedly it would. He pointed to the accident a year earlier that "cast a shadow over the immense amount of fine safety thinking that has gone into the space activity at NASA." Lederer said, "I am convinced that the spinoff of safety from space activity will have repercussions in accident prevention in all industry—not only in hardware and procedures, but also in organization and management controls to prevent undesired events."

Looking at air safety investigation, Lederer said the use of "telemetry and televised data" by NASA might be a way to ease problems of accident investigation in airline operations. "This would supplement the sophisticated flight recorders" coming to aircraft, he said. Lederer suggested situations "where the flight recorder might be lost—such as in a ditching—in which case telemetry could give the clues to the cause of an accident." He observed that the large amount of telemetry data currently produced could be sharply reduced by metering "only data that was outside allowable margins of safe operations."

Lederer declared that air accident investigations "should not end with the determination of probable cause." He said, "This determination and its cure touch only the symptoms of the accident prevention problem. The true cure should be to delve deeper to uncover the failure in the management organization which permitted the cause to appear." (See "Jerry Lederer: Gone But Not To Be Forgotten," page 9.)

At the seminar banquet in May 1968, held in Washington, D.C., guest speaker "and now honorary society member" Sen. Mike Monroney of Oklahoma praised SASI as an organization, according to Sam Parsons in his *PDQ*

bulletin. Monroney said the organization of the society was “long overdue” and described air safety investigators as the “unsung heroes of aviation—the men who perform the bone-tiring task of maintaining and promoting air safety.” SASI President Fluet presented the senator with an Honorary Member plaque, and Bobby R. Allen of the NTSB was presented a Lifetime Membership.

During the Board of Directors meeting, also that month, Secretary Finch reported income of \$11,800 and expenses of \$10,540 for the year. The Membership Committee chairman, SASI Vice President Gene Searle, said 98 new members joined SASI in the past year, bringing the total to 320—288 regular members, 20 associate members, 8 corporate, and 4 honorary. Other action at the meeting included

- authorizing preparation of a letter from President Fluet to appropriate U.S. Congressional committees and government agency officials offering SASI’s advice and expertise “on any matter dealing with a better method of preventing aircraft accidents.”
- directing the SASI president to appoint a Ways and Means Committee to determine structure of dues and fees and a feasible society budget.
- directing the president to appoint a Home Office Committee to study the feasibility of a home for the society and to report study results to the Ways and Means Committee.
- creating a committee to propose a program to raise money for air safety and accident prevention research.
- prohibiting the use of the SASI logo on anything but the SASI stationery, while allowing members to use the society’s initials on their personal stationery and business cards.
- restricted mailing of the *SASI Forum* to members only, but recognized that subscriptions could be granted to nonmembers at some future time with a \$10 annual fee.
- drafting a proposed constitutional amendment providing for regional SASI chapters, their administration, and their organization.

Later that year, Jerry Lederer was elected SASI president, and Sam Parsons became vice president. Francis Graves was secretary-treasurer. Joe Fluet and C.E. Searle became members of the Board of Directors.

In 1969, a new regional chapter in

New York City joined the existing SASI regional chapter in Los Angeles. By the close of the year, 105 new members joined SASI, bringing the total up to 407 members, 60 associate members, 18 corporate members, and 6 honorary members. The society had 34 members residing in 14 countries outside the U.S. By 1970, the SASI office was located at 8830 Cameron Street in Silver Spring, Maryland.

SASI’s first annual forum for air safety investigation was held Nov. 2–4, 1970, in Washington, D.C. SASI President Lederer told 159 participants that they would have an opportunity to meet and discuss problem areas with people who they would meet later when accidents happened in countries other than their own. “We will be able to exchange ideas on new techniques,” he said, “as well as the old proven techniques on aircraft accident investigation.” Lederer suggested that “aviation safety has no boundaries and that is why this is an international forum.” He welcomed representatives not only from the NTSB, the FAA, the military, and the news media, but also from the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO).

Russell Watts, the ICAO representative, told the forum participants that this was the first “informal” international meeting of this magnitude for air safety investigators. He observed that there had been three “formal” meetings, under the auspices of ICAO, but the record of those meetings “leaves much to be desired.” He said the first such meeting was in 1946, the second in 1947, and the last one in 1965—with no arrangements being made for the next formal gathering. He proceeded to outline a number of international issues and problems that were important to address for air safety investigation.

Charles O. Miller, director of NTSB’s Bureau of Aviation Safety, outlined the various panel discussions and seminars planned for the forum—what takes place before an accident occurs from the view of organization and planning, who really participates in these investigations, the parties to an investigation, the involvement of the news media, the unique environmental problems an investigator faces, and the “dirty details” of the investigation science/art. Participants would hear discussions about the development and use of reports and investiga-

tions that have raised unique problems.

The Oklahoma City Regional Chapter was established in 1970. SASI membership, as of September, stood at 570 total members—434 members, 109 associate members, 20 corporate members, one institutional member, and 6 honorary members. Later that year, D.E. Kemp was elected as SASI president and R.L. Froman as vice president. They served until 1974. H. White was secretary-treasurer from 1970 to 1972, and B.C. Doyle took over that office from 1972 to 1974.

SASI’s 1971 annual seminar was in Los Angeles, California, with 210 attending; its theme was “Human Factors in Aircraft Investigation.”

The 1972 annual seminar, in Washington, D.C., covered “The Future of the Air Safety Investigator,” and 139 members participated.

The SASI Air Safety Investigators Canadian Chapter hosted a seminar on “training” for aircraft accident investigators at the Hyatt Regency Hotel in Toronto, Ontario, Canada, on Aug. 28–31, 1973.

From 1974 to 1978, SASI’s president was W.J. MacArthur. C. Turner was vice president from 1974 to 1976, and H.P. Hogue took over from 1976 to 1978. A.D. Yates was secretary-treasurer from 1974 to 1976 and secretary from 1976 to 1978. Dagmar Witherspoon was treasurer from 1976 to 1978.

The society’s annual seminar in 1974 saw 181 participants in Washington, D.C. The theme was “Accident Prevention Through Investigation.”

In 1975, the annual seminar covered “Accident Investigation or Aviation Safety?” with 141 attendees in Ottawa, Ontario, Canada.

SASI’s annual seminar in 1976, in Arlington, Virginia, had the title “Management of the Investigation.” There were 118 participants. Keynote speaker Dr. John L. McLucas, the FAA administrator, praised the society’s accident prevention efforts. He said that “nothing is more important to the future and growth and health of our industry” than aviation safety. He noted that the society’s annual seminar was one of the best forums in the world in which aviation safety is discussed and where safety ideas are traded back and forth.

According to an article in the August 1977 *Forum*, nearly 97 percent of the voting membership approved changes to

the Constitution and Bylaws in the fall of 1976 to reflect the growing international stature of the society. The new language allowed the formation of national and regional societies. The overall organization's name was to be changed to the International Society of Air Safety Investigators. There would be only one national society recognized for an individual state that might include multiple regional societies. Each national society would have a councillor to represent its members on the ISASI Council. Steps were taken to create a U.S. national society. Also in that year the ISASI office was moved into the home of Secretary Yates as a cost-saving effort.

With the establishment of the Canadian and Australian Societies in 1977 and more than 100 individual members from 35 countries, the international stature of ISASI became a reality on Oct. 11, 1978.

The society's annual seminar in 1977, "Technology in Accident Investigation," was held in Caracas, Venezuela, during October. There were 131 participants.

Some 138 participants attended the October 1978 ISASI seminar, held in Seattle, Washington, to discuss developments and advanced investigation techniques. The national council for the United States—USSASI was created and recognized. Boundaries for the regional U.S. chapters were established. A.D. Yates was reelected as ISASI president. L. Edwards was elected vice president, J.R. McDonald secretary, and W.D. Barnhart treasurer.

In September 1979, 143 participants at the ISASI seminar in Montreal, Quebec, Canada, covered "The Investigator's Role in Accident Investigation."

"Advance Technology in the Investigation of Aircraft Accidents" was the theme for the 1980 annual seminar, held in late September in San Francisco, California; 147 attended. J.R. McDonald was elected ISASI president, C.R. Mercer vice president, S.J. Corrie secretary, and S.B. Conlon treasurer. These ISASI officials remained in office for two terms—into 1984.

In September 1981, 147 attendees of the annual seminar, held in Washington, D.C., covered "The Investigation: Back to Basics."

Ninety-six participants at the October 1982 annual seminar in Tel Aviv, Israel, took a little different approach. The first-day theme was "The Investigation of Avionics and Electronics Failures." The

next day was "The Investigation of Composite Material Failures," and the final day was "Investigation Cases of Special Interest during the Past Year."

The 1983 annual seminar, held in Chicago, Illinois, during October, covered "The Air Safety Investigator: Meeting the Future Challenge of Aerospace Technology." There were 126 participants.

"Resources" was the topic of the September 1984 annual seminar. Some 146 attendees traveled to London, England, for this gathering. J.R. McDonald, C.R. Mercer, and S.J. Corrie were reelected for another term in office. R.D. Rudich was elected as treasurer.

In September 1985, 167 attendees to the annual seminar traveled to Scottsdale, Arizona, to discuss "Expanding Horizons."

The October 1986 annual seminar was held in Rotorua, New Zealand. The theme was "Cooperation and Adaptation." There were 102 participants. C.R. Mercer and R.D. Rudich were returned to office for another term. T.J. Kreamer was elected as vice president, and R. Kapustin became treasurer.

Atlanta, Georgia, was the site for the October 1987 annual seminar. The theme was "Aircraft Accident Investigation in the Microprocessor Age." There were 189 participants. "New Zealand [NZ] SASI [NZSASI] was formed on Sept. 3, 1987, at a meeting of seven New Zealand resident ISASI members," says current NZ Councillor Pete Williams. The inaugural president was Ron Chippindale. Williams adds that "These members had organized the 1986 ISASI annual seminar, held at Rotorua. During ceremonies in Atlanta, NZSASI was presented with its charter."

In late October 1988, the annual seminar opened with the theme "Accident Investigation and Prevention—Working Together." The gathering, in Vancouver, B.C., Canada, had 189 participants. C.R. Mercer, T.J. Kreamer, and R.D. Rudich were reelected to office. F. Del Gandio was elected as ISASI secretary.

The 1989 seminar, held in Munich, West Germany, on September 5–7, had 167 participants. The theme was "Improving the Basics."

In 1990, O. Fritsch was elected ISASI president, R. Lomas vice president, L. Benner secretary, and I. Rimson treasurer. They remained in office for two terms. "Preventing and Investigating Air

Carrier Accidents in the Nineties" was the theme for ISASI's annual seminar held during October in San Francisco, California. There were 226 participants.

In November 1991, 216 attendees traveled to Canberra, Australia, for the annual seminar to discuss "Selling the Product—The Lessons of Investigation."

ISASI's August 1992 annual seminar was held in Dallas, Texas. There were 255 participants, and the theme was "The Future of Technical Investigation."

Ottawa, Ontario, Canada, was the site for the October 1993 annual seminar about "Accident Prevention—A Global Partnership." There were 198 participants.

Elections for ISASI officials in 1994 included R.B. Stone, president; P. Mayes, vice president; S. Daugherty, secretary; and J. Rawson, treasurer. In October, some 245 participants met in Paris, France, for ISASI's annual seminar. The theme was "Detecting and Eliminating the Hazard."

In October 1995, 304 participants met in Seattle, Washington, for the annual seminar. The theme was "Today's Investigator, Tomorrow's Trends & Technology."

The following year, in September, 199 persons attended the seminar held in Auckland, New Zealand. Its theme was "Accident Investigation and Prevention/Where to from Here?" R. Stone and P. Mayes were reelected as ISASI officials. F. Del Gandio was elected secretary, and T. McCarthy won election for treasurer.

In 1997, ISASI's ATS Group published *Guidance for Air Traffic Service Investigators and Investigations*. The year's annual seminar was held during late September in Anchorage, Alaska, with the theme of "Information Technology: Breaking Down Barriers to Communication Among Aviation Safety Professionals." Attendees numbered 243.

In 1998, F. Del Gandio was elected ISASI president, and K. Hagy was elected secretary. P. Mayes and T. McCarthy were reelected to their posts. This slate of officials remained in office for two terms. "Pushing the Envelope Toward Improvement" was the theme of the October 1998 seminar in Barcelona, Spain. There were 216 participants.

The annual seminar in 1999 was held in Boston, Massachusetts, during August. The theme was "Bridging the Gap Between the Investigation and Daily Operations." There were 312 attendees.

In March of 2000, ISASI purchased and opened an office in Sterling, Virginia—the society's current location. ISASI's Cabin Safety Working Group published *Cabin Safety Investigation Guidelines*. The society's annual seminar was held during October in Shannon, Ireland. The overall theme was "Learning from Incidents." Participants to the gathering totaled 266.

The first ISASI Reachout workshop was held in May 2001 in Prague, Czech Republic. ISASI's annual seminar was held during September in Victoria, B.C., Canada. The theme was "Sharing Lessons Learned." There were 172 attendees.

In 2002, ISASI established its Kapustin Memorial Scholarship Fund. F. Del Gandio, K. Hagy, and T. McCarthy were reelected to their offices. R. Schleede was elected ISASI vice president. This slate of ISASI officials remained in office for two terms. Taiwan, Taipei, was the site for ISASI's annual seminar in late September. Some 185 participants covered "Global Challenges in Accident Investigation and Safety Improvement."

