FLIGHT SAFETY FOUNDATION

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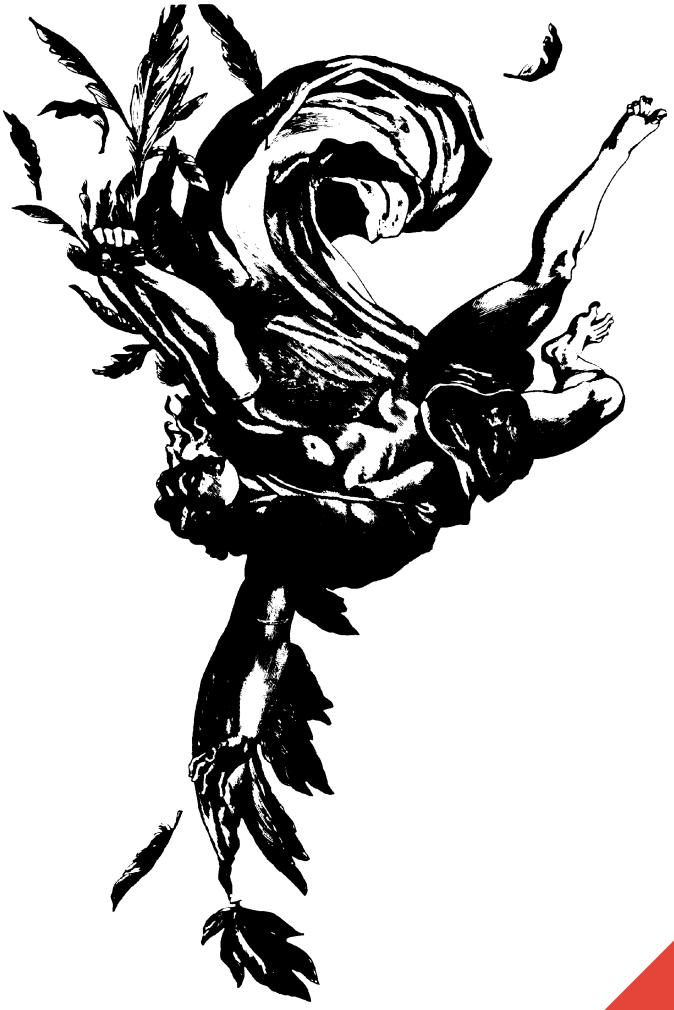
FLIGHT SAFETY
D I G E S T

Aviation Grapples with Human-factors Accidents



FSF Icarus Committee Casts Safety Strategies

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In This Issue

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About the cover: Despite warnings, Icarus's flight too near the sun resulted in disaster. (Illustration courtesy of the Smithsonian Institution's National Air and Space Museum, Washington, D.C., United States.)

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, the Foundation was launched in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 700 member organizations in 80 countries.

Foreword

This issue of *Flight Safety Digest* presents reports by the Flight Safety Foundation's Icarus Committee. The committee began work in 1992, when the Foundation gathered together a small group of specialists from throughout the aviation industry to study human factors issues in aviation safety.

The committee has contributed greatly to the understanding of human factors accidents, and has provided many tools for preventing such mishaps. To a great extent, the committee has helped to focus the aviation industry's attention on institutional factors and policies that facilitate human error. The committee's airline management self-audit and senior-management briefing papers are examples of tools that industry leaders can use to measure their margins of safety from human-error mishaps.

The committee has lent a strong voice in encouraging greater use of flight operational quality assurance (FOQA) programs to obtain and analyze data recorded during flight operations to improve flight-crew performance, air carrier training programs, operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design.

The committee also is directing the flight operations risk assessment (FORAS) project, which uses advanced mathematical modeling techniques to quantify risks associated with aviation operations. The project, funded by the U.S. National Aeronautics and Space Administration (NASA) Ames Research Center, ultimately will provide decision-making tools to manage risks. The committee currently is developing tools that will enable aviation managers to measure risks of accidents involving controlled flight into terrain (CFIT) and risks of accidents involving turbulence.

The FSF Icarus Committee is another example of the Foundation's ability to draw upon its international membership to provide leadership in improving aviation safety. The diversity of knowledge and experience that we can bring to bear on vital issues is the reason that the Foundation currently is leading or is playing a key role in virtually every major aviation-safety effort worldwide.

Stuart Matthews
Chairman, President and CEO
Flight Safety Foundation

FSF Icarus Committee Cites Advantages of FOQA for Trend Analysis, Knowledge Building and Decision Making

Created by the Foundation to explore methods to reduce human factors–related aviation accidents, the FSF Icarus Committee said that an effectively managed FOQA program is one of several tools that should be used by airline managers to improve safety.

FSF Editorial Staff
with
Jean Pinet and John H. Enders
FSF Icarus Committee

The Flight Safety Foundation Icarus Committee has been at the forefront in encouraging airlines to use flight operations quality assurance (FOQA) programs, and other safety-enhancement tools that can be integrated into FOQA programs, for more effective risk management.

"The data provided by a FOQA program help operators to evaluate the safety of flight operations," said the committee. "FOQA can become an essential ingredient in optimizing air-carrier training procedures and serve as a performance-measurement tool for company risk-management programs and for assessing training effectiveness."

The Foundation created the FSF Icarus Committee in 1992 to seek philosophical and practical solutions to human errors that result in aircraft accidents. Although the analysis of human factors in aviation safety was already being pursued in many places in the world, the Foundation believed that it was important to initiate additional action to synthesize what had been learned. The intent was, and is, to augment and enhance — not to replace — the Foundation's core activities, by posing questions and suggesting actions.

Despite the increasing general level of understanding of accidents and their causes, the emergence of new technologies for aircraft design, the development of training methods and equipment, and the growing ability to analyze human behavior and decision-making factors, aviation accidents and serious incidents continue to occur. These events often result from the decisions and actions of well-trained and highly experienced pilots, although these decisions and actions may have been enabled by other human decisions within the system.

The FSF Icarus Committee is addressing the reasons why the accident and incident rate has not declined proportionately to the advances in technique that the industry is making on many levels.

The committee has received support from major aircraft and equipment manufacturers, airlines, research organizations and regulatory agencies worldwide.

The committee comprises a small, informal group of recognized international specialists in aviation who have extensive experience in the human aspects of design, manufacturing, flight operations, maintenance, operating environments and research (Table 1, page 2). These individuals represent a cross-section of current human factors thinking in the international aviation community. While some of the world's regions are not directly represented, members of the committee are generally familiar with the many industrial, educational and social cultures that intersect aviation operations worldwide.

One international aviation leader applauded the committee's efforts as a "small group of wise people" addressing questions that are very important to the aviation community. He urged the committee to keep itself "lean" in numbers so as not to lose the ability to cut quickly to the cores of issues.

Jean Pinet and John H. Enders, who served as the first co-chairs of the committee, said that the challenge was to keep the group small enough to enable vigorous and candid debate, yet broad enough to bring as many viewpoints as possible into the discussion. Additional participants with special expertise are routinely invited to join the core committee to augment specific discussions.

Table 1
Members of the FSF Icarus Committee as of May 1999

Executive Committee

Douglas Schwartz, Chair
Aviation Director
AT&T

Hon. John K. Lauber
Vice President, Safety and Technical Affairs
Airbus Industrie of North America

Capt. Robert Sumwalt
Chairman, Human Performance Committee
Air Line Pilots Association, International

Members

René Amalberti, M.D., Ph.D.
Professor, Aeromedical Physiology, Ergonomics and Human Factors
Institut de Médecine Aérospatiale du Service de Santé des Armées (IMASSA)

Capt. Claude Bechet
Retired Flight Safety Advisor
Aero International (Regional)

Capt. Jim Duncan
Retired Vice President, Technical Training
Airbus Service Co.

Capt. Chet Ekstrand
Vice President, Government and Industry Technical Affairs
Boeing Commercial Airplanes Group

John H. Enders
President
Enders Associates International

H. Clayton Foushee, Ph.D.
Vice President, Regulatory Affairs
Northwest Airlines

Hon. Robert T. Francis
Vice Chairman
U.S. National Transportation Safety Board

Capt. Hugues Gendre
President
Syndicat National des Pilotes de Ligne

Maj. Gen. Francis C. Gideon
Chief of Safety
U.S. Air Force

R. Curtis Graeber, Ph.D.
Chief Engineer, Human Factors
Boeing Commercial Airplanes Group

Capt. Urpo Koskela
Retired Chief Pilot
Finnair

Capt. Y.L. Lee
Chairman, President and CEO
Far Eastern Air Transport Corp.

Stuart Matthews
Chairman, President and CEO
Flight Safety Foundation

Capt. Dan Maurino
Coordinator, Flight Safety and Human Factors Study Programme
International Civil Aviation Organization

John McCarthy, Ph.D.
Manager for Scientific and Technical Program Development
U.S. Naval Research Laboratory

Capt. Edward M. Methot
Airline Executive

Jean Pinet
Consultant
SEDITEC

John W. Saull
Executive Director
International Federation of Airworthiness

David M. Sheehan
Nestor International Partnership

Capt. Bill Syblon
AMR Sabre Consulting

Capt. Roberto Tadeu
Safety Advisor
Varig Brazilian Airlines

Capt. Etienne Tarnowski
Senior Director Training Development
Airbus Industrie

Source: FSF Icarus Committee

The committee named itself for the ancient Greek god, Icarus, who was given a gift of wings by his father, Daedalus. Icarus proved to be such a "bold pilot" that he did not heed the warning of Daedalus not to fly too high. He plunged into the sea after his wax-and-feather wings came apart when he flew too close to the sun. Thus, in this mythical story, Icarus was the first aviator to suffer an accident because of his incorrect behavior, ignorance of the operational environment and design deficiencies. Icarus serves as a symbol of the committee's objective to reduce human factors–related aviation accidents.