"From the Wright Brothers to the Right Solution—100 Years of Identifying Safety Deficiencies and Solutions" was the theme for the annual seminar held during August 2003 in Washington, D.C. There were 340 participants.

In 2004, ISASI launched its website, www.isasi.org. The society conducted its first Cabin Safety Reachout workshops in Delhi, India, and Karachi, Pakistan. ISASI's annual seminar in 2004 was held in Brisbane, Australia, during August; 332 attended, and the theme was "Investigate—Communicate—Educate." In October, ISASI membership was 1,366 individual members and 107 corporate members.

The ISASI International Council, meeting in September 2005, established the ISASI Award for Excellence, recognizing the author of the best technical paper presented at the annual seminar. Themed "Investigating New Frontiers of Safety," the annual seminar was held in September in Ft. Worth, Texas; 390 attended.

ISASI officer elections in 2006 saw F. Del Gandio, R. Schleede, and T. McCarthy reelected. C. Baum was elected secretary. This slate of officials remained in office for two terms. The annual seminar was held in Cancun, Mexico, during September. "Incidents to Accidents: Breaking the Chain" was the

theme for 250 participants.

ICAO granted the society partial observer status in 2007, and ISASI participated in ICAO's 2008 AIG Divisional Meeting. The membership committee reported 1,409 members and 133 corporate members. The annual seminar attracted 305 attendees and was held in the Republic of Singapore during August. The theme was "International Cooperation: From Singapore Investigation Site to ICAO."

In 2008, the European SASI (ESASI) inaugurated its regional seminars. The first was held at Cranfield University, outside of London. ISASI's annual seminar was held in Halifax, N.S., Canada, during September. Some 279 participants heard presentations and attended seminars about "Investigation: The Art and the Science."

At the May 2009 International Council meeting, the Membership Committee reported 1,474 individual members and 144 corporate members. Prior to the September council meeting, ISASI approved AsiaSASI affiliation. The annual seminar, with a theme of "Accident Prevention Beyond Investigations," was held in Orlando, Florida.

At the ICAO AIG Meeting in Montreal held in October, ISASI presented three papers: a working paper on cooperation between states and ISASI on conducting Reachout workshops, another working paper on the potential need for an ICAO safety recommendations database, and an information paper on the ISASI Rudolph Kapustin Memorial Scholarship. By the end of 2009, the ISASI Reachout workshop program had instructed more than 2,010 individuals in 22 countries.

In 2010, ISASI adopted a resolution opposing the practice of some states to seek criminalization of aviation accidents "absent acts of sabotage and willful or particularly egregious reckless misconduct (including misuse of alcohol or substance abuse)." ISASI says, "such action is not an effective deterrent or in the public interest" and "has a deleterious effect on the appropriate investigation of said occurrences, the finding of contributing factors and probable causation, and the formulation of recommendations to prevent recurrence."

The elections for ISASI top officials returned F. Del Gandio, C. Baum, and T. McCarthy to office. P. Mayes won election for vice president. The 2010 annual seminar was held in Sapporo, Japan,

during September and was attended by 200 persons. The theme was "Investigating with Asia in Mind—Accurate, Speedy, Independent, and Authentic."

The ISASI council in September 2011 approved a new program to mentor students who have an interest in aviation. The annual seminar held in Salt Lake, Utah, with a theme of "Investigation—A shared Product" drew 228 delegates.

ISASI member C. Donald Bateman received the highest U.S. honor for technological achievement, the National Medal of Technology and Innovation. President Barack Obama presented Bateman the award on Oct. 21, 2011. He was honored for developing and championing critical flight safety sensors now used on aircraft worldwide, including ground proximity warning systems and windshear detection systems. The FAA required the installation of these systems on all U.S. commercial aircraft.

In 2012, Pakistan SASI was recognized. The society's annual seminar attended by 339 delegates was held in Baltimore, Maryland, during August. The theme for the gathering was "Evolution of Safety from Reactive to Predictive." Elections for ISASI's top leaders in 2012, returned F. Del Gandio and C. Baum to office. R. Schleede was elected vice president, and R. MacIntosh was elected treasurer.

On May 29, 2013, the ICAO Council, in session, and while dealing with ICAO relations with the United Nations, the specialized agencies, and other international organizations, "...agreed that the International Society of Air Safety Investigators (ISASI)...should be included in the list of international organizations that may be invited to attend suitable ICAO meetings as observers."

Korean SASI was established in May 2013. In June, ISASI published the first issue of *ISASI Update*, its electronic newsletter, which is distributed via e-mail to each member. The annual seminar, attended by 288 delegates, was held in Vancouver, B.C., Canada, during August with a theme of "Preparing the Next Generation of Investigators." The ISASI council approved the affiliation of the Middle East North Africa SASI during the council's August meeting. ISASI membership was 1,413 individual members and 129 corporate members. At the end of 2013, 73 countries were represented in ISASI's membership. ♦

A look back to see how much difference ISASI's members have made in the aviation industry.

ISASI: 50 Years of Investigation

By Ludwig Benner, ISASI
Fellow (LW2202)



Ludwig Benner, a long-term ISASI member, was granted ISASI Fellow status in 1993 and has served in a variety of ISASI positions. He was the division chief of the NTSB's

Hazardous Materials Division from 1976 to 1982. A retired registered professional safety engineer, he has served on the editorial board for Journal of Safety Research and participated in the System Safety Society. He has published more than 90 articles and papers on safety, system safety, risk analysis, accident investigation, hazardous materials, and regulation and co-authored Investigating Accidents with STEP (1987 Marcel Dekker, New York). Open-source archives of his works can be accessed at www.ludwigbenner.org. In 2006, the International Association of Fire Chiefs' Hazardous Materials Committee presented him its highest award, the Level A Award, for his "leadership, service, and support to the hazardous materials response and training program." He hosts the investigation process research resource site (www.iprr.org), a pro bono website with hundreds of resources for safety investigation.

After 50 years, it is interesting to look back at the history of investigations to see how much difference ISASI's members have made in the aviation industry. They have participated in many investigations that brought about significant changes in the aviation community and in safety investigation practices. Publication of this contribution seems appropriate during ISASI's 50th year.

To prepare an article showing how members have contributed to improved safety and reducing risks in aviation, members were invited to nominate examples to include in this article. Every investigation produces new information that has some value for improving safety performance. I have chosen examples, to the best of my recollection, to be among the more noteworthy investigations in terms of the magnitude of the changes each precipitated. The selections are based predominantly on the new knowledge the investigations disclosed and disseminated and actions that knowledge enabled, rather than on the notoriety and public interest the accident garnered because of its spectacular nature. The listing does not include examples from before ISASI's founding, like the Comet or Electra investigations, and is presented in no particular order of importance. It is admittedly not exhaustive, so if any reader wishes to nominate additional candidates that should be mentioned, they would be welcomed. Please forward them to *ISASI Forum's* editor.

Notable investigations

Smoke emergency, diversion, and crash of Pan American World Airways, Inc., Clipper Flight 160 at Boston Logan International Airport, U.S.A., on Nov. 3, 1973

The Pan Am Boeing 707-321C transporting cargo, including hazardous material, experienced an inflight cargo fire, attributed to a shipment of improperly packaged and palletized nitric acid, a regulated hazardous material. The flight was diverted to Boston, but smoke prevented the crew from successfully landing the plane, and it crashed just short of the runway. The investigation produced new knowledge about smoke emergencies, which led to a number of equipment and procedural changes. It also disclosed new knowledge about the industrywide lack of familiarity with hazardous materials transportation regulations at the working level, the overlapping jurisdictions, and the inadequacy of government surveillance. That knowledge led to new statutes for hazardous materials regulations and their transportation by air, international hazmat safety initiatives at the International Civil Aviation Organization (ICAO), and significant industrywide changes in hazardous materials package shipping regulations and practices for air transportation and other modes.

For further information, see investigation report at <http://library-online.erau.edu/online-full-text/ntsb/aircraft-accident-reports/AAR74-16.pdf> (author viewed March 18, 2014) and discussion of accident at <http://aviation-safety.net/database/record.php?id=19731103-1>.



The crash of Eastern Air Lines Flight 66 during approach to John F. Kennedy Airport, New York, U.S.A., on June 24, 1975

On June 24, 1975, Eastern Air Lines Flight 66 on final approach from New Orleans, crashed into the runway lights short of runway 22L, killing 112 passengers and crew. This investigation was especially noteworthy because it shifted the focus of crashes on approach from pilot error to the environmental events occurring during approaches, identifying unexpected wind shear as a phenomenon pilots had to adapt to during approaches. It also triggered research into this newly recognized phenomenon, leading to an actionable understanding of microburst behaviors, and subsequent development of instrumentation to help pilots cope successfully with the phenomenon.

The investigation of the Aug. 2, 1985, Delta Air Lines Flight 191 crash on approach to Dallas-Fort Worth International Airport during a thunderstorm, largely attributed to wind shear, killed 8 of 11 crew members, 126 of 152 passengers on board, and one person on the ground. The knowledge disclosed by that investigation brought about specific changes in crew training, reprogramming of simulators to reenact such accidents, and the

installation of runway instrumentation to provide aircrews information about wind speeds and directions to help achieve safer performance.

The new knowledge of the wind shear phenomenon affected future behaviors not only in the civil air transportation industry but in the whole spectrum of the world's aviation community, including business, military, and personal aircraft operations; weather researchers; airport operators; regulatory agencies; instrument manufacturers; and accident investigators.

For further information, see investigation report at <http://libraryonline.erau.edu/online-full-text/ntsb/aircraft-accident-reports/AAR76-08.pdf> and discussion of accident at http://en.wikipedia.org/wiki/Eastern_Air_Lines_Flight_66.

The fatal collision between KLM Flight 4805 and Pan Am Flight 1736, two Boeing 747 passenger aircraft, on the runway of Los Rodeos Airport on the island of Tenerife, Spain, with almost

600 casualties, on March 27, 1977

The knowledge gained by the investigation of this on-airport collision of two Boeing 747s under adverse weather conditions, with almost 600 fatalities, produced very major changes in the aviation industry, including standardizing communication terms between pilots and air traffic controllers with English as their working language, communications procedure such as reading back controller instructions, a second airport on the island, new regulations, and the development and eventual adoption of mandatory crew resource management (CRM) training for all airline pilots.

For further information, see investigation report at <http://aviation-safety.net/database/record.php?id=19770327-1> (author viewed March 18, 2014) and discussion of the accident at http://en.wikipedia.org/wiki/Tenerife_airport_disaster.

The crash of Air New Zealand Flight 901 on Ross Island, Antarctica (aka Mount Erebus disaster), on Nov. 28, 1979

This investigation is listed because of the knowledge gained about investigation challenges for body recovery, identification, wreckage documentation in Antarctica-type environments, and navigation computer unit (NCU) data recovery. Also insights into cause determination difficulties were gained from the intense controversy surrounding the reports of investigations by the New Zealand Office of Air Accidents Investigation (1980) and by a Royal Commission of Inquiry about 10 months later. The 1980 report attributed the crash to pilot decision as the principal cause, while the 1981 report attributed the dominant and effective cause





to alteration of the flight plan waypoint coordinates in the ground navigation computer without advising the crew. Report differences led to subsequent litigation over allegations in the judicial report and even parliamentary action. Among other outcomes, the ANZ DC-10 fleet was retired, commercially operated Antarctic sightseeing flights were ended for years, and numerous news media treatments of the disaster followed.

For further information, see investigation report at <http://www.webcitation.org/6DubAjXCR> (author viewed March 18, 2014) and discussion of accident at http://en.wikipedia.org/wiki/Air_New_Zealand_Flight_901 or http://www.nzalpa.org.nz/Portals/4/Documents/Reports/Chippindale/79-139_section1.pdf.

Aborted takeoff and fire of British Airtours charter flight at Manchester International Airport, Manchester, Great Britain, on Aug. 22, 1985

This was a three-year investigation by the UK Air Accidents Investigation Branch (AAIB) of an unconfined engine failure and fire following an aborted takeoff at Manchester Airport in Great Britain. The report was issued on Dec. 15, 1988. This is considered a noteworthy investigation for several reasons, including the extensive documentation of the course of events during the ignition, propagation, and control of the fire in the aircraft passenger cabin; the pace-setting documentation of the passenger response and casualty location during the course of the accident; and the impact this investigation had on the aircraft manufacturing industry's movement toward increased



fire resistance and retardation for aircraft cabin interiors to increase passenger survivability in crashes. The graphic display of the timing of the accident events during the course of the accident process was also noteworthy.

For further information, see investigation report at [\[es.cfm?file=/8-1988%20G-BGJL.pdf\]\(http://es.cfm?file=/8-1988%20G-BGJL.pdf\) and discussion of accident at \[http://en.wikipedia.org/wiki/British_Airtours_Flight_28M\]\(http://en.wikipedia.org/wiki/British_Airtours_Flight_28M\).](http://www.aaib.gov.uk/cms_resourc-</p>
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Aloha Airlines Flight 243 inflight separation and loss of upper fuselage skin at Flight Level 240 near Maui, Hawaii, U.S.A., on April 28, 1988

As the Boeing 737-200 leveled at Flight Level 240 on an interisland flight from Hilo to Honolulu, an 18-foot-long section of the upper fuselage suddenly departed the airplane, sweeping a flight attendant overboard. The captain performed an emergency descent, diverted to Maui, and landed successfully. The knowledge gained from this investigation enabled changing the aging



aircraft program and industry with a renewed focus on identification of harmful corrosion of aircraft skin joints, and the industry replacing the lap joint skin construction using scrim cloth mastic and rivet bonding that was common to the B-727, -737, -747, and A300 airplanes with much more corrosion-resistant materials and assembly methods, and revised training for maintenance personnel for early detection of such problems.