In keeping with this objective, the first meeting of the Icarus Committee addressed the question: "Why do experienced and well-trained aircrews sometimes act against their experience and training, and have accidents?"

The meeting resulted in 18 findings that were released in a report, "Human Factors in Aviation: A Consolidated Approach," (page 15) published in the December 1994 *Flight Safety Digest.* The report has been widely circulated among airlines, corporate and military flight organizations, and government agencies, and is used in aviation safety-training seminars. The committee considered cockpit behavior factors, decision making, management commitment to safety, operational directives, peer influence, standards and crew resource management (CRM) to develop solutions to problems and risk-reduction strategies.

Twenty-six practical guidelines developed by the committee to assist airline managers in assessing the costs of aviation accidents, analyzing their causes and preventing their reoccurrence were released in a report, "The Dollars and Sense of Risk Management and Airline Safety," (page 9) also published in the December 1994 *Flight Safety Digest*.

A checklist developed by the committee to enable senior airline managers to conduct a self-audit, to identify administrative, operational and maintenance processes and related training that might present safety problems was released in a report, "Aviation Safety: Airline Management Self-audit," (page 3) published in the November 1996 *Flight Safety Digest*.

The accomplishments of the FSF Icarus Committee also include six briefings to senior airline managers on methods and tools that improve safety and support FOQA. (Reprints of the briefing papers begin on page 21.)♦

[Editorial note: This article is reprinted from Flight Safety Digest, *July–September 1998.]*

Aviation Safety: Airline Management Self-audit

Honest and critical self-assessment is one of the most powerful tools that management can employ to measure flight safety margins. The FSF Icarus Committee has developed a self-audit for airline management and their senior staff.

FSF Icarus Committee

Objective

This self-audit is for use by senior airline management to identify administrative, operational and maintenance processes and related training that might present safety problems. The results are to be used to focus management attention on areas that require remediation to prevent incidents and accidents.

Management and Organization

Management Structure

- ❑ Does the company have a formal, written statement of corporate safety policies and objectives?
- ❑ Are these adequately disseminated throughout the company? Is there visible senior management support for these safety policies?
- ❑ Does the company have a flight safety department or a designated flight safety officer?
- ❑ Is this department or safety officer effective?
- ❑ Does the department/safety officer report directly to senior corporate management, to officers or the board of directors?
- ❑ Does the company support periodic publication of a safety report or newsletter?
- ❑ Does the company distribute safety reports or newsletters from other sources?
- ❑ Is there a formal system for regular communication of safety information between management and employees?
- ❑ Are there periodic company-wide safety meetings?
- ❑ Does the company actively participate in industry safety activities, such as those sponsored by Flight Safety Foundation (FSF), International Air Transport Association (IATA) and others?
- ❑ Does the company actively and formally investigate incidents and accidents? Are the results of these investigations disseminated to other managers? To other operating personnel?
- ❑ Does the company have a confidential, nonpunitive incident-reporting program?
- ❑ Does the company maintain an incident database?
- ❑ Is the incident database routinely analyzed to determine trends?
- ❑ Does the company use outside resources to conduct safety reviews or audits?
- ❑ Does the company actively solicit and encourage input from aircraft manufacturers' product-support groups?

Management and Corporate Stability

- ❑ Have there been significant or frequent changes in ownership or senior management within the past three years?
- ❑ Have there been significant or frequent changes in the leadership of operational divisions within the company in the past three years?
- ❑ Have any managers of operational divisions resigned from the company because of disputes about safety matters, operating procedures or practices?

Financial Stability of the Company

- ❑ Has the company recently experienced financial instability, a merger, an acquisition or major reorganization?
- ❑ Was explicit consideration given to safety matters during and following the period of instability, merger, acquisition or reorganization?
- ❑ Are safety-related technological advances implemented before they are dictated by regulatory requirement, i.e., is the company proactive in using technology to meet safety objectives?

Management Selection and Training

- ❑ Is there a formal management-selection process?
- ❑ Are there well-defined management-selection criteria?
- ❑ Is management selected from inside or outside the company?
- ❑ Is operational background and experience a formal requirement in the selection of management personnel?
- ❑ Are first-line operations managers selected from the most operationally qualified candidates?
- ❑ Do new management personnel receive formal safety indoctrination or training?
- ❑ Is there a well-defined career path for operations managers?
- ❑ Is there a formal process for the annual evaluation of managers?
- ❑ Is the implementation of safety programs a specific management objective considered in the evaluation?

Work Force

- ❑ Have there been recent layoffs by the company?
- ❑ Are a large number of personnel employed on a part-time or contract basis?
- ❑ Does the company have formal rules or policies to manage the use of contract personnel?
- ❑ Is there open communication between employees and management?
- ❑ Is there a formal means of communication among management, the work force and labor unions about safety issues?
- ❑ Is there a high rate of personnel turnover in operations and maintenance?
- ❑ Is the overall experience level of operations and maintenance personnel low or declining?
- ❑ Is the distribution of age or experience level within the company considered in long-term company plans?
- ❑ Are the professional skills of candidates for operations and maintenance positions evaluated formally in an operational environment during the selection process?
- ❑ Are multicultural processes and issues considered during employee selection and training?
- ❑ Is special attention given to safety issues during periods of labor-management disagreements or disputes?
- ❑ Are the safety implications of deteriorating morale considered during the planning and implementation of reduction in work force or other destabilizing actions?
- ❑ Have there been recent major changes in wages or work rules?
- ❑ Does the company have a company-wide employee health maintenance program that includes annual medical examinations?
- ❑ Does the company have an employee-assistance program that includes treatment for drug and alcohol abuse?

Fleet Stability and Standardization

- ❑ Is there a company policy concerning cockpit standardization within the company's fleet?
- ❑ Do pilots/flight-operations personnel participate in fleet-acquisition decisions?

Relationship with the Regulatory Authority

- ❑ Are company safety standards set primarily by the company or by the appropriate regulatory authority?
- ❑ Does the company set higher safety standards than those required by the regulatory authority?
- ❑ Do the company's safety standards meet or exceed U.S. Federal Aviation Regulations (FARs)/European Joint Aviation Requirements (JARs) criteria?
- ❑ Does the company have a constructive, cooperative relationship with the regulatory authority?
- ❑ Has the company been subject to recent safety-enforcement action by the regulatory authority?
- ❑ Does the regulatory authority refuse to recognize the licenses issued by some other countries?
- ❑ Does the company evaluate the licensing requirements of other countries when deciding whether to hire personnel who hold licenses issued by those countries?
- ❑ Does the company consider the differing experience levels and other licensing standards of other countries when reviewing applications for employment?
- ❑ Does the regulatory authority routinely evaluate the company's compliance with required safety standards?

Operations Specifications

- ❑ Does the company have formal flight-operations control, e.g., dispatch or flight following?
- ❑ Does the company have special dispatch requirements for extended twin-engine operations (ETOPS)?
- ❑ Are fuel/route requirements determined by the regulatory authority?
- ❑ If not, what criteria does the company use?
- ❑ Does each crew member get copies of the pertinent operations specifications?

Operations and Maintenance Training

Training and Checking Standards

- ❑ Does the company have written standards for satisfactory performance?
- ❑ Does the company have a defined policy for dealing with unsatisfactory performance?
- ❑ Does the company maintain a statistical database of trainee performance?
- ❑ Is this data base periodically reviewed for trends?
- ❑ Is there a periodic review of training and checking records for quality control?
- ❑ Are check pilots periodically trained and evaluated?
- ❑ Does the company have established criteria for instructor/check-pilot qualification?
- ❑ Does the company provide specialized training for instructors/check pilots?
- ❑ Are identical performance standards applied to captains and first officers?
- ❑ Are training and checking performed by formally organized, independent departments?
- ❑ How effective is the coordination among flight operations, flight training and flight standards?

Operations Training

- ❑ Does the company have a formal program for training and checking instructors?
- ❑ Is there a recurrent training and checking program for instructors?
- ❑ Does the company have required training and checking syllabi?

Does this training include:

- ❑ Line-oriented flight training (LOFT)?
- ❑ Crew resource management (CRM)?
- ❑ Human factors?
- ❑ Wind shear?
- ❑ Hazardous materials?
- ❑ Security?
- ❑ Adverse weather operations?
- ❑ Altitude and terrain awareness?
- ❑ Aircraft performance?
- ❑ Rejected takeoffs?
- ❑ ETOPS?
- ❑ Instrument Landing System (ILS) Category II and Category III approaches?
- ❑ Emergency-procedures training, including pilot/flight attendant interaction?

- ❑ International navigation and operational procedures?
- ❑ Standard International Civil Aviation Organization (ICAO) radio-telephone phraseology?
- ❑ Volcanic-ash avoidance/encounters?

❑ If a ground-proximity warning system (GPWS), traffic-alert and collision avoidance system (TCAS) and other special systems are installed, is specific training provided for their use? Are there clearly established policies for their use?

❑ Are English-language skills evaluated during training and checking?

❑ Is English-language training provided?

❑ At a minimum, are the procedures contained in the manufacturer's aircraft operations manual covered in the training program?

❑ Is initial operating experience (IOE) mandated?

❑ Is first/second officer IOE required to be conducted "in seat" rather than in the observer's seat?

❑ Are there formal means for modification of training programs as a result of incidents, accidents or other relevant operational information?

Training Devices

❑ Are approved simulators available and used for all required training?

❑ Is most of the company's training performed in the simulator?

❑ Do the simulators include GPWS, TCAS, background communications and other advanced features?

❑ Are simulators and/or training devices configuration-controlled?

❑ Has the company established a simulator/training device quality-assurance program to ensure that these devices are maintained to acceptable standards?

❑ Does the regulatory authority formally evaluate and certify simulators?

Flight Attendant Training

❑ Do flight attendants receive comprehensive initial and recurrent safety training?

❑ Does this training include hands-on use of all required emergency and safety equipment?

❑ Is the safety training of flight attendants conducted jointly with pilots?

❑ Does this training establish policies and procedures for communications between cockpit and cabin crew?

❑ Are evacuation mock-up trainers that replicate emergency exits available for flight attendant training?

Maintenance Procedures, Policies and Training

❑ Does the regulatory agency require licensing of all maintenance personnel?

❑ Is formal maintenance training provided by the company for all maintenance personnel? Is such training done on a recurrent basis? How is new equipment introduced?

❑ Does the company have a maintenance quality assurance program?

❑ If contract maintenance is used, is it included in the quality assurance program?

❑ Is hands-on training required for maintenance personnel?

❑ Does the company use a minimum equipment list (MEL)?

❑ Does the company's MEL meet or exceed the master MEL?

❑ Does the company have a formal procedure covering communications between maintenance and flight personnel?

❑ Are "inoperative" placards used to indicate deferred-maintenance items? Is clear guidance provided for operations with deferred-maintenance items?

❑ Are designated individuals responsible for monitoring fleet health?

❑ Does the company have an aging-aircraft maintenance program?

❑ Is there open communication between the maintenance organization and other operational organizations, such as dispatch? How effective is this communication?

❑ Does the company use a formal, scheduled maintenance program?

- ❑ Are policies established for flight and/or maintenance personnel to ground an aircraft for maintenance?
- ❑ Are flight crew members ever pressured to accept an aircraft that they believe must be grounded?
- ❑ Are flight crews authorized to ground an aircraft for maintenance?

Scheduling Practices

- ❑ Are there flight- and duty-time limits for pilots?
- ❑ Are there flight- and duty-time limits for flight attendants?
- ❑ Do the flight- and duty-time limits meet or exceed FARs/JARs requirements?
- ❑ Do flight- and duty-time limits apply regardless of the type of operation, e.g., cargo, passenger, ferry, charter?
- ❑ Does the company train flight crew members to understand fatigue, circadian rhythms and other factors that affect crew performance?
- ❑ Does the company allow napping in the cockpit?
- ❑ Are on-board crew-rest facilities provided or required?
- ❑ Are there minimum standards for the quality of layover rest facilities?
- ❑ Does the company have a system for tracking flight- and duty-time limits?
- ❑ Has the company established minimum crew-rest requirements?
- ❑ Are augmented crews used for long-haul flights?
- ❑ Are circadian rhythms considered in constructing flight crew schedules?
- ❑ Are there duty-time limits and rest requirements for maintenance personnel?

Crew Qualifications

- ❑ Does the company have a system to record and monitor flight crew currency?

  Does the record-keeping system include initial qualification, proficiency checks and recurrent training, special airport qualifications, line-check observations and IOE observations for:

  - ❑ Pilots in command?
  - ❑ Seconds in command?
  - ❑ Flight engineers?
  - ❑ Instructors and check pilots?
  - ❑ Flight attendants?
- ❑ Does the regulatory authority provide qualified oversight of instructor and check-pilot qualification?
- ❑ Are the company simulator instructors line-qualified pilots?
- ❑ Does the company permit multiple-aircraft qualification for line pilots?
- ❑ Do company check pilots have complete authority over line-pilot qualification, without interference from management?
- ❑ If the company operates long-haul flights, does the company have an established policy for pilot currency, including instrument approaches and landings?
- ❑ Does the company have specific requirements for pilot-in-command and second-in-command experience in type for crew scheduling?

Manuals and Procedures

- ❑ Does the company have an airline operations manual?
- ❑ Is the airline operations manual provided to each crew member?
- ❑ Is the airline operations manual periodically updated?

  Does the airline operations manual define:

  - ❑ Minimum numbers of flight crew members?
  - ❑ Pilot and dispatcher responsibilities?
  - ❑ Procedures for exchanging control of the aircraft?
  - ❑ Stabilized-approach criteria?
  - ❑ Hazardous-materials procedures?
  - ❑ Required crew briefings for selected operations, including cockpit and cabin crew members?
  - ❑ Specific predeparture briefings for flights in areas of high terrain or obstacles?
  - ❑ Sterile-cockpit procedures?
  - ❑ Requirements for use of oxygen?
  - ❑ Access to cockpit by nonflight crew members?
  - ❑ Company communications?
  - ❑ Controlled flight into terrain (CFIT)-avoidance procedures?

- ❑ Procedures for operational emergencies, including medical emergencies, and bomb threats?
- ❑ Aircraft deicing procedures?
- ❑ Procedures for handling hijacking and disruptive passengers?
- ❑ Company policy specifying that there will be no negative consequences for go-arounds and diversions when required operationally?
- ❑ The scope of the captain's authority?
- ❑ A procedure for independent verification of key flight-planning and load information?
- ❑ Weather minimums, maximum cross- and tail-wind components?
- ❑ Special minimums for low-time captains?

❑ Are emergency escape routes developed and published for flights in areas of high terrain?

❑ Are all manuals and charts subject to a review and revision schedule?

❑ Does the company have a system for distributing time-critical information to the personnel who need it?

❑ Is there a company manual specifying emergency-response procedures?

❑ Does the company conduct periodic emergency-response drills?

❑ Are airport-facility inspections mandated by the company?

❑ Do airport-facility inspections include reviews of notices to airmen (NOTAMs)? Signage and lighting? Runway condition, such as reverted rubber accumulations, foreign object damage (FOD), etc.? Aircraft rescue and fire fighting (ARFF)? Navigational aids (NAVAIDS)? Fuel quality?

Dispatch, Flight Following and Flight Control

❑ Does initial/recurrent dispatcher training meet or exceed FARs/JARs requirements?

❑ Are operations during periods of reduced ARFF equipment availability covered in the company flight operations manual?

❑ Do dispatchers/flight followers have duty-time limitations?

❑ Are computer-generated flight plans used?

❑ Are ETOPS alternates specified? ♦

[Editorial note: This self-audit is reprinted from Flight Safety Digest*, November 1996.]*

The Dollars and Sense of Risk Management And Airline Safety

Risk management programs are essential tools for airline management to achieve acceptable safety standards while pursuing production objectives.

FSF Icarus Committee

Responsibility for aviation safety begins at the very top of an airline company. History has demonstrated repeatedly that without the complete commitment of the highest management levels within a company, operational safety margins are seriously eroded. This does not suggest that a company *will* have an accident, but it does suggest that the risk of having an accident is high — the laws of probability will prevail.

Management has great leverage in affecting operational safety within a company. Through its attitudes and actions, management influences the attitudes and actions of all others within a company: Management defines the safety culture of an organization. This safety culture extends all the way to the maintenance shop floor, to the ramp, to the cabin and to the cockpit. Furthermore, the public and government authorities are increasingly recognizing management's role in air safety by holding management accountable for a serious incident or accident; this accountability is magnified many-fold if a company suffers several such incidents or accidents during the course of a few years.

The following information is designed to provide insight into the costs, causes and prevention of aviation accidents — to be a practical guide for management, not a theoretical treatise.

Safety Fits into Production Objectives

Accidents and incidents are preventable through effective management; doing so is cost-effective. An airline is formed to achieve practical objectives. Although frequently so stated, safety is not, in fact, the primary objective. The airline's objectives are related to production: transporting passengers or transporting goods and producing profits. Safety fits into the objectives, but in a supporting role: to achieve the production objectives without harm to human life or damage to property.

Management must put safety into perspective, and must make rational decisions about where safety can help meet the objectives of the organization. From an organizational perspective, safety is a method of conserving all forms of resources, including controlling costs. Safety allows the organization to pursue its production objectives without harm to human life or damage to equipment. Safety helps management achieve objectives with the least risk.

Although risk in aviation cannot be eliminated, risk can be controlled successfully through programs to identify and correct safety deficiencies before an accident occurs. Such risk management programs are essential tools for management to achieve acceptable levels of safety while pursuing the production goals of the organization.

The airline has to allocate resources to two distinct but interrelated objectives: the company's primary production goals and safety. In the long term, these are clearly compatible objectives, but because resources are finite, there are on many occasions short-term conflicts of interest. Resources allocated to the pursuit of production objectives could diminish those available for safety and vice versa. When facing this dilemma, it may be tempting to give priority to production management over safety or risk management. Although a perfectly understandable reaction, it is ill-advised and it contributes to further safety deficiencies that, in turn, will have long-term adverse economic consequences.

1. Safety is of major concern to the aviation industry and to the public. When compared with other transportation industries — maritime, rail or road transportation — the aviation industry enjoys a superior safety record. Safety consciousness within the industry and the resources that aviation organizations devote to safety are among the reasons for this record.

Nevertheless, there are continuing concerns about maintaining, and improving, the favorable aviation safety record. The ever-increasing capacity of transport aircraft and the growth of global air traffic justify these concerns. For example, transport aircraft seating 300 to 500 passengers are now common, and plans for larger aircraft are under way; congestion in air traffic at complex hubs is also commonplace.

These are but two examples of what can become a statistician's — and an airline manager's — nightmare considering the potential for economic catastrophe to the industry. Newspaper headlines and extensive television coverage of aircraft accidents will become more sensational and more frequent even if safety levels remain the same. Simply put, as a consequence of growth, accident rates deemed acceptable in the past will be inappropriate in the future.

2. All those involved in aviation operations at every level have some responsibility for the safe outcome of such operations. There are, of course, different levels of human involvement and intervention. The physical proximity of a particular level to operational settings does not have a straight-line relationship with the potential for influencing risk in such operations.