For further information, see investigation report at <http://www.airdisaster.com/reports/ntsb/AAR89-03.pdf> (author viewed April 14, 2014) and discussion of accident at http://en.wikipedia.org/wiki/Aloha_Airlines_Flight_243 (author viewed April 14, 2014).



The Crash of USAir Flight 427 in Hopewell Township, Beaver County, Pennsylvania, U.S.A., on Sept. 8, 1994

This was a four-and-a-half-year investigation by the National Transportation Safety Board (NTSB) of a mysterious low-level upset of a Boeing 737-3B7 with 132 fatalities near Pittsburgh International Airport. The report was issued March 24, 1999.

This is considered a noteworthy investigation for several reasons, including the new knowledge gained from extensive testing and simulations to enable the understanding of what happened in this and at least two other mysterious 737 crashes—United Flight 585 on March 3, 1991, and Eastwind Airlines Flight 517 on June 8, 1996—and the wide dissemination of warnings to pilots and training for dealing with insufficient aileron control at approach speeds on the widely used 737s, revisions to data captured by flight data recorders to help investigators capture data needed to understand more kinds of accidents, and U.S. Congressional action on airline treatment of crash victims' families, which has resulted in significant improvements in those relationships in recent years.

For further information, see investigation report at <http://www.ntsb.gov/doclib/reports/1999/>

AAR9901.pdf (author viewed March 18, 2014) and discussion of accident at http://en.wikipedia.org/wiki/USAir_Flight_427.

The disappearance of Air France Flight 447 in international waters of the Atlantic Ocean on June 1, 2009

This was a 3-year and €34 million investigation by the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) of the mysterious disappearance of an Airbus A330-200 with the loss of 219 passengers plus its crew over the Atlantic Ocean on June 1, 2009. It is considered a particularly noteworthy investigation for several reasons, including the novel and extraordinary measures needed to recover from the remote undersea location the instrumentation and debris needed to provide the knowledge to enable the wide dissemination of the intricacies of high-altitude aircraft behaviors and changes in pilot training for managing those behaviors; reducing loss of control risks in crises at those altitudes; the widespread attention directed toward inflight loss of airspeed instrumentation systems and equipment makers' and operators' responses to those kinds of incidents; and an advisory circular with good practice guidance that provides crews with appropriate methods and tools to



prevent, recognize, and recover from a stall; and theoretical training, simulator exercises, CRM, startle factor, and upset recovery training aid.

In addition, the investigation is also noteworthy for the manner in which available investigation input data were integrated graphically to describe the interactions between the crew and aircraft during the accident. This showed the cascading interactions among the people, objects, and energies as the accident process progressed toward its final outcome.

The degree and pace of international cooperation to address the new understanding of the problems disclosed by this investigation is also worth noting because of the precedents it offered for investigating such civil aviation losses.

For further information, see investigation report at www.bea.aero/en/enquetes/flight.af.447/rapport.final.en.php (author viewed April 11, 2014) and discussion of accident at http://en.wikipedia.org/wiki/Air_France_Flight_447 (author viewed April 11, 2014).

Other noteworthy investigations

Many other investigations contributed significantly to improve air safety. The 1982 Air Florida Flight 90 crash investigation, for example, resulted in several improvements. Deicing practices and the deicer fluid, crew procedures for monitoring engine performance during takeoff, and the procedure for line checking a new captain were changed. The investigation of the 2009 FedEx

MD-11 accident (see http://www.mlit.go.jp/jtsb/eng-air_report/N526FE.pdf) at Narita International Airport, Japan, recognized the impact of kinematic effects in large transports, which has a direct impact on evaluation of pilot reactions and handling qualities analyses.

The investigation of the 1997 FedEx MD-11 accident (see <https://www.nts.gov/doclib/reports/2000/AAR0002.pdf>) at Newark International Airport in Newark, New Jersey, involving the most detailed simulation of structural failure the NTSB had ever conducted provided knowledge of the transfer of loads that had not been found previously to improve aircraft design.

New knowledge from investigations has not been limited to air carrier aviation incidents. For example, investigation of an engine failure of U.S. Air Force remotely piloted aircraft (RPA) during March 2012 in the Afghanistan theater of operations disclosed previously unknown engine failure modes during certain operating conditions, explained numerous similar previous mishaps, affected future RPA mishap investigations, prompted RPA industry initiatives to reduce airframe loss due to propulsion-related incidents and to increase engine survivability, and enabled changes to RPA aircrew training and operating procedures to reduce future losses in similar incidents.

Helicopter safety has also benefited from new knowledge gained during investigations. For example, the investigation of the crash of helicopter

transporting firefighters under contract (IRON 44), with fire and eight fatalities, provided new knowledge about problems with the performance chart, flight crew performance, accident survivability, flight recorder requirements, and heliport weather observances, among others. (See <http://www.nts.gov/doclib/reports/2010/AAR1006.pdf>.) Investigations of helicopter accidents during servicing of North Sea oil platforms have also produced knowledge that has enabled safer operations.

Summing up

Accident and incident investigations usually produce new knowledge that can improve future safety performance in any of several ways. The knowledge can be narrowly focused, as with improvements to a specific aircraft or model in widespread use, as in the USAir B-737 investigation.

Alternatively, it can have broad application within the aviation community, as with the discovery of wind shear phenomena in the Eastern Flight 66 investigation or the Aloha Flight 423 investigation.

It can also affect activities outside the aviation community, as with the knowledge of un-informed hazardous materials shipment practices in the Pan Am Flight 160 investigation. Sometimes initiatives to gain new knowledge to improve safety from investigation outputs have also disclosed ways that investigations might be improved, as occurred during the International Helicopter Safety Team efforts to find safety measures in aggregated helicopter investigation outputs. All are valuable contributors to safety improvement.

With continuing energy, persistence in the pursuit of understanding, receptiveness to innovation, and diligence for objectivity by everyone contributing to the conduct of investigations, our 50-year record of safety achievements should become even more noteworthy. ♦

That statement was true in the 1920s, the 1930s, the 1940s or any other time it may have been uttered; it remains true today and for the future. The author, through tracing the time line of aviation accident investigation, explains why.

By Robert Matthews (MO4626), Ph.D., FAA (Retired)



Dr. Bob Matthews began working at the FAA in 1989 but is now retired from the agency. Up until his retirement, he was the senior safety analyst in the Office

of Accident Investigation. His previous professional experience includes nine years in national transportation legislation with the U.S. Department of Transportation, two years as a consultant with the Organization of Economic Cooperation and Development in Paris, and several years as an aviation analyst for the Office of the Secretary at the U.S. Department of Transportation. His academic credentials include a Ph.D. in political economy from Virginia Tech's Center for Public Administration and Policy Analysis, and he was an adjunct assistant professor at the University of Maryland from 1987 through 2002.

'Aviation Is Safer Than Ever'—Why?

SASI has turned 50 as accident investigation turns about 100, depending on one's chosen benchmark of 1912 or 1915. Either way, accident investigation was born in the United Kingdom (UK). Throughout those 100 years, accident investigation has been a primary factor in persistent improvements in aviation safety. This article outlines the historical context in which that success story has unfolded and the role played by accident investigation.

Aviation came of age during World War I. The same demands of war led to the first organizations dedicated to accident investigation. In 1915, the UK's Royal Flying Corps established the Accidents Investigation Board (AIB). After the war, the AIB moved to the new Ministry of Civil Aviation as the Air Accidents Investigation Board (AAIB), which issued its first regulations for investigations in 1922. Since then, the AAIB has been part of several departments, including today's Department for Transport. The AAIB has maintained its identity for nearly a century. More importantly for accident investigators, the AAIB earned the public's respect early for competence and integrity.

In France, the military had established an investigative unit, followed by a civilian unit after the war. Today's Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) was established under the Fourth Republic in 1946 and retained its form under the Fifth Republic.

Australia at first relied on individual Boards of Inquiry for selected accidents. That approach soon became unworkable, and Australia established the Air Accident Investigation Committee in 1927. That evolved into the Bureau of Air Safety Investigation (1983) and, in 1999, into today's Australian Transport Safety Bureau.

The story was not as smooth in the U.S., which did not establish a civil regulatory or investigative authority until 1926. Under the Commerce Act of 1926, a new Aeronautics Branch was responsible for certain regulatory func-

tions and the promotion of civil aviation. The branch also was required to investigate and to "make public the causes of aviation accidents." The dual mandate to regulate and promote civil aviation did not seriously compromise the new agency's regulatory actions, contrary to popular belief, but it significantly compromised the early investigative authority.

The branch released full reports at first (1926–1927) that included the operator's name, the aircraft make-model, narratives, and causes. However, the industry rebelled, and, by 1928, the branch issued only annual statistical summaries to satisfy the requirement to "make public the causes of accidents." Those summaries said little more than "4. weather, 3. pilot error," etc. This was useless to outsiders. The branch was reorganized for other reasons in 1934 as the Bureau of Air Commerce, but the investigative function remained compromised. This was resolved in 1938, when Congress created a new safety regulator, the Civil Aeronautics Authority (CAA) and a new economic regulator, the Civil Aeronautics Board (CAB). The CAB became responsible for investigating accidents and determining cause. Yet, the investigation of some commercial accidents and most general aviation (GA) accidents remained with the new safety regulator.

The CAA and selected CAB functions evolved into the Federal Aviation Administration (FAA) in 1958. Congress required the new FAA to investigate accidents, but the authority to investigate and determine cause remained with the CAB. That authority was transferred to the new National Transportation Safety Board (NTSB) in 1967. The NTSB became an independent agency in 1974 and remains responsible for determining cause. This tortuous history explains a unique structure in the U.S.: an independent investigative authority (the NTSB) that investigates and determines cause, and a regulator (the FAA) that also investigates accidents, but without the authority to determine cause.

Important early investigations

Investigative authorities in Europe were spared such political uncertainty. That proved to be important when the UK's new AAIB investigated its first fatal accident involving a UK airline. In December 1924, an Imperial Airways DH34 stalled and crashed on takeoff from Croydon in London. All eight occupants were killed. This was a big number in 1924, and the accident became a sustained page-one story.

Public attention focused on engine failure because another pilot had reported low oil pressure the preceding day, and because some witnesses reported hearing engine problems, though others said it sounded fine. "Experts" also quickly emerged to claim that the engine (a Napier Lion) had well-known problems that the Air Ministry, de Havilland, and Napier had failed to address. Finally, the aircraft recently had its wings replaced and had just recently received a new airworthiness certificate. In short, public speculation focused on engine problems, aircraft structures, and the integrity of the Ministry of Civil Aviation. The young AAIB investigated this front-page accident by applying techniques that remain familiar to investigators today. The report started with a factual section, followed by analysis, conclusions, and recommendations.

Besides gathering and evaluating contradictory statements from witnesses, the AAIB examined maintenance records and tore down the engine. The AAIB found the engine had been properly serviced overnight. All 24 spark plugs were new and tested properly. The engine also was properly oiled and had proper pressure. The AAIB found that no engine malfunction explained the accident. It also dismissed as baseless the "expert testimony" about known problems with the engine. The AAIB then analyzed the wreckage and found no evidence of structural failures. All of the early speculation had been dismissed.

Instead, the AAIB established that rain had softened the grass strip and that the takeoff roll was abnormally long for all aircraft operating in the hours before and after the accident. The aircraft had not accelerated properly in the softened turf, rotated near the end of the runway, and stalled. These findings led to what might be the first action to improve safety based on a civil accident investigation. The airport immediately received new funding from Parliament to lengthen its

runway by 600 feet. Most importantly for us, the AAIB had firmly established its capacity to conduct a professional and technically competent investigation in the midst of controversy. This strengthened the AAIB's legal mandate by adding public respect and a degree of moral authority to its investigations.

Another early accident that led to an abrupt improvement in safety occurred in the U.S. in March 1931, when the wooden wing of a Fokker F-10A separated in flight. Among the eight fatalities was Knute Rockne, a legendary football coach at the University of Notre Dame. The intensity of the public's interest in Rockne's death is hard to overstate. Every American in 1931 knew of Rockne. The accident consumed the country for months and illustrated how the politics of an accident can turn out differently than in Croydon.

The Aeronautics Branch conducted a technically sound investigation that provided the first hard evidence to confirm long-time suspicions about "dry rot," in which the glue that bound wooden wings together eventually failed. Based on this finding, the branch banned the use of aircraft with wooden wings in scheduled service. This was dramatic action. It significantly injured American Airlines, which had recently purchased F-10s, plus General Motors, which had recently invested in Fokker to produce aircraft in the U.S. and it substantially improved safety.

However, the branch's leadership bungled the politics of the accident. The branch had released only useless summary statistics since 1928 because, said the branch, Congress had not given it the power of subpoena to require someone to testify or to provide information. Therefore, the branch had to rely on the good will and trust of manufacturers, airlines, and pilots if any information was to be gathered. Even Congress could not get accident reports. Yet the branch routinely shared full reports with manufacturers and airlines (so much for pilots' trust). This practice guaranteed conflict with Congress after any visible accident, and no U.S. accident was ever more visible in its day than the Rockne accident.