Conventional wisdom allocates safety responsibilities almost exclusively to those at the operational end: flight crews, air traffic controllers, technicians and others.

Safety responsibilities often have been perceived to diminish as one moves away from the cockpit and toward the executive suite. Nevertheless, this notion does not hold true when viewed through the wider lens of systems safety.

Simply put, as a consequence of growth, accident rates deemed acceptable in the past will be inappropriate in the future.

From a top-down perspective, within any aviation organization there are at least four levels of human intervention that can greatly affect the level of risk:

- Senior management;
- Line management;
- Inspectors and quality control personnel; and,
- Operational personnel.

Within any civil aviation system, there are at least four major institutions to which these personnel might report:

- Civil aviation administration;
- Safety/accident investigation agency;
- Operators; and,
- Training, maintenance and other support organizations.

3. Each organizational and institutional level has unique opportunities to contribute to safety within the air transport industry, and overall system safety is determined by the interdependent actions of each. There are decisions that senior management — and only senior management — can take (or refrain from taking) that will directly affect safety. No other level can fully compensate for flaws in these decisions after they are implemented; they can only attempt to minimize the adverse consequences of flawed decisions.

By the same token, there are risky or unsafe decisions by operational personnel over which senior management has little or no direct control. And there are inherent limitations to the effectiveness of safety measures that operators can take when facing, for example, flawed regulations.

These flawed regulations may, in turn, result from the failure of an accident investigation agency to uncover fundamental safety deficiencies underlying accidents. Such deficiencies may be traced to deficient training of the investigators or may be fostered by flawed national legislation.

Actions and decisions within the exclusive domain of each organization can greatly affect the ability of the other organizations to discharge their safety responsibilities. Strong and sometimes complex interactions exist among the decisions and actions taken by various levels within and between air transportation organizations and institutions.

4. Historically, safety activities have focused on the organizational and institutional levels in closest temporal or physical proximity to an accident, i.e., operators and operational personnel. Improving the performance of operational personnel, primarily through high-quality training, has greatly enhanced aviation safety.

The industry, however, has reached a point of diminishing returns from this approach; it has reached the stage where a greater expenditure of resources at the operational end of the system will not result in proportionate safety benefits.

New methods of accident prevention emphasize looking at the total picture and taking into account accident prevention strategies in all industrial activities.

Another objective is to develop a perspective that views safety, or risk management, in the context of the primary production goals of civil aviation organizations. Because risk management activities, and the failure to manage risk, involve the expenditure of resources, it is critical that such a perspective be developed.

How Much Does an Accident Cost?

5. There are two basic categories of accident costs: (1) insured costs, generally including hull losses, property damage and personal liability; and (2) uninsured costs. Insured costs — those covered by paying premiums to insurance companies — can be recovered to a greater or lesser extent. Uninsured costs cannot be recovered, and they may double or triple the insured costs. Typical uninsured tangible and intangible costs of an accident include:

- Insurance deductibles;
- Increased operating costs on remaining equipment;
- Loss of spares or specialized equipment;
- Fines and citations;
- Legal fees resulting;
- Lost time and overtime;
- Increased insurance premiums;
- Cost of the investigation;
- Liability claims in excess of insurance;
- Morale;
- Corporate manslaughter/criminal liability;
- Cost of hiring and training replacements;
- Reaction by crews leading to disruption of schedules;
- Loss of business and damage to reputation;
- Loss of productivity of injured personnel;
- Cost of corrective action;
- Cost of restoration of order;
- Loss of use of equipment; and,
- Cost of rental or lease of replacement equipment.

6. The costs of accidents vary greatly from country to country, and although such costs may be quantified, the monetary value is not always the most critical factor. Some uninsured costs can acquire greater importance than the direct financial effect measured by accounting methods.

The economic and political context largely determines the relative importance of the monetary costs of an accident, as opposed to other factors. In industrialized nations, monetary costs of an accident may be the overriding consideration. In other countries, avoiding damage to the public's confidence in the nation's air transportation system may be a more important consideration. Where airlines are flag carriers, perceived damage to the national image among the international community may be the central consideration. In some situations, the loss of equipment in an accident might disrupt regular international services, a consideration that also might override the monetary costs. The fundamental message is twofold: first, there are economic consequences of aviation safety; second, the costs and benefits of safety cannot be measured only in economic terms.

7. "Unwanted outcomes" other than accidents also incur significant costs for an airline. Maintenance and ramp incidents, for example, present safety issues that can have significant costs, and must be considered as part of a global strategy for safety management. Ramp and ground-handling operations have the potential to cause a major accident, such as through unreported ground-handling damage to aircraft. Costs in maintenance and ramp operations should be a major concern, because aircraft and other equipment are easy to damage and expensive to repair. Indirect costs also include schedule disruption following damage of aircraft or equipment. The ramp and the hangar are also dangerous environments in which to work, given the risk of accidental death or disabling injury. As with flight accident prevention, responsibility for hangar and ramp safety resides at four levels within an organization:

- Senior management;
- Individual supervisors;
- Quality control personnel; and,
- Operational personnel.

Human Errors Occur at Management Level Too

8. Human error is the primary cause for hull losses, fatal accidents and incidents. To devise the appropriate countermeasures, human error must be put into context. Human error in aviation has been almost always associated with operational personnel (pilots, mechanics, controllers, dispatchers, etc.), and measures aimed at containing such error have usually been directed to them. Nevertheless, during the last decade or so, a significant shift toward a substantially different perspective on human error has developed. It has considerable implications in terms of prevention measures and strategies.

9. The aviation system includes numerous safety defenses. Accidents in such a system are usually the result of an unfortunate combination of several enabling factors, each one necessary, but in itself not sufficient, to breach the multiple layers of system defenses. Because of constant technological

progress, equipment failures rarely cause aviation accidents. Likewise, operational personnel errors — although usually the precipitating factors — are seldom root causes of accidents and incidents.

The analysis of recent major accidents both in aviation and in other high-technology industries suggests that it is necessary to look beyond operational personnel errors, into another level of human error: human decision-making failures that occur primarily in managerial sectors.

10. Depending on how immediate their consequences are, human failures can be viewed either as active failures — errors having an immediate adverse effect and generally associated with operational personnel (pilot, controller, technician, etc.) — or latent failures, which are decisions that may not generate visible consequences for a long time.

Latent failures become evident when combined with active failures, technical problems or other adverse conditions, resulting in a break-through of system defenses, thus producing accidents. Latent failures are present in the system well before an accident, and are originated most likely by decision makers and other personnel far removed in time and space from the event. Examples of latent failures include poor equipment design, improper allocation of resources to achieve the declared goals of the organization and defective communications between management and operational personnel. Through their actions or inaction, operational personnel unknowingly create the conditions under which these latent failures become apparent, often with tragic and costly consequences.

Typical latent failures in line management include inadequate operating procedures, poor scheduling and neglect of recognized hazards.

The implication for accident prevention strategies is clear. Safety management will be more successful and cost less if directed at discovering and correcting latent failures rather than at focusing only on the elimination of active failures. While it is vital to minimize them, active failures are only the proverbial tip of the iceberg.

11. Even in the best-run organizations, some important high-level decisions are less than optimum because they are made subject to normal human limitations. Typical latent failures in line management include inadequate operating procedures, poor scheduling and neglect of recognized hazards. Latent failures like these may lead to inadequate work-force skills, inappropriate rules or poor knowledge; or they may result in poor planning or workmanship.

12. Management's appropriate response to latent failures is vital. Response may consist of denial, by which operational personnel involved in accidents are dismissed or otherwise punished and the existence of the underlying latent failures is denied; repair, by which operational personnel are disciplined and equipment modified to prevent recurrence of a specific observed active failure; or reform, by which the problem is acknowledged and global action taken, leading to an in-depth reappraisal and eventual reform of the system as a whole. Only the last response is fully appropriate.

To Err Is Normal

13. Error must be accepted as a normal component of human behavior. Humans, be they pilots, engineers or managers, will from time to time commit errors. Exhortations to "be professional" or to "be more careful" are generally ineffective, because most errors are committed inadvertently by people who are already trying to do their job professionally and carefully. They did not intend to commit the errors.

The solution is to devise procedures and equipment that resist human error. Because technology or training cannot prevent all errors, an equally vital step is to introduce error tolerance into equipment and procedures, so when an error does occur, it is detected and is corrected before there is a catastrophic outcome. Error resistance and error tolerance are important strategies in accident prevention. Of fundamental importance, however, is the recognition that human error must be treated as a symptom, rather than a cause, of accidents and incidents.

14. Psychological factors underlie human error. Often, personnel assigned to tasks do not possess the basic traits or fundamental skills needed to successfully perform them. While formal personnel selection techniques provide some degree of protection, it is impossible to guarantee that all candidates will be able to perform satisfactorily in line operations. The issue is further complicated because proper performance under unsupervised conditions — such as during line operations — rests essentially on proper motivation, and although most professional aviation personnel are highly motivated, other factors can adversely affect such motivation.

Even with these limitations, proper selection techniques constitute an important line of defense. If an organization uses inadequate personnel screening and selection techniques, a latent failure exists within that organization, and may only become manifest through a serious incident or accident.

15. Training deficiencies frequently underlie human error. Training aims at developing basic knowledge and skills required for on-the-job performance; deficient training will obviously foster deficient performance and pave the way for error. Other potential sources of human error include poor ergonomic design of equipment or deficient procedures for using such equipment. Training deficiencies and flawed

operational procedures are latent failures, and thus usually do not have immediate consequences. But, when combined with active failures in operational settings, these latent failures can lead to accidents.

16. Selection, training and equipment design focus on the performance of individuals in the system. Big dividends are obtained by addressing individual performance, but the biggest dividends require a larger frame of reference. Human performance does not take place in a social vacuum, but it is strongly influenced by the environmental, organizational and institutional context in which it occurs. The socioeconomic and legal environment, the way in which the organization is designed and the institutions to which personnel belong, all influence human performance. These are also the breeding grounds for latent failures. From a monetary viewpoint, it makes sense to address latent failures. Canceling one latent failure (for example, training deficiencies) will eliminate multiple active failures, and thereby have a major effect on risk. By focusing on identifying and correcting latent failures, management leverages its ability to control risk.

With the Proper Tools, Human Error Is Manageable

17. The primary message here is that human error is manageable. Error management requires understanding the individual as well as organizational and institutional factors. Human-error accidents, which most accidents are, can then be controlled cost-effectively.

18. Education is an essential prerequisite for effective management of human error. The concepts of accident causation, human error and error management discussed in this brief are the bedrock of such education. Implementing training systems that develop knowledge and skills among operational personnel consistent with organizational objectives, and operational procedures that are compatible with human capabilities and limitations, is fundamental. A quality control system that is oriented toward quality assurance rather than pointing fingers and allocating blame completes the necessary feedback loops to ensure effectiveness of training and procedure development programs.

19. An active management role in safety promotion involves:

Allocation of resources. Management's most obvious contribution to safety is allocating adequate resources to achieve the production objectives of the organization (transporting people, maintaining aircraft, etc.) at acceptable levels of risk.

Safety programs and safety feedback systems. Such programs should include not only flight safety, but also maintenance safety, ramp safety, etc.

Internal feedback and trend monitoring systems. If the only feedback comes from the company's accident statistics, the information arrives too late to be useful for controlling risk, because the events that safety management seeks to eliminate have already occurred. Identification of latent failures provides a much greater opportunity for proactive enhancement of safety.

Incident reporting programs. It has been estimated that for each major accident (involving fatalities), there are as many as 360 incidents that, properly investigated, might have identified an underlying problem in time to prevent the accident. In the past two decades, there has been much favorable experience with nonpunitive incident and hazard reporting programs. Many countries have such systems, including the Aviation Safety Reporting System (ASRS) in the United States and the Confidential Human Factors Incident Reporting Program (CHIRP) in the United Kingdom. In addition to the early identification and correction of operational risks, such programs provide much valuable information for use in safety awareness and training programs.

Besides the national programs, many airlines have found it useful to add their own internal incident reporting systems. These systems can range in complexity and cost from simple and inexpensive telephone "hot lines" to more complex (and usually more cost-effective) systems involving computer databases, trend identification and monitoring programs, and other sophisticated safety management tools. Some of these systems have been made available to the airline community at a modest cost by their developers.

One notable system is the British Airways Safety Information System (BASIS), which allows active tracking of many different kinds of safety-related information. A similar system, "Safety Manager's Tool Kit," is available from the International Air Transport Association (IATA). Systems like these have tended to show a positive short-term economic benefit in addition to improved operational safety.

Standardized operating procedures. Standardized operating procedures (SOPs) have been recognized as a major contribution to flight safety. Procedures are specifications for conducting actions; they specify a progression of steps to help operational personnel perform their tasks in a logical, efficient and, most important, error-resistant way. Procedures must be developed with consideration for the operational environment in which they will be used. Incompatibility of the procedures with the operational environment can lead to the informal adoption of unsafe operating practices by operational personnel. Feedback from operational situations, through observed practices or reports from operational personnel, is essential to guarantee that procedures and the operational environment remain compatible.

Risk management. The purpose of internal feedback and trend monitoring programs is to allow managers to assess the risks involved in the operations and to determine logical approaches to counteract them. There will always be risks in aviation operations. Some risks can be accepted; some — but not all — can be eliminated; and others can be reduced to the point where

they are acceptable. Decisions on risk are managerial; hence the term "risk management."

Risk management decisions follow a logical pattern. The first step is to accurately assess hazards. The second step is to assess the risk involved in such hazards and determine whether the organization is prepared to accept that risk. The crucial points are the will to use all available information and the accuracy of the information about the hazards, because no decision can be better than the information on which it is based. The third step is to find which hazards can be eliminated and proceed to eliminate them. If none of the identified hazards can be eliminated, then the fourth step is to look for the hazards that can be reduced. The objective is to reduce the probability that a particular hazard will occur, or reduce the severity of the effects if it does occur. In some cases, the risk can be reduced by developing means to cope safely with the hazard.

20. In large organizations, such as airlines, the costs associated with loss of human life and physical resources mean that risk management is essential. To produce recommendations that coincide with the objectives of the organization, a systems approach to risk management must be followed. Such an approach, in which all aspects of the organization's objectives and available resources are analyzed, offers the best option for ensuring that recommendations concerning risk management are realistic.

Resources Are Required

21. The safety monitoring and feedback programs should be administered by an independent company safety officer, reporting directly to the highest level of corporate management. The company safety officer and his or her staff must be quality control managers, looking for ways to correct corporate safety deficiencies, rather than pointing fingers at individuals who commit errors.

To discharge their responsibilities for the company and the industry, they need information that may originate through several sources: internal safety audits that identify potential safety hazards, internal incident reporting systems, internal investigations of critical incidents and performance monitoring programs. Armed with information, the safety officer can implement a program for dissemination of safety critical information to all personnel. The stage is then set for a safety-oriented organizational climate.

22. Management attitudes can be translated into concrete actions by the provision of well-equipped, well-maintained and standardized cockpits and other workstations; the careful development and implementation of, and rigid adherence to, SOPs; and a thorough training and checking program that ensures that operational personnel have the requisite skills to operate the aircraft safely. These actions build the foundation on which everything else rests.

Resources Are Available

23. Honest and forthright self-examination is one of the most powerful, and cost-effective, risk-management tools available, and should be performed regularly by all organizations. To help airline managers identify risks and hazards in their organizations, an "Icarus Self-audit Checklist" is in final development and will be available from Flight Safety Foundation in mid-1995. Its questions are designed to identify specific areas of vulnerability and potential latent failures within a company so that appropriate corrective and preventive measures may be taken. Various sections should be completed by the appropriate organizational elements within a company.

24. Flight Safety Foundation is a valuable and affordable risk management resource. In addition to sponsoring a variety of safety workshops, seminars and other meetings, the Foundation also has a group of operations and safety experts available to conduct independent aviation safety audits. These audits are comprehensive and confidential, and are conducted by senior personnel who have direct experience in airline operations and management.

25. Aircraft and equipment manufacturers also can be a valuable resource for risk identification and management. Manufacturers can be particularly helpful in providing guidance for the development of operating procedures, operating manuals, maintenance and personnel training. Often, they can provide experienced operational and maintenance personnel to help carriers operate their equipment safely and efficiently.

26. Many valuable safety publications are available from government and research organizations to assist managers and decision makers in their safety objectives. Some of the most prominent of these sources of information are:

- Accident investigation reports from national authorities;
- FSF reports and publications;
- International Civil Aviation Organization (ICAO);
- International Air Transport Association (IATA) ; and,
- U.S. National Aeronautics and Space Administration (NASA).

No matter what resources are available, they will be of the greatest value in a company that demonstrates that aviation safety begins at the very top of its management.♦

[Editorial note: The preceding article was adapted from a briefing prepared by the FSF Icarus Committee and presented in a workshop in Geneva, Switzerland, in October 1994.]

[Editorial note: This article is reprinted from Flight Safety Digest*, December 1994.]*

Human Factors in Aviation: A Consolidated Approach

FSF Icarus Committee produces 18 findings and 10 recommendations for safety actions.

Jean Pinet and John H. Enders
Founding Co-chairmen, FSF Icarus Committee

The Icarus Committee was created by former Flight Safety Foundation (FSF) Vice Chairman John H. Enders and FSF Board of Governors Member Jean Pinet to explore ways to reduce human factors–related aviation accidents. Although the analysis of human factors in aviation safety was already being pursued in many places in the world, the Foundation believed that it was important to initiate additional action to synthesize what had been learned. The intent was, and is, to augment and enhance — not to replace — the Foundation's core activities, by posing questions and suggesting actions to the board and, through the governors, to the worldwide aviation community.

Despite the increasing general level of understanding of accidents and their causes, the emergence of new technologies for aircraft design, the development of training methods and equipment, and the growing ability to analyze human behavior and decision-making factors, aviation accidents and serious incidents continue to occur. They include events that were the direct result of decisions and actions of well-trained and highly experienced pilots, although these decisions and actions may have been enabled by other human decisions within the system. The fact that the accident and incident rate has not declined proportionately to the advances in technique that the industry is making on many levels, is the problem that the FSF Icarus Committee was formed to address.

The FSF Icarus Committee has received support from major aircraft and equipment manufacturers, airlines, research organizations and regulatory agencies worldwide.

The committee comprises a small, informal group of recognized international experts in aviation who have extensive experience in the human aspects of design, manufacturing, flight operations, maintenance, operating environments and research. These individuals represent a cross-section of current human-factors thinking in the international aviation community. While some of the world's regions are not directly represented, members of the committee are generally familiar with the many industrial, educational and social cultures that intersect aviation operations worldwide.

One international aviation leader recently applauded the committee's efforts as a "small group of wise people" addressing questions that are very important to the aviation community and its customers. He urged the committee to keep itself "lean" in numbers so as not to lose the ability to cut quickly to the cores of issues.

Achieving this required a team limited in number, but representative of all the players in the field. The challenge was to keep the group small enough to enable vigorous and candid debate, yet broad enough to bring as many viewpoints as possible into the discussions. Additional participants with special expertise are routinely invited to join the core committee to augment specific discussions.