Branch leaders at first refused to release any information, but within days they reversed course in response to intense public demand. With little hard evidence yet available, the leadership announced, in succession, pilot error in

an abrupt maneuver, inflight separation of a propeller, and icing of the wings—all statements were retracted within days. Further, the leadership refused Congress a copy of its final report. Ultimately, the leadership had severely damaged the branch's standing with the public and with Congress. This was the environment in which a new economic regulator in 1938 (the CAB) became responsible for accident investigation.

The Croydon and the Rockne accidents were early illustrations that accident investigation often operates in a volatile environment. The outcome for the AAIB after Croydon was superb, but the Aeronautics Branch had suffered a self-inflicted political disaster. Yet both accidents showed that competent accident investigations could produce important changes in safety.

The Rockne accident also indirectly accelerated one of the most substantial and sudden leaps in aircraft technology in aviation history. The world's airline fleet then was dominated by aircraft like the DH34, the Fokker F-10, and the Ford Trimotor. However, with the abrupt demise of wooden wings, many airlines needed new aircraft. United Airlines, formerly Boeing Airlines, turned to Boeing for a new, all-metal aircraft to support a larger and more comfortable passenger cabin. The outcome was the 12-seat Boeing 247, which entered service in 1933, but Boeing refused to sell the aircraft to TWA, which directly competed with United. In response, TWA issued its own specifications for a "commodious, all-metal, high-performance air transport that could takeoff fully loaded on two engines at any airport served by United, including high-elevation airports."¹

Douglas won the competition with the DC-2, powered by two 690-horsepower engines that set new standards for reliability. Douglas then developed a larger version of the DC-2 when American asked for an aircraft with sleeping berths and more capacity for longer routes. The "Douglas Sleeper," with 14 berths, entered service in June 1936. An alternative configuration with 32 seats entered service in September 1936 as the DC-3.

These aircraft broke new ground with stressed-skin, alloys, cantilever wings with multiple spars, the NACA cowling, a single elevator and rudder, flaps, retractable gear, an automatic pilot, and two instrument panels. They also forged gear struts, spar booms, and engine

Figure 1: U.S. Air Carrier Fatalities Per 100 Million Persons Flown, 1946-2012

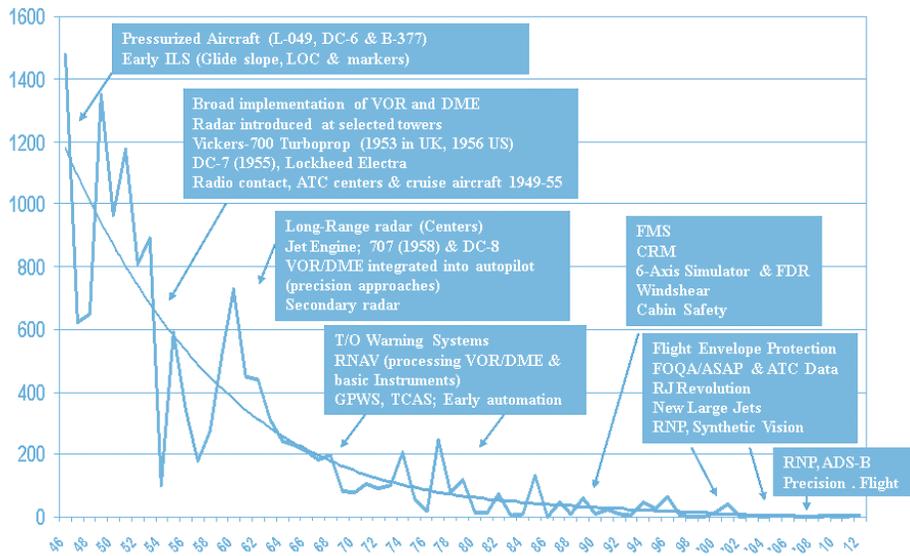


Figure 1

mounts into single pieces to support the aircraft's heaviest loads. The DC-3 was bigger, faster, more comfortable, more reliable, and far less costly to operate (and much safer) than any other aircraft. Its extended range also eliminated some interim stops, increasing its advantage in cost and net speed.

Overnight every airline had to have the new aircraft to compete. The DC-3 dominated the market as no other aircraft before or since. By 1938, the DC-2/3 carried 90 percent of all airline traffic in the U.S.² Passenger air miles in the U.S. increased fivefold from 1935 to 1941, an average of 31 percent per year, and the overall accident rate improved by half.

Post-war years

During World War II, several aircraft that had just entered the fleet or were about to enter were pressed into military transport service, such as the DC-4 and the pressurized Boeing 307, which could operate up to 20,000 feet. After the war, these and other new, large aircraft such as the pressurized Avro Tudor-V, the HP Hermes, and new designs from Sud Ouest and Sud Est of France soon entered the civilian fleet, leading to tremendous growth in aviation, and also a new sense of scale when accidents occurred.

At the start of World War II, few "air disasters" exceeded 12 fatalities—and none had yet exceeded 20 fatalities.³ That changed post war: Two DC-3s

operated by Air France crashed on successive days in September 1946, killing all 41 occupants and one person on the ground. In 1947, four U.S. accidents in just three weeks killed 160 people, which exceeded the previous high for an entire year in any country.

The first of the U.S. accidents occurred on May 29, 1947, when a United DC-4 crashed on takeoff at New York's LaGuardia Airport due to a faulty gust lock, killing all 43 occupants. The next day an Eastern Air Lines crew in a DC-4 lost control in cruise. All 53 occupants died. Two weeks later, a Pennsylvania Central DC-4 flew into high terrain near Washington, killing all 50 occupants. Six days later, a Pan American Constellation L-1049 suffered an engine fire in flight; 14 of the 36 occupants were killed. Just four months later, an inflight fuel overflow on a United DC-6 caused an on-board fire and an inflight breakup near Bryce Canyon. All 52 occupants were killed. These were shocking numbers.

Then came "the big one." In March 1950, a chartered Avro 689 carrying rugby fans stalled and crashed at Llandow, Wales, on its return trip from Ireland. All five crew and 75 of 78 passengers died. This was, by far, the biggest civil aviation accident ever. The airline, Fairflight, claimed the pilot's seat had slipped, causing him to pull back on the stick. However, the aircraft was certified to carry just 60 passengers. The aircraft had stalled due to a severe aft center of gravity. This crash was a consuming

story in the UK that continues to be remembered on badges of two rugby clubs in Wales and by a local museum.

Llandow soon was followed in the U.S. by three crashes involving aircraft flying into or from Newark. All three crashed in the nearby Elizabeth, New Jersey, killing 108 occupants and 11 on the ground. A new generation of investigators learned that investigations sometimes operate in volatile environments. With a public uproar around Newark, an army of experts surfaced to claim that the airport was inherently unsafe. The airport, then the busiest in the New York market, was closed for more than four months.

In the first accident, the CAB quickly established that a Miami Airlines C-46 had taken off with one engine on fire, killing 56 on board. Five weeks later, an American Airlines CV-240 crashed in central Elizabeth after flying significantly off course on approach, killing 23 occupants and 7 on the ground. Twenty days later, a National Airlines DC-6 lost power in the No. 3 engine on climb out. The crew shut down the wrong engine and crashed, killing 29 of 63 occupants and 4 on the ground. As the economic pain increased from closing the busiest airport in the New York area, the CAB and others convinced political leaders that the accidents constituted a random cluster of events that had little to do with the airport.

Throughout these years, accident rates in fact improved significantly. The new pressurized fleet flew above much of the weather and above terrain, at least in cruise. Nav aids also changed rapidly. In the late 1940s, the very high frequency omnidirectional beacons (VOR) entered service. VORs were more accurate and far less vulnerable to static interference than was the nondirectional radio beacon (NDB) in use at the time. VORs also transmitted a 360-degree signal, producing an infinite number of radials to a transmitter. However, VORs could determine only bearing to a transmitter, not distance. A VOR also transmits a line-of-sight signal, so each airway requires detailed information on minimum safe altitude. Those shortcomings were solved in the early 1950s with distance measuring equipment (DME), which computed slant distance to a ground station. By placing DME at VOR sites, a pilot now knew the proper heading and the distance to ground stations. For the first time, instruments told

crews where they were.

Full instrument landing systems (ILS) also were introduced with VHF directional localizers, UHF glideslope transmitters, and outer and inner beacons. At the time, approach minima typically were 400 feet vertical and one mile horizontal. In the U.S., the CAA said under certain conditions crews could make approaches with ceilings at 200 feet and visibility of a half mile, which soon became 200 feet and a quarter mile.

ILS and VOR/DME, plus the entry of pressurized aircraft, provided another quantum leap in safety by reducing controlled flight into terrain (CFIT) accidents, inflight loss of control, and approach-and-landing accidents, though such accidents remained common. Safety was hardly the only factor that encouraged these changes, but accident investigation was the primary source of knowledge on exactly how risks associated with these scenarios often played out in accidents.

As with the DC-3, airlines could not afford to be without these improvements. The increased power, range, and comfort of the new aircraft opened a matrix of new nonstop city pairs with a level of service that made air travel more attractive. Economics also made ILS equipment and ILS training a must. No airline could afford to be locked out of key airports due to weather while competitors continued operating. Airlines had to have the new (safer) aircraft and ILS procedures. Advances like ILS and pressurized aircraft can be overlooked today as safety breakthroughs, but, as illustrated in Figure 1 (see page 26), their impact was immediate. Yet the era still had accident rates that were remarkably high by today's standards.

With this new fleet, U.S. revenue passengers increased by an average of 19 percent per year over the first 10 years after World War II.⁴ In just three years (mid-1950 to mid-1953), the number of aircraft in the fleet increased by 17 percent, and lift capacity increased 42 percent.⁵ However, such growth in an era when large portions of airspace had no radar coverage introduced a new problem. Midair collisions suddenly increased in frequency and scale

One midair changed everything. On June 30, 1956, a TWA Constellation with 70 occupants and a United DC-7 with 58 on board collided over the Grand Canyon at 21,000 feet shortly after leaving controlled airspace. The

128 fatalities exceeded the previously "biggest ever" accident at Llandow by more than half. Reaction was intense. Within weeks, Congress funded 82 new long-range radars that began coming on line in September 1959. The accident also led directly to the Federal Aviation Act of 1958, which created today's FAA. The core of that act was to establish a national system of positive ATC control to separate IFR from VFR traffic and fast traffic from slow traffic. Positive control was established over all continental airspace above 24,000 in 1957. By 1971, all airspace from 18,000 to 60,000 MSL was reserved for IFR aircraft with transponders.

Yet the spike in midairs continued. Two in 1958 between airliners and military aircraft took 60 lives. Europe added to the 1958 list when an Italian military jet struck a British European Airlines Viscount at 23,000 feet, killing all 31 on board the Viscount. In 1960, Paris added a midair between a GA aircraft and an Air Algerie Caravelle on approach to Orly. The Caravelle's ceiling ripped open, but the aircraft landed safely. That same year, four more midairs occurred in the U.S. The first three had no fatalities on commercial aircraft but had fatalities among military and GA aircraft.

Then the New York midair in December 1960 put the issue back on page one. A United DC-8 on approach to Idlewild (now JFK) was told to hold near a fix for clearance to Idlewild, but the DC-8 overshot the fix and, above Staten Island, struck a TWA Constellation awaiting clearance into LaGuardia. All 44 people on the Constellation and all 84 on the DC-8 died, as did 6 people on the ground. This exceeded the Grand Canyon total.

Midairs got a three-year reprieve after Staten Island but resumed in February 1965, with a nonfatal midair over Long Island. That December, the crew of an Eastern DC-7 lost control trying to avoid a midair and crashed into the ocean near New York, killing 84. In 1967, two midairs between GA aircraft and airliners in Ohio and North Carolina killed 108 people. After two more nonfatal midairs in 1969, with the new terminal system being implemented in stages, an Allegheny DC-9, descending into Indianapolis, struck a PA-28, killing the GA pilot and 82 on board the DC-9. This was followed by still more midairs, including one between a DC-9 and a military F-4B over Duarte, California, in

June 1971, with 50 fatalities.

All these accidents led to the development of a secondary radar environment, with Mode-C transponders that transmit an aircraft's identity, altitude, and ground speed. The addition of Mode-S capability created TCAS, which enabled aircraft to communicate with each other. Each aircraft interpolated the data to project a potential airborne conflict. Onboard algorithms then issued different evasive instructions to each aircraft. Figure 2 (see page 28), which shows the number of midairs, fatal plus nonfatal, illustrates the effects of these changes. Though the figure shows only U.S. data, it indicates the reduction in risk in most of the world.

This summary does not do justice to long-range radar, transponders, or TCAS. Together, they have nearly eliminated airline midairs, but not entirely. Risk is not zero.

The jet age

As piston-driven aircraft increased in power in the late 1940s and 1950s, their rate of engine failure also increased because piston technology had essentially reached its limits. At their peak, four-engine piston aircraft operated with a total of 112 pistons. All those moving parts invited problems. In the early 1950s, time between overhaul (TBO) for piston engines was 1,500 hours. In practice, TBOs of 1,000 hours were a luxury. At such levels, every flight had a real risk of losing an engine, especially on a four-engine aircraft. The chances of losing two engines also were real on every flight. From 1946 to 1958, U.S. airlines alone averaged four-and-a-half major accidents and 50 fatalities per year just from engine-related accidents. On average, one of those four-and-a-half involved the failure of two engines. New engine technology was needed if aviation was to continue growing and if the accident rate was to continue improving.