The name Icarus was chosen for its symbolic value. [In Greek mythology, Icarus, who flew with wings made by his father, Daedalus, was such a "bold pilot" that he ventured too near the sun. The wax in Icarus' wings melted, plunging him into the sea.] Icarus was the first to suffer an "accident" because of his incorrect behavior, ignorance of the operational environment and design deficiencies, thus giving the FSF Icarus Committee a perfect counterexample and a reminder of its objectives.

Although the committee has gathered together competitors and potentially oppositional bodies, the respected rule for its deliberations has been to speak with the greatest objectivity

Flight Safety Foundation Icarus Committee

(Members as of December 1994)

Capt. Claude Bechet
Flight Safety Advisor
Avions De Transport Regional (ATR)

Capt. James Duncan
Vice President–Technical Training
Airbus Service Co.

Capt. Chet Ekstrand
Director, Flight Crew Operations
Boeing Commercial Aircraft Group

John H. Enders (Co-chairman, Icarus)
President
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H. Clayton Foushee, Ph.D.
Vice President–Flight Operations
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Robert T. Francis
FAA Representative–Paris
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Yoshi Funatsu (Hon. Dr.)
Senior Advisor, Safety Promotion Committee
All Nippon Airways

Capt. Hugues Gendre
President
Syndicat National des Pilotes de Ligne

Capt. Urpo Koskela
Chief Pilot (retired)
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John K. Lauber, Ph.D.
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David Sheehan
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Capt. Robert Sumwalt
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Ray Valeika
Vice President–Technical Operations
Delta Air Lines

Robert Vandel
Director of Technical Projects
Flight Safety Foundation

and openness. This makes its meetings extremely productive. The neutral context of the Foundation facilitates the committee's work.

Icarus Discussion Results In 18 Findings

In 1992, the first FSF Icarus Committee meeting addressed the basic question of "Why do experienced and well-trained aircrews sometimes act against their experience and training and have accidents?" The members were urged to range broadly in their thinking and discussion. This provoked a wide spectrum of thinking about enabling factors, latent factors and what lies behind mistaken actions. ["The Dollars and Sense of Risk Management and Airline Safety" (page 9) includes some of the ideas that emerged.]

The meeting resulted in 18 findings, some of which may seem obvious, but they present a thought-provoking picture of aviation operations today. Taken as a whole, the findings provide a means of focusing finite resources on those problems whose solution will result in the greatest savings of life and property.

1. Cockpit behavior is the product of many factors.

Individual and group behavior of crewmembers forms the "tone" of cockpit operations. Crew coordination, communication (intracockpit as well as external), and decision making all flow from the degree of harmony that exists in the cockpit. Crew often bring into the cockpit extraneous matters that can be distracting to themselves and others. The operating philosophy of the organization, whether it is an airline or corporate operator, affects attitudes that prevail in the cockpit. Personal factors often intrude. Personality clashes may not be manageable by some individuals. The availability of critical information (e.g., airplane condition, air traffic control [ATC], weather, and air and ground communications efficacy) can affect the functioning of the crew. The degree of self-discipline and procedural discipline affects the overall cockpit environment and, in turn, determines the level of risk at which the flight crew operates.

These and many other factors, and their potential effect on sound and timely decision making, must be taken into account by management at the organizational and operational levels.

2. Sound aircrew decisions need support and encouragement that the system does not always provide.

The organizational and infrastructure system must give the aircrew sufficient training, direction, information and assistance during critical situations to maximize the integrity of crew decisions. Any failure to do so erodes the safety margin and increases risk, not only to the airplane and its occupants, but to the system and its components. Such support entails, among other things, consistent organizational behavior; ample training

for the particular operation undertaken and the equipment to be used; an understanding of shortcomings of the infrastructure so that alternatives may be provided; and reliable weather and facility information. Each of these support factors, and others, are missing in one situation or another, and crews often have to devise last-minute strategies to work around them in dealing with a potentially troublesome situation.

3. Management commitment is vital to support changes in corporate culture.

Much is said about the corporate culture, by which is meant the way in which an organization deals with its day-to-day challenges and strategic initiatives. The current move toward changing the corporate culture to provide a lower risk for those in its care, and in the organization itself, is threatened by managements that fail to actively commit themselves to effective support and productive changes.

A healthy attitude toward safety among employees cannot be achieved unless the organization's leadership is visibly committed and seen to be engaged in risk management. In the words of current management gurus: "Walk like you talk."

4. Operational directives should be realistic and should be supported by consistent management attitudes and behavior.

It is surprising to find many organizations where operational directives are frequently unrealistic and inconsistent. Just as bad laws do not inspire compliance, neither do management attitudes, decisions and behavior that undercut the foundation of a professional, efficient and low-risk operation. Although many of these shortcomings may be caused by carelessness, rather than intent, the effect is the same. Morale suffers, and if not remedied, these situations may put at high risk the flight operation and the continued viability of the organization itself.

5. Peer influence is of great importance in maintaining safe practices.

Social and organizational behavior is greatly influenced by the peer group, as has been demonstrated repeatedly. The aviation operation is influenced heavily by peer behavior, whether a crew tries to outperform a rival company's attempts to land in risky conditions, or an individual overcomes a personal weakness with the support of colleagues. Peer influence has been responsible for fatal accidents and for raising the professional standards of a company's crewmembers. Peer influence is a powerful tool, and should be encouraged to support professional behavior and sound decision making.

6. Professional standards must be given high priority by pilot associations and groups. They have significant opportunity to affect pilot behavior and performance.

This is a corollary to Finding 5. Pilot associations exert strong peer influence, over their members and over other elements in the organization. The professional standards committees, found in many pilots' associations and unions, can be a powerful tool to ensure that operational risk is minimized. The lack of an identifiable professional standards entity within an organization correlates strongly with the perception of higher-risk operations. To be effective, however, the fostering of professional standards must avoid petty organizational politics.

7. The root causes of errors may remain dormant for a long time and only may become evident when triggered by active failures, technical problems or adverse system conditions.

Systems safety analysis often reveals the presence of factors, distant in time or place from the accident/incident event, that "set up" the operator (aircrew, industrial plant operator, ground transportation vehicle, etc.) for the failure. This is the "accident chain of events" that links the initial event to later events that eventually reach the pilot.

Training can overcome most of these situations; however, everyone in the system must find and eliminate such latent problems. This is the foundation of the quality movement, and organizations that effectively apply this approach lower risk to life and property.

8. Crew resource management is an embedded operational behavior. It should be introduced at the earliest (ab initio) stage of a pilot's education and then integrated into the routine of training throughout the pilot's career.

Experience with crew resource management (CRM) has demonstrated its value in reducing operational risk, when properly taught and applied. Some cultural factors may require special adaptation of CRM techniques, but overall, the use of all resources to operate with high safety levels is the desired goal.

The early assimilation of CRM philosophy into a pilot's behavior and subsequent reinforcement through recurrent training effectively counteracts the carelessness and complacency that are part of the human condition.

9. Firm operational directives are necessary to ensure that modern high-technology cockpit features and options are used effectively.

Modern transport and business aircraft employ technologies that have drastically altered the cockpit environment. Notable among the changes is the increase in modes available to the pilot to control the airplane, either directly or through automation. Some of these modes may be more appropriate to a particular operational scenario than others, and the organization should provide unambiguous directives governing the use of the operationally desired features. Lacking this, the aircrews are subject to nonstandard operations that might create additional and subtle opportunities for error.

10. New aircraft technologies surpass the capabilities of the present ATC system. This situation promotes potential cockpit work-load conflicts.

The ability to precisely navigate with modern aircraft equipment and systems gives to the crew capabilities that cannot be used effectively with the present ATC system. Conforming to ATC capabilities, the crew cannot take advantage of the workload-reducing features of the aircraft and its systems.

11. Continued effort and research is necessary to ensure flight crew vigilance and alertness on long-range flights and extended duty time.

The U.S. National Aeronautics and Space Administration's (NASA's) leadership role in fatigue research has yielded new understanding of fatigue during long-range transmeridional flights that can make possible more rational decisions in balancing extended duty times with crew fitness for duty. The prospect for additional value from continued research in this area argues against any lessening of effort. Continuing this research can yield cockpit design, layout and fixtures that promote efficient and low-risk human duty cycles.

12. While total flight time is an important determinant of experience for pilots, the quality of past experience must be considered too.

Experience has traditionally been measured by total flight time, time in type, etc. It is also evident that large amounts of hours are not necessarily an accurate indicator of experience. The *type* of experience in accumulating a given number of hours may be more indicative of a pilot's experience level, and should be considered during selection and evaluation.

13. There is a need for professional flight operations management, recognized as a career path with appropriate focused training.

Individuals promoted to management responsibilities should be given the appropriate training, especially when coming from a cockpit position. Establishing a career path for professional flight operations management signals the intent of the organization to provide the individual with the tools that will be needed to deal with the very different world of managing a flight operation instead of flying in it. This practice adds to the efficiency of the organization's operations and minimizes risk of errors that could result in loss of life and property.

14. As aircraft technology becomes more sophisticated, more "disciplined" training is needed to ensure that technical and human-factors needs are met.

Technological advances in aircraft and systems designs promise greater efficiency and reliability. Training operators and maintenance technicians at a level of sophistication commensurate with the technologies introduced is essential. Training is the beneficiary of new technologies that provide alternative means of transferring information in ways that are more easily learned. Ensuring that the level of human performance is linked to the systems' capabilities is essential to achieving the promised efficiencies and reduced risk.

15. The financial health of a corporation is related not only to the direct cost of potential accidents, but also to the public's perception of its commitment to safety.

The financial well-being of an organization affects its ability to conduct operations in a way that meets the industry standard for level of risk. Public perception of a carrier's safety levels affects its ridership and profits. Accident potentials are affected not only by financial problems, but also by managements that are not committed to an operating philosophy that values minimization of accident risk.