The necessary change began in 1953 when British European Airways introduced its 65-seat Vickers Viscount 700 turboprop (a very successful aircraft, with a production run of 445). Of the turboprops that followed, the Fokker F-27 was the most successful, with a production run of 915. Then came the 85-seat Bristol Britannia and, later, the 99-seat Lockheed Electra. But large turboprops were significant in long-haul travel only briefly, as large jets soon reached the market.

However, the new turboprop technology also introduced a fleet that could operate efficiently in small markets. Airliners required a certain capacity to be economical. “Large” aircraft had a minimum of 20 to 30 seats. By 1953, most new aircraft had 50 to 100 seats. No aircraft were being produced in the 10-to-20-seat range. That changed in 1966 with the 19-seat DHC-6 and the Beech 99 in 1968. Much of this new fleet operated nonscheduled cargo flights, but many were used in new scheduled services. The market for smaller turboprops survived into the 1990s, but they, too, eventually were brushed by regional jets.

The jet is often cited as the most significant change in airline safety, but the jet’s early years were difficult. British Overseas Airways (BOAC) introduced commercial jet travel with Comets in the spring and summer of 1952. On May 2, 1953, a BOAC Comet took off from Calcutta, encountered a severe squall at 7,500 feet, and broke up passing through 19,000; all 43 occupants died. A Court of Inquiry erroneously attributed the accident to overstressing in the squall. On Jan. 10, 1954, a second BOAC Comet disappeared at 27,000 feet after takeoff from Rome (35 fatalities). BOAC immediately grounded the Comet.

In response to pressure from the industry, Prime Minister Winston Churchill intervened to get the Comet back into service on April 1, 1954. A week later, with the second accident still under investigation, another BOAC Comet disappeared at 35,000 feet (21 fatalities) after departing Rome. The Comet again was grounded.

Consider the pressure that our French colleagues faced in the search for Air France Flight 447 and the response to the disappearance of MH-370 then imagine the pressure on the AAIB after the Comet accidents. The AAIB was expected to figure out what explained the disappearance of three aircraft at unprecedented altitudes, and without the benefit of recorders—but this was not half the story. The nation’s aerospace industry had bet its future on its jet technology, and three of its first five aircraft, all operated by the national flag carrier, had disappeared. To complicate matters, wreckage from the third crash could not be recovered.

The AAIB responded by giving birth to modern accident investigation. Wreckage from the second accident was

reconstructed (a first) and showed signs of inflight breakup. The Italian coroner also found injuries that indicated an abrupt decompression. The AAIB then conducted numerous and complex experiments with the wreckage from the first accident and with models to establish that the airframe of the Comet, which operated at unprecedented altitudes, had expanded and contracted during every pressurization cycle, causing metal fatigue. Designs were changed to avoid points of added stress, such as sharp corners or square openings, and included fewer but stronger joints. The Comet resumed normal production in 1958 and remained in production for 30 years. It was a successful airplane, but the damage had been done.

The Boeing 707 and the DC-8 were the beneficiaries of the knowledge developed from the Comet. When Pan Am introduced the 707 in the U.S. in late 1958, BOAC had several years of jet experience, and Aeroflot, the world’s first jet operator, had 57 Tu-104s.⁶ Obviously, the 707 was not the start of jet transport. Nevertheless, the 707 and the DC-8 a year later truly established the jet age. Within just five years, jets accounted for 75 percent of all airline seat miles in the U.S.

While the largest piston-powered aircraft had practical TBOs of about 1,000 hours, jets started with a TBO of 6,200 hours and quickly established performance of 20,000 hours then approached 50,000 hours. Regulators soon abandoned TBO as a regulatory standard and replaced it with an on-condition standard: an engine could operate indefinitely, provided it satisfied certain performance criteria,

though various components still had defined lifecycles.

By necessity, advances in materials and precision manufacturing accompanied the jet. The industry moved to nickel alloys and titanium for greater strength under heat, then to composites,

such as spun glass and resins, to resist impact and stress. Fiberglass resins and reinforced plastics followed, and, by the mid-1960s, manufacturers used carbon fiber (graphite) and graphite-reinforced plastic in airframes and selected components. These changes produced lighter, stronger, more efficient, and much safer aircraft.

From 1980 through 2013, U.S. airlines had just two fatal jet accidents attributed directly to engine failure. Both involved uncontained engine failures—at Sioux City in July 1988 (111 fatalities) and at Pensacola in July 1996 (two fatalities). In early 2004, the FAA reported an average approaching just one serious engine failure per 11 million flight cycles for the preceding three years. By 2009, even that rate had been cut in half. Compare all this to an average of four-and-a-half major accidents and 50 fatalities annually in a much smaller system.

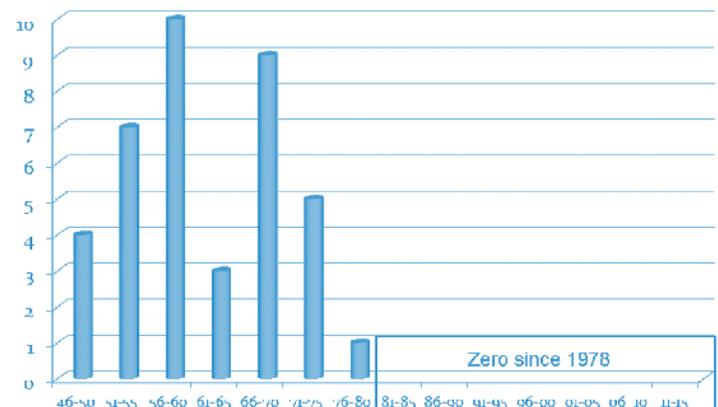
Engine failure long ago stopped being a common cause of catastrophic airline accidents. Admittedly, accident investigation can claim little direct credit for the jet engine. However, the jet cannot be ignored in any conversation about the evolution of accidents.

Accident investigation and ISASI

Accident investigators from the 1920s would still recognize the basic approach to investigations and would recognize many contemporary issues, such as engine failure, CFIT, and weather issues. However, they would not recognize many of the tools that assist investigators today, including cockpit voice recorders, flight data recorders with 2,000 or more parameters, other sources of nonvolatile

Figure 2

Figure 2: U.S. Airline Midair Collisions In 5-Year Periods, Aircraft Over 12,500 Pounds Since 1946



memory, plus data from cell phones, pervasive video devices, and more. Former investigators might be most surprised by the rarity of major accidents.

Since ISASI's founding, accident investigation has been a primary source of knowledge in the adoption of TCAS, GPWS, plus cabin safety, time and duty limits, crew coordination and human factors, automation, envelope protection, FMS, and more. It also played a primary role in documenting the nature of wind shear and the development of terminal doppler weather radar and onboard weather radar (see the L-1011 accident at JFK in 1975 and accidents at Dallas in 1985 and 1987). Equally important is the cumulative effect of modest improvements that accident investigation makes every day to a procedure, a checklist, or a training curriculum at a single airline, or when we get lucky and improve some procedure industrywide. In addition, accident investigation is fully responsible for the pressure that led to the use of cockpit voice recorders and flight data recorders, the latter of which evolved from just five parameters to well more than 2,000 and has become the basis of today's operational data analysis. All these and other contributions help to explain the persistent improvement in the rate of major accidents illustrated in Figure 1.

The pattern has been for rates to fall suddenly after one or more major changes in the system, then rates stabilize briefly at a new level but with steady incremental improvements, then they fall sharply again, stabilize again at a lower level, fall sharply again, etc. Figure 1 shows this pattern since World War II, but the pattern was established at least as early as the improvements led by the DC-3 on the eve of World War II. Highlighting every significant contribution that accident investigation has made to this improvement would require a book, but Figure 1 at least begins to outline those contributions since ISASI was established 50 years ago. In lieu of the book required for appropriate attention to every contribution, two examples are outlined in some detail, below: GPWS and cabin safety.

GPWS

The ground proximity warning system (GPWS) may be second only to stall warning systems in the number of lives saved over the years. For the record, long-time ISASI member Don Bate-

man (the 2008 ISASI Lederer Award recipient) invented GPWS and one of the early stall warning systems. Don's role in GPWS is the best example of the two sides of ISASI, investigation and prevention, working together. Don was never an investigator. Instead, he has been a student of aviation accidents and a gifted engineer. He used accident reports and other information to identify flight paths for as many CFIT accidents as possible then flew all those flight paths to identify where, when, and how an onboard warning might have avoided those accidents. He then designed the warning system: GPWS.

We might forget how frequent CFIT accidents once were. In the first 10 years after World War II (1946–1955), large airline aircraft in the U.S. had 35 major CFIT accidents with 750 fatalities. France and the UK added a proportionally higher 16 CFITs and 366 fatalities. These three countries alone averaged an airline CFIT accident every 10 weeks for a decade. Over the next two decades (1956–1975), the CFIT rate decreased; but with system growth, the number of fatalities increased fourfold.

As with TCAS, efforts to require GPWS were resisted for years. Then a CFIT accident in December 1974 provided the necessary political support for mandating GPWS. A TWA 727, on approach to Dulles Airport in heavy rain, struck terrain 35 miles from Washington, D.C., killing all 92 occupants. The accident involved several factors, including the absence of an alerting system to warn of dangerously close terrain. Within months, all commercial aircraft in the U.S. with more than 30 seats were required to use GPWS.

Like any warning system, the mere presence of GPWS cannot stop an accident. Some crews continue to strike terrain despite receiving valid GPWS or sink-rate alerts. Nevertheless, in much of the world, CFIT no longer populates the accident data, and most of the credit goes to a single gentleman.⁷

Cabin safety

Accident investigators understood for years that some accidents were needlessly lethal. In too many cases, people could survive an impact but die from rapidly spreading fire and toxic smoke, or by injuries incurred when seats ripped away on impact. The Llandow accident in 1950 made this case early, when a badly overloaded aircraft stalled

and crashed on approach. Just 3 of 83 occupants survived. Two of the three were belted into seats that were recently added for some of the excess passengers. By chance, these seats were better secured than others. Many of the 80 fatalities also would have survived had they been in stronger seats. A local museum that commemorates the crash notes a comment from a police officer at the scene:

"The bulk of the [80 fatalities] were huddled in a mass in the fore part of the wreckage. Most were still strapped in their seats, which had been ripped away from their moorings by the force of the impact, and piled in a mass among the dead."

Cabin safety began receiving targeted attention in the 1980s in response to three accidents. Two involved airborne fires, Saudia at Riyadh in 1980 and Air Canada at Cincinnati in 1983. The third accident occurred in 1989 when a British Midland 737 crashed at Kegworth. One lesson from Riyadh and Cincinnati was that when a crew has reason to suspect a possible fire, get on the ground quickly and sort things out there. Riyadh and especially Cincinnati, where 23 of 47 occupants died from toxic smoke, also made the case for the use of fire-resistant and less-toxic materials.

British Midland added an emphatic lesson on the need for stronger seats when the 737 crashed into an embankment on the M1 Motorway, killing 47 and seriously injuring 74. On impact, the 9-g seats failed, and most occupants' lower legs were thrust beneath forward seats, where occupants were instantly immobilized by "gross fractures" to lower legs, feet, and ankles.

These accidents again taught us that we needed better crashworthiness, improved fire detection, a reduced rate at which fire could spread, and less toxicity during fires. Investigation of these accidents led to major changes in cabin safety, including

- fire-resistant seat bottoms and back cushions,
- less-flammable and less-toxic aircraft interiors,
- emergency floor lighting,
- Halon fire extinguishers,
- smoke detectors in lavatories and built-in fire extinguishers in waste receptacles,
- 16-g seats,
- protective breathing equipment

(Continued on page 38)

Year 2050: 'SkyArc 71

A fictional account by Tom Farrier (M03763)

(When I was asked to contribute an article to the ISASI Forum commemorating the society's 50th anniversary, it was suggested that I discuss the possible future of air safety investigations. Early on, I decided that I'd prefer to do so with a fictionalized, speculative story building on present-day issues and emerging technologies. One key element of the preliminary plotline—which I first started pulling together in mid-January 2014—that has been present ever since was the examination of "off-board" flight data, a concept I first heard discussed in a serious vein almost 20 years ago by two leading lights of ISASI: the late Jerry Lederer and Capt. James McIntyre, the 1999 Lederer Award recipient.)



Tom Farrier has been an ISASI member since 1995. He began his aviation safety career in the U.S. Air Force, serving as an on-scene investigator as well as performing

prevention and programmatic duties at wing, major command, and headquarters Air Force levels. After his military retirement, he was the national safety coordinator for the National Air Traffic Controllers Association, later becoming director of safety for the Air Transport Association. Since 2005, he has been a government contractor addressing aerospace safety matters ranging from heliport design to space tourist safety to his current work in the emerging field of unmanned aircraft systems.

Ray Lassiter was sitting at his desk when the call came, but it arrived on his mobile phone instead of the desktop. A quick glance at the readout took in the call's origin—Montreal—and its importance, signified by the flashing "priority" light that only could be triggered by a select few official agencies.

"Bonjour, Henri, ça va?" he said upon pressing the answer key.

"Ça ne va pas, my friend. A high/low flight from Seattle to Perth has gone missing."

Lassiter straightened in his chair and frowned at the screen. "What do you mean, 'missing'?" he asked sharply.

"Just what I said," Henri Bernard replied with a slight edge to his voice. "It was on profile, in its descent, having coasted in over the north shore of Australia when it stopped transmitting. We're talking with the Australian military authorities right now to see if they have any broadband radar coverage that might help out. Otherwise, nothing."

"When did this happen?" Lassiter asked, pulling his tablet toward him and bringing up a scratchpad page.

"About 25 minutes ago. It should have been directly in contact with Perth 10 minutes ago, but nothing has been heard since its re-entry call, oh, about 5 minutes before it went quiet."

"Do you have the data ID from ICAO ops yet?"

Bernard sighed. "Yes, of course. It came in with the unusual occurrence report. I should have linked it to this call. One moment."

Lassiter saw a hotspot appear on the screen and thumbed it. Instantly, the display split in half, with Henri Laurent on one side and an alphanumeric identifier on the other. Lassiter pointed his phone at his desktop and selected the data tag. New windows opened at once, showing the air traffic display, flight plan, controller communications log, and streamed flight data. One other window he expected to see remained stubbornly dark.

"No flight deck ambient?" he asked

with some surprise.

A shrug. "The data stream contained it, but it seems to have been corrupted somehow. The engineers downstairs are trying to piece it together."

Lassiter frowned. "A technical problem of some sort or deliberate interference?"

"We don't think it's anything more than an encode or decode anomaly. Nothing out of the ordinary seems to have been going on with them. All very routine."

Routine, Lassiter mused, tapping on the communications log first. The usual exchange of datalinked traffic control clearances appeared, along with digital files of the half-dozen voice communications between the surface and the intercontinental scramjet. He listened to each in turn, sharing each in turn over the phone with his colleague, who had now been joined by several other important-looking people gathered around his workstation. Lassiter ignored them as he replayed the last two calls and then slid their files side by side in a waveform analyzer.

Bernard cocked his head. "Yes, I heard it, too. What is that?"

"Not sure, Henri. If this was an old helicopter, I'd say it sounded almost like something rotating at a high frequency starting to go bad. On a scramjet, I can't think of anything that'd generate a sound like that."

Sure enough, the second of the two transmissions showed a soft, high-frequency tone behind the pilot's calm report of atmospheric re-entry. No stress in the voice, no identifiable warning system associated with the sound in the analyzer's library...just a label saying "anomalous tone" with its precise frequency in Hertz and a time stamp showing it was present throughout the entire radio call. Strange.

"A thought, Raymond. Is the quality of the recording good enough to tell if the sound changed volume during the radio call?"

Lassiter considered this. "I'm not sure. The area mikes would be a lot better for something like that, and they

, Surveillance Lost'



might give us a better idea as to exactly when it started, too. This is barely at detection levels right now. Give me a minute."

His hands flew over the audio controls, zeroing in on the trace of the almost-buzz behind the pilot's voice. "I wouldn't put a really high level of confidence on this, Henri, but it seems to have gone up perhaps two or three decibels from the start of the call to its end."

Bernard glanced to his side at a different display. "The end of the flight data stream correlates within 700 milliseconds to the loss of the air traffic trace. This is not good."

No merde, pal, Lassiter thought. He brought up the controller's side of the conversations, which included three additional short calls.

"SkyArc 71, surveillance lost, say your altitude."

"SkyArc 71, OrbitCon, comm check."

"SkyArc 71, Orbital Operations Control on emergency SATCOM, how copy?"

The silence after each unanswered transmission actually seemed to grow deeper with each passing second. That young lady's a pro, Lassiter said to himself. No extraneous chatter, just a quick, by-the-book set of calls and then she hit the alarm.

The ATC display, slaved by time stamp to the radio calls, was equally damning in its bald depiction of the sequence of events. There one second, gone the next. The data tag for SkyArc 71 showed the track had shifted into "coast" mode, projecting the flight trajectory and ready to re-synchronize as soon as it reacquired an aircraft with more than 140 souls aboard... a step the system now seemed unlikely ever to take.

Lassiter turned his attention back to his phone. "Okay, Henri. My aircraft, my operator, my departure, so I'm the IIC, right? We need to get moving on this."

Henri Bernard unconsciously leaned slightly in toward his own phone. "Well, as you might imagine, there is quite a bit of concern up here"

"Cut the crap, Henri. Annex 13 provides for exactly this kind of situation, and there are what, eleven other scrams up right now?"

Bernard read the outburst as intended, stifling a quick grin but speaking soothingly. "Raymond, please. I never would have suggested any other approach. I merely wanted to make sure you were aware that there are other interested parties."

"Yeah, I see about half your headquarters over your shoulder. I'm calling this a preliminary investigation, as of right now. Recording is on," Lassiter added, bringing up a formal notice tinged in red on the main display, "and I respectfully request that all parties not directly accredited leave the conference immediately."

The faces in the background, some pale, a few noticeably pink, filed away from the Montreal desk. Bernard stretched casually, then addressed his counterpart at the other end of the call.

"That was... elegantly... handled, Raymond," he smiled.

Lassiter snorted. "Uh, huh. Probably at least three irate calls headed to my front office already. Who else is in the loop?"

Bernard consulted a checklist beside him. "ULA is finding a design representative, and SkyArc just advised that they have a pilot headed into their office to join us." A pause. "The Australians have just notified us that they have no direct track on the aircraft, but there is a cloud of some radar-opaque material descending approximately 350 kilometers north-east of the Karlamilyi National Park in western Australia. They are sending an aircraft in that direction."

Lassiter said unhappily, "That's just them doing the right thing. The aircraft is down. At the speed it was going when it dropped off surveillance, there won't be any recovery. Pass along my thanks to the Australians for the fast response and keep the lines open to them, okay? Meanwhile, let's concentrate on figuring out which way to go with the investigation and let the humanitarian work go

forward."

Bernard replied, "I can conference them in right now if you'd like."

"Sure," Lassiter said.

A new window opened on the desktop, showing a grim-faced older man in a blue-gray uniform jacket. "Group Capt. Greg Parsons, Mr. Lassiter. Sorry for your apparent loss. The aircraft we sent out looking has orders to try to spot where the debris is coming down. Pretty dark night, but we're hoping infrared will help find hot spots."

"Appreciate your fast response, group captain. Airplanes don't just fall apart, and scrams in particular are built like tanks. Either it blew up or it took itself apart. Either way, physical evidence is going to be crucial."

"And that's the early line, eh?" Parsons said, sitting back and nodding. "Well, there's a lot of emptiness in the area we're checking out, but that might work to our advantage. Anything unnatural is likely to stand out in overheads. I'll be your liaison for now, so please make sure I can log in directly when we have more for you, all right?"

Lassiter nodded agreement and enabled the line from Australia for permanent conference access, then closed it out. Turning his attention back to the desktop, he spoke as he worked.

"Henri, let's start building the history of the flight. I'll do the profile, you do the instrumentation. Okay?"

His counterpart silently nodded, hands moving across his own desktop. Neither spoke for some minutes.

"Raymond, a moment if you please."

Lassiter looked up in puzzlement. "I know you're good, Henri, but we've been at this for less than a half an hour!"

Bernard didn't meet his friend's eyes. "Of course, it's foolish to think we could be on the exact trail so quickly, but I would like your opinion on these engine readings."

He made a sliding motion toward the display, and a new window popped up on Lassiter's desktop. Lassiter studied it intently, then dropped the data table into the wireframe scramjet model he had



just finished assembling. He then shared the combined object back to Montreal, and the two investigators watched as Lassiter set it in motion.

From a third-person point of view, they saw the aircraft take off, rotating smoothly and climbing swiftly. Lassiter accelerated the playback until the aircraft was just short of reaching the apex of its climb, then abruptly froze it.

“Look at the trim, Henri. The aircraft looks fine on all three axes, but it’s definitely out of trim.”

Bernard nodded agreement. “I think that’s what caught my eye as well, but it seems to be correlated with the starboard engines. They’re developing perhaps 3 percent less power than those portside.”

“What the hell?” Lassiter muttered. “The automation is compensating for the difference, but there shouldn’t be a difference.”

“My thoughts exactly. Why would the pilots have been unaware of this?”

Lassiter mentally reviewed what he knew about the scramjet’s subsystems, calling up a copy of its flight crew operating manual that he shared through his desktop. “The power differential is on the ragged edge of being out of limits; but unless you catch it by comparing the engines from minute to minute, it’s just below the annunciation range.

“Same with the trim. The aircraft is plenty strong, but it has to stay in pretty much fully coordinated flight to avoid structural problems. This out-of-trim condition we’re seeing isn’t anywhere near the aircraft’s real limits, though, so unless you’re actually looking at the turn and slip indicator—and why would anyone bother doing that in the outer atmosphere?—again, there’s no caution threshold being violated.”

Bernard looked troubled. “So we have a slight imbalance in the engines, and a resulting slightly out-of-trim condition. I went the rest of the way through the engine data, though, and neither of these ever changed. Until...”

He touched the object on his screen, quickly advanced the playback, and released it. The wireframe model smoothly

descended, then abruptly twisted into an impossible geometry and froze in that position before two horrified pairs of eyes.

“I guess that’s what the aircraft would do if the starboard engines rolled back while the port ones went to full throttle,” Lassiter said, slightly dizzy from the suddenness and finality of the images before him.

“That is what the computer thinks it would do, anyway,” Bernard said, affecting his own air of bemused indifference.

Both sat quietly, considering what they had watched. Lassiter spoke first.

“So there have only been three previous scram losses, right? The first one was in testing, and it involved a catastrophic failure of thrust, but the

“The automation is compensating for the difference, but there shouldn’t be a difference.”

fuselage held together pretty well. The second one was that passenger flight that got hit by the unforecast solar flare; trashed all of the avionics, but the scram stayed together and the pilots became the first crew to fly dead stick hypersonic since the Space Shuttle, and they landed okay. The last one was the bombing in WestPac, but we knew what we were looking for because the data were clean right up to the moment when everything went dark.”

Bernard joined in. “All three were as you say. This seems like a bomb, but we have evidence of some peculiarities in the aircraft’s operation. Of course, the airframe is strong enough to survive an instantaneous shutdown of its engines, even though such a thing is supposed to be impossible because such deceleration will instantly kill everyone aboard.

“So what are we missing?”

Lassiter’s regular phone rang. He was tempted to ignore it, but the fact that it showed an unfamiliar name from an unknown number piqued his curiosity. He decided to answer.

“Chief Lassiter? Capt. Maria Alonso, SkyArc. Sorry to be so slow calling in, but I didn’t trust the security of my personal phone.”

“Hello, captain. I’m patching you into our board conference. Right now it’s just you, me, and Henri Bernard at ICAO. I’m assuming you’ve been briefed in.”

“Only through notification code words, but they were bad enough. May I assume the aircraft has not been accounted for?”

Lassiter briefly studied the pilot’s image. Younger than he usually worked with, but highly recommended. Calm, intelligent eyes. Wary, but self-assured. Not a rookie. Good.

“We’re working under the assumption that the aircraft broke up in flight. Australian authorities reported indications consistent with such an event, and they’re investigating. Henri has been going through the systems data, and

I’ve been retracing the flight profile. All we’ve been able to see so far is a very small thrust differential between the left and right side engines, and a corresponding out-of-trim condition, but nothing outside operating limits.”

“The crew didn’t seem to perceive anything out of the ordinary?” Alonso asked evenly.

“Nothing they considered worth reporting to ATC. We don’t have a clean download of the flight deck environmental recording yet, so no visuals and no chatter.”

Alonso’s eyebrows briefly rose at that, but she didn’t comment further. “May I assume, then, that the flight data showed nothing else obviously out of order?” she asked.

Lassiter hesitated. He said slowly, “Henri passed along the engine and performance data log, and I mounted it into the profile to see if the two married up. They did, right up to the moment when the aircraft apparently folded itself in half.”

Alonso started, then swallowed hard and briefly looked away, blinking twice. Her level gaze then returned to the screen. “I see. I assume that the event you describe is a computer extrapolation of the data, not anything confirmed by wreckage or other data, correct?”

Lassiter bobbed his head affirmatively, a little unnerved by the speed with which the captain had recovered her



professional composure. “Right. I have to say you seem to be taking the notion of something like this pretty much in stride.”

Alonso shrugged briefly. “I’ve lost friends in aviation accidents before. Apart from the bombing, only three people have ever died in scrams, and those of us who fly them figure it’d be like being in a submarine crushed under pressure if one went out of control.... You’d never know what hit you.”

She continued in a businesslike tone. “Was there anything else to be seen on first inspection of the data?”

Bernard took that one. “Absolutely nothing to suggest a ‘why.’ Only a ‘what,’ and that itself must be treated with caution until we have more information.”

The captain stared meditatively at the screen for almost a minute. Then she asked, “When they talked to ATC, did they say anything at all out of the ordinary?”

Lassiter replied, “They didn’t say anything other than the usual altitude and position reports. We heard something in the background that we can’t explain, but I don’t see how it could be related to an engine problem.”

“What exactly did you hear?” Alonso asked quickly.

“Listen for yourself,” Lassiter said, cuing up and starting the recording of the last radio call.

“Again, please,” Alonso said at the end of the brief transmission.

She listened three more times, eyes closed, then opened them and stared at the screen.

“That is not a normal sound, and I have never heard it before,” she said firmly.