16. Safety initiatives will continue to be challenged until their benefits can be determined in financial terms.

New technologies, new procedures, new equipment, additional training, etc., all of which have the potential for improving safety levels, have a cost that will be evaluated against the financial benefit of safety. Managing risk appears to be a more feasible and quantitative approach to this problem, and may offer a means of evaluating the true safety benefits of a particular initiative.

17. Attention should be given to desired attributes and characteristics of pilots, enabling improved preparation for such careers and improved screening of candidates.

Traditional criteria for screening and selecting pilots may not meet future aviation requirements. These criteria should be examined carefully to ascertain what new capabilities exist for evaluating the future performance of candidates for aviation piloting careers and to define new criteria that may or may not include those of today.

18. Language communication difficulties are an important contributor to stress and should be dealt with in preparing pilots for flight-related duties. Some problem areas are: English ATC for those to whom English is not a native language; differing English accents used by ATC in different geographical areas (even within countries); and flight crews comprising individuals with differing language abilities.

Effective communication has been a topic of discussion for many years. With the increasing globalization of air carriers and corporate operators, and with the increased hiring of crew members whose native language may not be that of the employing organization, the potential for misunderstanding and miscommunication is great. In addition, some ATC controllers' lack of fluency in English contributes to the communications barrier. Although pilots and controllers can function effectively in standard phraseology, they may not be able to communicate effectively in an emergency. The problem

ranges from difficulty in understanding heavily accented English to a total lack of comprehension. While evidence of accidents and serious incidents caused by language difficulties is elusive, the heavy dependence of the system on the quick and efficient voice transfer of information is at greater risk if this information is miscommunicated, misunderstood or not transmitted at all.

Findings Lead to Recommendations for Action

The FSF Icarus Committee converted the substance of these findings into 10 recommendations for action by such groups as the Foundation, International Civil Aviation Organization (ICAO), International Federation of Air Line Pilots Associations (IFALPA), industry, governments and academia.

Recommendation 1

The Foundation should provide to top management briefings on safety issues and recommendations. Topics would include the:

- Support and encouragement for sound aircrew decisions;
- Importance of visible management commitment to safety and to support operational and technical management;
- Need for professional flight operations/maintenance management training as distinct career paths;
- Encouragement of peer influence on safety attitudes;
- Awareness of latent failures in the system, coupled with their financial risk to the company;
- Necessity for firm operational directives to ensure effective use of modern high-technology cockpit features and options. Manufacturers should encourage operators in this regard; and,
- Need to couple aircraft technologies with disciplined training to bridge human-machine interfaces.

These briefings should be in two forms:

- Traveling "road shows" with small teams of respected experts (no more than two per team) to convey safety concerns to operators' top managements, worldwide, especially to smaller operators (commuter/regional) and operators in less developed countries; and,
- Short, concise (one page or less) written communications sent to top managements, calling attention to one or two safety issues and FSF's recommendations, based on aviation community expertise. Written communications should be simple and frequent, rather than complex and lengthy, to encourage reading and assimilation by busy CEOs and top management.

Recommendation 2

The study by L.G. Lautman and P.L. Gallimore ("Control of Crew-caused Accidents," in *Proceedings of the 40th Annual International Air Safety Seminar*, Flight Safety Foundation, Arlington, Virginia, U.S., 1987, p. 81) should be updated. Although it originally covered customers of only one manufacturer, the update should include all manufacturers' customers.

Recommendation 3

The Foundation should press countries to provide legal protection of identities in flight operational quality assurance (FOQA) programs to encourage nonpunitive discussions of incidents and to promote the use of FOQA programs among worldwide operators.

Recommendation 4

Prepare and distribute to the aviation community a "yes-no" self-audit questionnaire that will indicate to the user the presence of latent factors that present an unsafe situation for the air carrier (including commuter/regional and corporate operators).

Recommendation 5

Universities and research organizations should continue to promote safety among educators to facilitate assimilation of safety philosophies by their students, who will take their own places in the operational world. Regulatory authorities and manufacturers should encourage embedding crew resource management (CRM) into training programs in accordance with ICAO (Annex I) to achieve more standardization and to address cultural aspects of CRM implementation.

Recommendation 6

Airlines operating advanced technology aircraft should minimize crew confusion by selecting the automation options and methods best suited to their own operations, and training for those options/methods as *preferred* methods. Line flight crews should be involved in the selection of the preferred methods. Command pilots should be permitted to deviate, but only with appropriate briefings to their crews on the reasons for the deviations. Furthermore, authorities should require appropriate principal operations inspector (POI) training with regard to evaluating crews on preferred options.

Recommendation 7

Airlines should improve their air traffic controller familiarization programs. Authorities of all countries should ensure that their controllers are included in flight familiarization programs.

Recommendation 8

Industry and government research should address the problem of crew fatigue, including *quality* of rest at home and at en route overnight stops, to ensure fitness for duty.

Recommendation 9

Operators should attend to the problem of mixed-language flight crews who do not have sufficient language proficiency to deal effectively with nonstandard situations. Managements and pilot associations should evolve a creditable management framework (communications, "bottom-driven" program) to deal with this issue.

Recommendation 10

The principal character profiles and the methods used to determine the current entry-level pilot requirements of major worldwide airlines and corporate operations should be validated. This validation should include consultation with *ab initio* schools and universities to evaluate the selection processes that lead to producing a professional airline or corporate pilot. Work is well underway on Recommendations l and 4. [The first of the briefings to top management on issues outlined in Recommendation #1 is the article: "The Dollars and Sense of Risk Management and Airline Safety." (page 9)]

The remaining recommendations have been assigned to working groups that will present action plans and time lines at the next FSF Icarus Committee meeting.

As the committee continues to work toward realizing its recommendations, it will consider other safety issues and recommend actions. The committee will continue to involve the expertise of the international aviation community in its deliberations.♦

[Editorial note: The preceding material was adapted from information presented by John H. Enders and Jean Pinet at an FSF Icarus Committee workshop held in Geneva, Switzerland, in October 1994.]

[Editorial note: This article is reprinted from Flight Safety Digest*, December 1994.]*

Managing for SAFETY

Flight Safety Foundation

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT

SEPTEMBER 1997 NO. 1

The Dollars and Sense of Risk Management and Aviation Safety

Statistics demonstrate that human error is the primary cause for the majority of aviation accidents and incidents. Does this mean that the only solution is to insist, with ever-increasing urgency, that those involved in aviation must be more careful, or demand that they be error-free? No.

"To err is human." Error must be accepted as a normal component of any system where humans and technology closely interact. (Aviation is an excellent example of such a system.) Because error cannot be eliminated, effective measures must be employed to minimize its effects on aviation safety.

Error Management

While not altogether avoidable, human errors are *manageable*. One method to contain or manage human errors includes improved technology, relevant training and appropriate regulations. This method is typically directed towards improving the performance of the front-line personnel, such as pilots, maintenance technicians, ramp crews and air traffic controllers. We must understand, however, that the performance of these personnel can be strongly influenced by organizational, regulatory and cultural factors affecting the workplace.

Because errors are unavoidable, another method of dealing with them is to minimize their effects. This method focuses on correcting the organizational processes that constitute the breeding grounds of human errors: inadequate communications, unclear policies and procedures, unsatisfactory planning, insufficient resources, unrealistic budgeting and any other process that an organization can control.

A combination of both of these error management strategies will increase system tolerance to errors and will help make errors evident before they can cause damage.

Safety Management

"Safety" is an abstraction, and in a sense a negative one — the absence of accidents and incidents — which makes safety difficult to visualize. Hazards and risks are usually easier to identify and to visualize, making them easier to address by practical measures. How many risks can be accepted and how many can be eliminated will depend on available resources. Identification of hazards and allocation of resources to minimize their associated risks is a managerial process — *safety management*.

Resources

Error management and safety management are the elements on which an aviation organization's integrity is built. The very top-level management of a company *must* take an active role in providing the organization with the resources to manage errors and safety. Some of these resources are listed below (and will be the subject of future briefings).

- **An independent company safety officer.** He or she should report directly to the highest level of management. The safety officer is a quality-control manager, acting on information obtained through internal feedback, trend monitoring and incident-reporting systems. He identifies *corporate safety deficiencies* (rather than individual human errors), and provides top-level management with the necessary information to take decisions in managing risks.
- **An internal confidential incident-reporting system.** Such a system favors active risk management, which can prosper only within a corporate atmosphere where personnel are not fearful of being admonished for reporting errors that might have led to incidents or accidents. Estimates cite that there are more than 300 incidents for every accident of the same type.
- **A formal internal feedback and trend-monitoring system.** This system anticipates failures and errors, and obtains early information that can be useful in controlling risks.
- **A formal risk-management structure.** Risks are inherent to aviation. Some risks can be accepted, some can be eliminated, others can be reduced to where they become acceptable, and some risks must be avoided. Risks can be managed.

Experience has proven these to be particularly effective resources in successful safety management, although other resources can be useful in achieving safe operations. To err is human … but errors, and safety, are manageable.♦

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Managing for SAFETY

Flight Safety Foundation

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT NOVEMBER 1997 NO. 2

The Airline Safety Department: A Solid Foundation for Confidence

How safe is your airline? You have taken steps to achieve safety. You believe that your operations are safe. But unless your company has a *safety department*, your belief may be ill-founded. The company safety department performs a self-monitoring function that ensures that there is a solid foundation for confidence — that the airline's operations *are* safe.

Safety specialists agree that for an airline to accurately determine its safety quotient, a well-functioning safety department is a necessity. More than that, the department must be given a large measure of independence and command the attention of the company's top executives.