Lassiter looked at her closely. “The audio trace looks like a high-frequency vibration of some time. But as I understand it, the only things that could create a sound like that are all pump-related, and well separated from the occupied part of the aircraft.”

“Correct,” the captain said crisply. “This sound is quite faint, but the pilots should have heard it if it was loud enough to be heard through their microphones. However, re-entry buffet is quite loud. Can you please compare when this transmission was made to the cessation

of re-entry vibration.”

It was not a question. Bernard quickly accessed the communications log and aligned the time stamps with those of the flight data.

“The characteristic excursions of g-forces associated with re-entry essentially end 15 seconds before the last radio call.”

“Good,” Alonso said with satisfaction. “There is no way they would have heard something that faint so soon after the shake and bake.” She paused for a moment, flushing slightly. “Please forgive my use of scramspeak. It’s hardly appropriate under these circumstances.”

“Why do you call it that?” inquired Bernard with interest.

“Re-entry is bumpy, and exterior heating is impressive,” Alonso replied dismissively. “For a flight with as short a deceleration and descent phase as Seattle/Perth, the entire airframe is still uncomfortably hot for at least an hour after landing, even in the winter. Touch it and get burned.”

Lassiter said nothing for a few moments, his eyes having shifted slightly out of focus. “Henri,” he said slowly after a pause, “do you remember the Space Shuttle *Columbia* accident?”

“Of course,” Bernard replied. “However, that involved damage to heat-resistant tiles experienced during launch. The heat protection of scrams is integral to their fuselage design. It dissipates heat throughout the structure.”

“Yes, but the result they experienced was awfully similar to what we see here, right? High altitude, but steadily increasing aerodynamic pressure on the airframe, followed by a break-up that started at a vulnerable point.”

“But a scram is almost an armored vehicle,” Alonso said briskly, “and the flight control computers keep the aircraft on profile even if the pilots don’t attend to things properly because of the criticality of its attitude during re-entry.”

“Is there ever a need to maneuver the aircraft at all, even slightly, while you’re still in the re-entry phase?” Lassiter asked.

“We occasionally receive an advisory to make S-turns to assist the deceleration if we weren’t precisely on profile going over the top,” Alonso replied.

Bernard was busy sorting through display options. “Where would such an advisory appear, and what does it look like?” he asked, eyes locked on his desktop.

Alonso responded to his intensity. “Central screen. Both pilots receive a voice alarm saying ‘Decel, decel’ and are shown the direction for the initial S-turn on their primary screen. It’s impossible to overdo, but there’s a course correction factor figured in that decides which way to turn first. Then it’s ‘roll-two-three-four, reverse-two-three-four’ until you get a ‘profile resolved’ message.”

Lassiter said excitedly, “I remember that on my sim rides. The instructor basically told me to ignore it, that it was mainly busy work to make the pilots feel like they’re doing something during a critical phase of flight.”

Alonso’s mouth twitched. “That’s not exactly true. If you don’t do the decel when commanded, the aircraft can’t initiate it on its own until you are much lower. If it has to do it late, the crew gets an unhappy ride, and SkyArc gets many unhappy e-mails from passengers. We still are pilots, you know.”

At that moment a conference join request chimed on Lassiter’s desktop. “Looks like we have our engineer,” he told the others, selecting the incoming call.

“Prakesh!” Bernard exclaimed with pleasure. “So good to see you, although I wish it was under more pleasant circumstances.”

“Hello, Henri. Chief Lassiter,” replied the face on their desktops. He shifted his gaze downward for a moment, then inclined his head. “Capt. Alonso. Your reputation precedes you.”

The pilot smiled briefly. “Thank you. We have some common acquaintances, I believe, but it’s good to put your name with your face. You are a structures engineer, then?”

“Yes, from my time at MIT. I also spent two years at TsAGI on a fellowship dealing with aerodynamics and fluid dynamics.”

Lassiter broke in. “We’re all acquainted with each other’s credentials, so if you don’t mind I’d like to get back to the line of reasoning we were following when Dr. Rai joined. As we were saying,



the only abnormalities we've identified so far are slightly out-of-balance thrust resulting in the aircraft being very slightly out of trim, and an unidentified high-frequency vibratory sound—very muffled—in the background of their last recorded radio transmission. Capt. Alonso was just explaining the profile correction maneuver that's sometimes commanded during re-entry.

"Yes, we know SkyArc obtained approval to do that several years ago. The airframe can handle the added stresses, of course, but it's completely unnecessary to do it so far from the destination."

"The earlier the correction, the faster the profile is optimized," Alonso observed smoothly. "If we delay until we're closer to landing, we have to make much larger maneuvers. More uncomfortable for the passengers, more fuel and flight time required as well."

Rai waved a hand. "All true, of course, but not how the scrams were designed to be operated." He looked slightly to his left. "Henri, why are we discussing this?"

The ICAO investigator looked up from his desktop. "We started talking about it based on a question Chief Lassiter asked regarding re-entry maneuvering. I looked in the data and determined that the crew did in fact receive a command to perform deceleration turns, and they did so. It is how they did so that has me puzzled."

"What do you mean?" Lassiter asked, eyes narrowing.

"Watch the model. It's easier to see." Bernard made a few quick gestures, and the wireframe model disappeared for a moment, then reappeared at the apex of a violet climb-and-descent profile curve. Set in motion, the scramjet slid smoothly over the top of its climb—still with a slight but unmistakable yaw—and started to descend.

The nose rose slightly, and then the model began a series of shallow left and right rolls. Lassiter found himself silently mimicking Alonso's sing-song "roll-two-three-four" count as the craft bobbed back and forth. All as described. Except...

Alonso spoke first, eyes widening. "The rolls aren't equal. What are they doing?"

Rai murmured, "At that pitch attitude,

the aircraft should be much closer to coordinated flight. Look at the yaw. The nose is hunting all around with each reversal of the roll."

Lassiter considered the image before him. "Dr. Rai, can your aerodynamic models be overlaid on our re-creation?"

"Yes. The airframe is generated by the same data we use for virtual wind tunnel work." He hesitated. "I'll need as much performance and atmospheric data as you can give me. I can use a standard lapse rate for pressure and temperature changes, but I need exterior conditions at top-of-climb to extrapolate them properly."

"Give me a moment," Bernard replied. Lassiter briefly thought to marvel at his colleague's skill at teasing out obscure data from unlikely sources. He saw inlet pressure and windscreen temperature quickly appear before him, then slide into a pre-built program that correlated both with reported altitude. Less than a minute later, Bernard extracted a small file that he placed in the shared desktop workspace. Prakesh Rai immediately tagged and merged it with a program he already had open and waiting.

The wireframe model blinked off, then reappeared in the middle of a multicolored depiction of moving air surrounding it. "I can't make the airflow move around the model along the flight path," Rai said apologetically. "What we'll see is the model moving as it did in the animation around its pitch, roll, and yaw axes, and the resulting airflow changes as it descends and maneuvers. I'll keep an eye on the airframe stress predictions once it's in motion."

Lassiter nodded understanding. Rai started the simulation, and the colored flow of air immediately spread around the modeled aircraft. All of the investigators watched as it again began its four-second back-and-forth rolls.

"Must have been one hell of a rough ride," Lassiter observed, watching ripples of red disturbed air spiraling off almost the entire length of the aircraft.

"Indeed," agreed Rai, clicking on certain spots along the fuselage and studying the resulting data. "However, all of this is well within design tolerances."

"There's nothing normal about this," Alonso objected. "Their S-turns aren't at all balanced in roll, and that kind of dif-

ference should have resulted in a warning to discontinue decels. Did it?"

Bernard scrolled forward in the flight data. "If that would be a central screen message like the S-turn command, no, there is nothing."

The captain frowned. "We're missing something important here. The crew would have felt how abnormal the deceleration buffeting would have been. Without being cued to discontinue the decels, though, they probably would have continued them until the proper profile was restored. When did they stop?"

The man in Montreal scrolled farther forward then stopped. "'Profile resolved' 22 seconds after the 'decel, decel' advisory. The crew damped out the roll they were in within three seconds of the resolution message."

Three investigators sat back without speaking. Dr. Rai remained leaning forward, staring expressionlessly at the model before him. A quick movement increased the size and detail on the model dramatically.

Rai raised his eyes. "Am I correct that the flight deck environmental data are not available to us at present?"

Lassiter and Bernard exchanged glances. They hadn't mentioned this to Dr. Rai yet. "Yes, why?" asked Lassiter cautiously.

Rai's face took on a slightly less opaque, grimmer expression. "The wind tunnel data suggest that there was seriously disturbed flow over the forward antenna fairing starting before top-of-climb. It became dramatically worse as re-entry began. By design, the fairing itself would not have been torn off, but its trailing edge could have been loosened by flexing."

Bernard got it first. "Our mysterious high-frequency sound?"

"Highly possible," Rai agreed. He paused. "Something I've not tried before with the wind tunnel program is correlating airflow with the temperatures associated with re-entry. We use a different program to look at that, and it's simpler in how it generates the model. Less freedom of movement, since pitch is so safety critical. Give me a few minutes."

Rai's screen disappeared from the shared desktop. "What do you think he's talking about?" asked the captain.



Bernard replied, “I don’t think he liked where he saw the disturbed airflow going over the fuselage. I cannot imagine the airframe being unable to handle the re-entry temperatures, though.”

Lassiter was about to make his own observation when Rai’s screen flashed back to life. “My apologies. I needed to tinker with some proprietary software, and I didn’t want any witnesses.” He smiled briefly, without humor. “I’m going to run the simulation again. This time, don’t think of the colors as representing pressure gradients. They’ll be showing temperatures instead. It probably will be a much more... muddled presentation.”

He started the program, instantly surrounding the wireframe model with a riot of colors. Rai slid his cursor furiously from point to point along the virtual fuselage, sometimes touching structures familiar to the others, sometimes lingering over points of no obvious importance.

As the simulation ended, Rai kept his head down, obviously making some adjustments to the program. “The presentation will play again at one-twentieth of the previous speed. I’m limiting the temperatures that will be shown to 1,000 degrees Centigrade and higher, and this time they will be fuselage surface temperatures as the heat diffusion system comes into play.”

The replay began again. This time, all watching could tell that it had been started during the climb; apart from a faint tinge of pink along the leading edge of the wings, there was virtually no color at all. That quickly changed as the aircraft passed the top of its climb, nosed over, then slowly increased pitch as it descended. Streaks of angry colors spread quickly back from the front of the aircraft, noticeably more vivid along the forward left side of the fuselage.

The left and right rolls began. The colors on the fuselage brightened noticeably, especially under its belly, converging into a red-orange stripe running its entire length. “Keel beam. Main heat sink.” Rai noted briefly. At the same time, an odd stripe of glowing orange started reaching across the tail empennage from the middle of the left wing, curving toward the trailing edge of the right delta wing. The orange smear seemed to intensify slightly, spreading

farther fore and aft, just as the playback ended.

Rai sighed. “Please look at this, all of you.”

A second scram appeared next to the first. The model, much more roughly rendered, looked like it was painted with the same colors they had seen moving like living things over the first animation. Rai spoke again.

“This is an example of how we established that our heat control measures worked during the scram’s design. There are two key observations to be made. First, the pattern of heating is uniform on the left and right sides. Second, the dorsal spine of the fuselage never allowed an area of superheating to cross the aircraft’s midline.

“This model,” he continued, bringing up a finely detailed representation of the production scramjet, “shows how we met our weight management goals while ensuring the safety and integrity of the aircraft. Basically, we used titanium and vanadium in all of the heat-critical areas and ensured the sinks were distributed throughout them.”

Alonso said slowly, “The flight control power converters are in the aft spine, and the engine support frames are attached to the carry-through spars on the trailing edges of the wings.”

“Correct, captain,” Rai replied crisply. “As we saw, the airflow and thermal propagation both appear to be radically affected by what should be an innocuous anomaly in trim. A thermal crossover most likely started just after re-entry began. At that point, critical structures not directly protected by materials or temperature management provisions would have begun being exposed to excessive temperatures.”

“You had to have known about the criticality of preventing this type of condition from occurring,” objected Bernard. “The yaw tolerances are narrow for that very reason, are they not?”

“Quite right,” Rai conceded. “However, the superheating did not appear to trespass into sensitive areas until after the deceleration maneuvering began, and the maneuvering itself seemed quite asymmetric. At that point, I would theorize that the aircraft’s attitude defeated at least some of the active and passive temperature control provisions, allowing

rapid heating of the less-protected areas as suggested by the model.

“So I must ask, what would have made the deceleration S-turns so unbalanced, and why would the pilots not have commented on it?”

“We don’t know that they didn’t,” Capt. Alonso said, a trace sharply. “We don’t have flight deck audio or video yet.”

“Quite so,” Bernard said soothingly. “This suggests a useful line of inquiry, but it still raises many questions. No one should think the mystery is solved, eh?”

Lassiter had been silent throughout this exchange, trying to place himself in the cockpit of the stricken scramjet. Something about the replay had bothered him, but he couldn’t put his finger on it....

“Wait a minute,” he said suddenly. “The deceleration maneuver was exactly the way Maria—sorry, Capt. Alonso—described it. Four seconds one way, four seconds the other. Right?”

“Agreed,” Bernard said at once. “I counted to myself as well. A useful technique they seem to have followed precisely.”

“But the roll rate would have to have been different... a lot different. Left to right should have taken much less time than right to left to achieve what the data say the aircraft did, right?”

All four investigators watched as he cued up the original model and set it in motion.

“It doesn’t seem to make sense,” Alonso said half to herself.

“What are you doing with your hands, captain?” Lassiter asked abruptly.

The captain glanced down and then shrugged. “I was just visualizing moving the stick as I would during decel turns.”

“Please do that again,” Lassiter urged, “and pull your cam back a bit so we all can see you going through the motion.”

Alonso obliged without comment, although her expression of skepticism was obvious.

“So it’s an equal left and right of the sidestick controller,” Lassiter prompted.

“Yes, yes,” the captain said impatiently. “Very subtle, a little finesse on the reaction controls. At that altitude you aren’t using any of the aerodynamic surfaces for maneuvering.”

The AHA! light flashed brightly on



in Lassiter's consciousness. "Walk us through how the aircraft's automation would have been correcting for the thrust imbalance.

"I know the resulting yaw was below annunciation values," he added hastily, "but humor me. Would some kind of automatic compensation have been taking place?"

Alonso gave a quick affirmative jerk of her head. "Of course, it was maintaining the specified heading. So naturally, it...." Color suddenly drained from her face. "The adaptive controls!"

Rai nodded instant understanding. "Quite possibly. If the sidestick received equal inputs, and the flight control system was still in normal mode, the reaction thrusters would respond with equal left and right force beyond whatever they were firing to maintain the commanded baseline heading."

Lassiter picked up the thread. "So if the reaction thrusters were firing continuously trying to keep the aircraft on the proper heading, that means they'd really start working when the rolls were commanded."

Bernard's mouth tightened. "The stick position wouldn't be off-center because the system tries to provide a normal control feel even when the aircraft in an abnormal condition. Capt. Alonso, would a pilot typically refer to instrumentation when performing deceleration turns?"

"We're taught to watch our pitch angle closely, but the aircraft is supposed to automatically keep roll within limits. The count between left and right is intended to provide a suitable interval between inputs while keeping us on course." The SkyArc officer had regained her professional demeanor; Lassiter noted, although she still looked a little pale. Probably remembering how often she's done exactly the same maneuver.

"Let's see where we're at. There's a thrust differential during climb and over the top—not enough to trigger a warning, but enough for the automation to be compensating for it with some reaction thrust. The slightly out-of-trim way the aircraft is presenting itself means it would have heated a little unevenly going into re-entry, but still within the capabilities of the thermal protection provisions, so no warnings there.

"The automation commands a high-altitude deceleration at a normal point in the flight, and the pilots respond with a normal set of S-turns. However, in doing so, the continuous firing of the right-side reaction thrusters suddenly was amplified by a combination of the roll inputs plus the pitch attitude of the aircraft. This exaggerated the out-of-trim condition and changed the superheated airflow to make it cross over the airframe and potentially affect thermally sensitive but less protected components.

"Does everybody agree that that scenario is plausible based on what the data are telling us?"

Silent nods on all screens. Lassiter continued, "Okay, we'll call this a working theory of the accident. I'll ask the Australians to give priority to locating dynamic components—and the antenna fairing," he added, receiving an affirmative jerk of the head from Rai. "I'll also ask that they secure anything that looks like it shows melting of any type.

"Does anyone have anything to add to the preliminary investigation record?"

Capt. Alonso said gravely, "I'd just like to make sure that the record reflects this to be a previously unsuspected failure mode. Asymmetric thrust is a threat to aircraft control, and the limits were established on that basis. I don't think there's any way the designers ever would have anticipated temperature extremes outside protected areas being encountered in any normal flight regime.

"Decel turns wouldn't be attempted in any mode other than normal operations because the automation wouldn't command them. Limiting is supposed to prevent the kind of roll excursions seen in the flight data. The heads-up display clearly shows them, but we're taught that pitch is paramount during re-entry, so we've probably fallen into a pattern of simply timing the rolls rather than monitoring them closely." A quick grimace. "I know I have."

"Does anyone have a problem with this subject-matter expert opinion being incorporated into the record?" Lassiter asked formally. "Nothing heard, it is so entered."

Looking around the desktop at the sober faces it displayed, Lassiter's shoulders sagged a bit. "Thank you all for your contributions to the preliminary

investigation. Everybody knows how much work we all have ahead of us, but I'm totally comfortable going to the chairman with this theory. At the very least, I think we've built a scenario that all of our respective working groups can explore from a design and procedural perspective. It should be an interesting couple of months.

"Any last thoughts?"

The only answer was silence. "Again, thank you all for participating in the preliminary investigation. Working groups will be formed by this time tomorrow, and you'll be contacted individually to start mapping out your formal lines of inquiry. Recording off."

Data, Lassiter thought as he wiped his desktop clear and the participant windows shut down. It always comes down to data. The more we have, the better we use it, the faster we can get to the truth.

Author's Afterword

While the full story of Malaysian Airlines Flight 370 has yet to be understood as this story goes to press, it already is clear that this tragedy has started a serious conversation regarding the need for both better worldwide surveillance of operations and better means of capturing flight data as they are collected. The community of air safety investigators has never handled uncertainty well, and many ISA-SI members have fought long and hard for both of these improvements. Also, I selected the location of the fictionalized accident and ensuing investigation described in this story in tribute to the 2014 ISASI seminar venue and the desirability of high-speed transportation connecting Australia with major cities around the world; any unfortunate parallels between real-world events and those of the story are strictly coincidental.

I would have preferred that an occurrence like MH-370 not be the driving force for needed and logical change, and my story was based at least in part on a hope that it would have come along as a natural part of technology's evolution. However, I'm more confident than ever that future investigations will be starting from a much richer body of data than is the case today. If that comes to pass, no matter how we get there, it will be a welcome future indeed. ♦

JERRY LEDERER: GONE BUT NOT TO BE FORGOTTEN

(Continued from page 13)

municate his ideas about safety. He further believed that defining the task as risk management would help attract the caliber of personnel he wanted at NASA, because “it served as more of a challenge to mental resources than safety, because it stresses the uncertainties.” His close friend, Charles Lindbergh, supported this view in a note written in 1969.

Jerry dedicated much of his free time to investigations of unique and challenging safety problems, such as drug abuse, subtle cognitive incapacitation of pilots, cockpit boredom, and interpersonal communications. He also served as chairman of the Crew Fitness Panel, the Society of Automotive Engineers (SAE) Committee on the Technology of Human Behavior. He is listed in *Who's Who in America*, *Who's Who in Engineering*, *Who's Who in Aviation*, *American Men of Science*, and the *Architects of the Age of Flight*. He was elected into the OX-5 Aviation Hall of Fame, the Safety and Health Hall of Fame, and the International Space Hall of Fame.

Following his retirement from NASA, Jerry turned to academia to spread his safety beliefs. He served as adjunct professor and lecturer at the Institute of Safety and Systems Management at the University of Southern California. He actively lectured at various civil aviation safety seminars as well as at the United States Air Force Safety Center at Norton Air Force Base. He organized and conducted numerous meetings on aviation safety for the FSF, ISASI, the System Safety Society, the National Fire Protection Association, the Institute of Navigation, SAE, and the American Institute of Astronautics and Aeronautics. And he served as president emeritus of ISASI.

Following the Three Mile Island nuclear power accident, Jerry became a member of the, Institute of Nuclear Power Operations (INPO) Advisory Council, a group mandated to enhance the safety of nuclear generations. He served two 3-year terms with the council where he was instrumental in transferring aerospace risk-management concepts to the nuclear power industry. Jerry's fundamental accident prevention advice about incident reporting, team training, involvement of top management in safety issues, etc., became accepted as major parts of INPO's *modus operandi*.

Honors

As one might expect, many organizations bestowed membership upon Jerry, for example, Honorary Fellow of the Institute of Astronautics and Aeronautics Society; Fellow of the Aerospace Medical Association; Fellow of the Human Factors Society; Honorary Fellow of the System Safety Society; Honorary

Member of the National Academy of Engineering, Tau Beta Pi, and Pi Tau Epsilon; Fellow of the Royal Aeronautical Society and Royal Society of Arts; and Honorary Member of the Institute of Navigation, the Air Traffic Controllers Association, and the Air Line Pilots Association.

Jerry received more than 100 honors, including the 1999 Edward Warner Award, one of civil aviation's highest honors, from the council of ICAO. In November 2003, he received the 2003 Cliff Henderson Award for Achievement from the National Aeronautics Association. In February 2003, he was selected as one of the Laurel Legends for 2002 by *Aviation Week & Space Technology*; the award honors individuals who have made significant contributions to the global aerospace field. In 2002, he received an honorary doctorate in safety science from Embry-Riddle Aeronautical University. Among his other awards are the NASA Exceptional Services Medal, the FAA Distinguished Service Medal, the Daniel Guggenheim Medal, the Amelia Earhart Medal, the Von Baumhauer Medal of the Royal Dutch Aeronautical Society, the Airline Medical Directors Award, and the Aerospace Life Achievement Award of the American Institute of Aeronautics and Astronautics (AIAA). In 1988, Lederer received the K.E. Tsiolkovsky Medal from the Soviet Federation of Cosmonauts. In 1965, he was awarded the prestigious Wright Brothers Memorial Award. The citation read, in part: “Aviation's extraordinary safety record to a significant degree is a result of the tireless and devoted efforts of Mr. Lederer. For 35 years, he has worked unceasingly to improve all elements of the flight safety spectrum and concentrated on making compatible the primary elements of flight—the man, the machine, and the ground environment—to ensure maximum safety. In accomplishing this objective, he has taken the leadership in correlating, coordinating, and improving the flight safety activities of the many varied organizations and agencies comprising world aviation.”

In May 1997, the U.S. Congress recognized the then 95-year-old aviation safety innovator by bestowing upon Jerry the title “Father of Aviation Safety” and presenting him “special Congressional recognition” for his numerous achievements and outstanding service toward the improvement of aviation safety for all Americans.

But if the Father of Aviation Safety, with all he accomplished, didn't believe that title described him, what did he think did? He once said that the following words from an FSF Distinguished Service Award, which he received in 1967, best defined his career: “For pioneering the flight safety discipline at a time when it was all but unknown, and for pursuing the objective of safer flight with a singular dedication, wisdom, and courage. His belief in, and application of, the sharing of flight safety information and experience formed the cornerstone of the effort.” ♦

'AVIATION IS SAFER THAN EVER'—WHY?

(continued from page 29)

- for flight attendants,
- stronger fuel tanks,
- more heat-resistant liner panels in storage compartments,
- shorter maximum distance from any seat to an exit,
- independent power source for public address systems,
- improved fire-suppression systems, and
- fuel inerting.

The benefits of these changes were visible quickly. In August 1988, a Delta 727 aborted takeoff and crashed; 94 of 108 people survived an intense fire. The NTSB found the survivors were saved by new fire-blocking seats. In July 1989, an uncontained engine failure severed a DC-10's hydraulics. On emergency landing at Sioux City, the aircraft cartwheeled into a fireball; 111 died but 185 survived. In March 1991, Halon was used to extinguish an inflight fire beneath the cabin floor of an L-1011 midway across the Atlantic by penetrating otherwise inaccessible spaces. Other success stories include Little Rock in 1998, Toronto in 2005, Denver in 2008, Heathrow in 2009, and more.

The ditching of an A320 in the Hudson River after multiple bird strikes in January 2009 is the best known recent success story. All 155 occupants escaped this "miracle on the Hudson," but none of these successes were "miracles." They were the product of hard work for several decades by accident investigators, flight attendants, and others.

What's next?

Unless history suddenly ends, accident rates will continue to improve, and accident investigation will continue to save lives. Yet the profession will face some challenges, such as unmanned aerial systems—but that challenge will be met with processes that have been fundamentally in place for 100 years. Similarly, continued growth in long-haul international flights suggests that Air France 447 and MH-370 will not be the last deep-water challenges. We will also confront unusual events, such as the 777 in Heathrow, and longstanding challenges such as weather, runway excursions, and efforts to improve standard operating procedures, crew response to onboard warnings, and more. The big-

gest challenge may be an accelerating public demand for instant answers to complex accidents.

Many of the issues will be addressed by analyzing "big data" from air traffic and flight operations, maintenance information, voluntary reporting systems, weather information, and more. That change is well under way, but it will continue as data tools improve. Yet accident investigation will remain the primary knowledge source that identifies the problems that big data analyze.

To some degree, the more accident investigation has changed, the more it has remained the same. The field will change, but it will remain the primary source for understanding the interaction of pilot input, ATC, human factors, airworthiness, weather, etc., when things go badly wrong—even as "badly wrong" becomes ever more rare.

Endnotes

¹See *Centennial of Flight Commission (U.S.A.) essays on the DC-2 and DC-3, and The Cutting Air Crash, A Case Study in Early Federal Aviation Policy, Nick A. Komons, FAA; Washington, D.C., 1984, p. 13.*

²See *Centennial of Flight (DC-3).*

³*Lufthansa and Aeroflot had bigger accidents in the midst of the war, but those two accidents appear to have been quasi-governmental flights rather than something approaching common-carriage airline flights.*

⁴*Annual reports, Civil Aeronautics Board, U.S.A.*

⁵*FAA Historical Chronology, page 51.*

⁶*Fleet data from Airclaims.*

⁷*Don Bateman is a past winner of ISASI's Jerry Lederer Award and is an inductee to the Inventors' Hall of Fame. ♦*

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NATIONAL AND REGIONAL SOCIETY PRESIDENTS

AsiaSASI, Chan Wing Keong

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