Begin the safety commitment at the top. Every airline should have a formal statement of its company safety policy. This helps create a "company safety culture" by sending the message that every person in the company is expected to make a commitment to safety, beginning with the highest levels of management. If top management takes safety seriously, the rank-and-file will be more likely to do the same.

Put the safety department behind a firewall. The safety function should be independent of the operations, marketing and other cost-driven departments. The head of the airline's safety department should report directly to the CEO or another top manager. This will ensure that decision-makers receive information about safety issues that is not compromised by operational or administrative concerns. This top-level reporting structure will also ensure that genuine attention is given to safety issues by those ultimately accountable for the safety and the reputation of the airline.

Establish system redundancy. The key to any safety program is redundancy. It is neither reasonable nor realistic to assume that every person within the company will perform day-to-day safety responsibilities without some oversight. The safety department must monitor the operations, maintenance and training functions within the airline to ensure that safety is a top priority. When deficiencies are noted, the emphasis should be on correcting the problem, not on assigning blame.

Maintain effective communications. Communicate safety information to the entire workforce, in as many ways possible (for example, through safety reports, newsletters and employee meetings). Identification of problems is meaningless unless employees know about them. Moreover, dissemination of positive safety news can reinforce the "emphasis-on-safety" message that top management has created to enable safety-conscious employees to know that their efforts are successful.

Use incident data and employee feedback effectively. Many airlines have found that an internal confidential incident-reporting system sheds light on "latent" or hidden safety problems. Without a proactive incident-reporting system, these latent problems can go undetected until they contribute to an incident or an accident.

For such a system to be effective, management must make clear to employees that reported information will be used only in a constructive and nonpunitive way. Additionally, establishing an internal database of incident and accident data can provide a basis for avoiding similar events in the future and can be enormously useful in spotting safety-related trends. Programs can be administered as "in-house" systems or on a larger scale. A good example of one such successful program is the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS). Since its beginning in 1976, the NASA ASRS has been credited with clarifying many problems, which led to their resolution.

Give the safety department an essential tool: a flight operations quality assurance (FOQA) program. A proactive approach to safety should include a FOQA, or digital flight data recorder (DFDR)–monitoring, program. Such programs, which have long been in use by some European airlines and which have recently been endorsed by U.S. Federal Aviation Administration Administrator Jane Garvey, can provide the airline safety department with a crucial early warning of potential trouble areas. With such a program, the safety department has an objective, quantitative basis for action that cannot be dismissed as speculation or worrying about extremely unlikely events. And management, which is accustomed to making decisions based on specific information, can understand the rationale behind safety-department initiatives.♦

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Managing for SAFETY

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT

Flight Safety Foundation

JANUARY 1998 NO. 3

An In-house Incident-reporting Program: Overcoming Dormant Factors That Can Contribute to Accidents

Incidents are not accidents — so why collect data about your airline's incidents?

The lack of accidents does not accurately indicate safety within a complex system such as an airline. Policies, procedures and practices sometimes introduce unforeseen hazards into the airline operations system. If these hazards remain undetected and thus uncorrected, they might eventually interact with other conditions, leading to an accident.

Such undetected hazards are called latent, or "dormant" (from the Latin word for "sleeping"), factors. While they are dormant — which can be for a long period — the dormant factors do not result in an accident because "front-line operators" such as pilots, mechanics and air traffic controllers often employ last-minute, compensatory defenses, such as deviating from standard operating procedures.

These improvised defensive measures, based on each person's experiences and skills, may repeatedly overcome the accident potential. But if the dormant factors are not identified, then the problems in the system will persist. Sooner or later, the compensatory-defense mechanism will not work for some reason, and the dormant factor will awaken — hungrily.

Dormant factors' origins are often far removed in space and time from the incidents that reveal them. Examples of dormant factors include poor equipment design, management miscalculations, ambiguously written procedures and inadequate communication between management and line personnel.

Dormant factors are often introduced, unknowingly, with the best intentions. Line management can generate such dormant factors by issuing operating procedures that might be desirable in theory but do not function under "real-world" conditions. Besides incorrect action, inaction — for example, tolerance of conditions that are only marginally safe — can create dormant factors.

A properly managed in-house incident-reporting program can help identify many of these deficiencies. By collecting, aggregating and then analyzing incident reports, safety managers can better understand the specific problems encountered during line operations. Armed with this knowledge, they can create basic solutions instead of short-term fixes that only hide the real problems.

Management must take responsibility for uncovering and correcting dormant factors. The wrong response is denial — often signified by criticizing or punishing operational personnel involved in incidents while ignoring the underlying system failures. Better, but still not fully responsive, is repair, in which operational personnel are disciplined and equipment or procedures are modified to prevent recurrence of a specific problem. But the best preventive measure is reform, in which the problem is acknowledged, the system is reappraised in depth and the system as a whole is revised to eliminate the dormant factors as much as possible.

Costs are low. Benefits are high. An incident-reporting program can be implemented and maintained at relatively low cost using commercially available computer programs that can be run on desktop computers. Although the greatest benefit will be improving the safety of your airline, an incident-reporting program can provide measurable financial benefits, too.

For example, one airline required that all of its pilots' "go-arounds" be reported through the airline's incident-reporting program. As a result, a trend became evident: At one airport a disproportionate number of go-arounds was occurring. Investigators learned that the airline had recently begun exclusively using at that airport an aircraft type that could not descend as quickly as aircraft previously used on that route. Discussions with air traffic control management highlighted the problem. Airspace was redesigned so that descents could begin earlier. Not only did the airline eliminate the hazard of frequent unstabilized approaches, but there was also a reduction in costly go-arounds.

Confidentiality and immunity are essential. Before employees will freely report incidents, they must receive a commitment from top management that reported information will remain confidential and will not be used punitively against employees. The success of an in-house incident-reporting program depends largely on this management commitment.

Take an important step to further ensure that your airline's safety envelope remains intact — implement an incident-reporting system, or "fine-tune" the current one.♦

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Managing for SAFETY

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT

Flight Safety Foundation

MARCH 1998 NO. 4

Protect Employees Who Identify Safety Issues

Knowledge Is Power

"All men by nature desire knowledge," wrote Aristotle some 2,300 years ago. Today, mankind continues to seek knowledge. In an airline operation, knowledge enables strategies to enhance the airline's profitability, competitiveness, safety and ultimately, success. But, as the saying goes, "You don't know what you don't know." Although not as profound as Aristotle's words, that statement has its own wisdom: You may believe that you are aware of everything concerning your airline, but how can you be certain?

For expanding management's knowledge of safety issues, an airline has dozens, perhaps hundreds or thousands, of knowledge resources — employees. Employees are the "eyes and ears" of the airline. Like the sensor probes located strategically in an aircraft engine, employees are located throughout the airline, available to signal the system's strengths and weaknesses. These resources are available to management at no additional financial cost; the majority of employees would be willing — even eager — to report their observations and information about safety.

Nevertheless, reporters must be free from apprehension that they will suffer personally as a consequence of their reports.

A climate must be established to encourage employees to participate in expanding the knowledge base; employees need senior management's assurance that (1) they will not be disciplined, ridiculed or otherwise punished when they report information, and (2) the identities of the reporter and anyone involved in a safety-related event will remain confidential.

Nonreprisal Policy Required

Conveying this message to employees is best handled in a written "nonreprisal policy" statement signed by the top-level officer(s) in the company, such as the CEO and president. If employees are unionized, union representatives should be involved in drafting the statement. The following is the statement of one large international airline; but the words could be adapted to fit almost any air carrier:

> The airline is committed to the safest flight operation possible. Therefore, it is imperative that we have uninhibited reporting of all incidents and occurrences that in any way affect the safety of our operations.
>
> It is each employee's responsibility to communicate any information that may affect the integrity of flight safety. To promote a timely, uninhibited flow of information, this communication must be free of reprisal.
>
> The airline will not initiate disciplinary proceedings against an employee who discloses an incident or occurrence involving flight safety.
>
> The airline has developed a format for reporting incidents, whether in the air, on the ground or related to cabin safety, that protects to the extent permissible by law the identity of the employee who provided the information.
>
> We urge all employees to use this program to help the airline be a leader in providing our customers and our employees with the highest level of flight safety in our industry.

Actions Must Support Words

A written non-reprisal policy is important, but some employees will continue to be apprehensive until management *demonstrates* its commitment to adhere to the policy.♦

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Managing for SAFETY

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT

Flight Safety Foundation

MAY 1998 NO. 5

Safety — Costs Avoided and Benefits Gained

A strong safety program aims to prevent accidents and incidents that can cause loss of life and property, and serious injuries. The human losses in an airline accident are traumatic for surviving families and friends. But in addition to its moral duty to prevent accidental death, injury and suffering, the senior management of an airline is charged to protect the company's financial "bottom line." So questioning the cost/benefit ratio associated with implementing a new or strengthened safety program is reasonable and responsible.

There is a paradox, however, when trying to measure the benefits of a safety program: If the program is effective, there are few incidents and accidents. So, how does the company assign a cost savings to the incidents and accidents that did not occur?

Poor safety performance equals poor financial performance. The consequences that some airlines have suffered following highly publicized accidents leave no doubt that safety can strongly affect an airline's position in the marketplace. These unwelcome events can damage an airline's reputation, financial health and employee morale.

A few years ago, a major international airline suffered several fatal accidents; two of the accidents occurred within a 90-day period. Government, media and public scrutiny of the airline's management of safety increased, and for the three-month period immediately following the two accidents, the airline's revenues dropped by US$150 million; the public's perception that the airline was unsafe had frightened away customers.

Another fatal accident involved a highly profitable, low-fare airline. Following the accident, questions surfaced about a variety of safety issues; within weeks of the accident, the civil aviation authority grounded the airline's fleet amid public examination of the airline's safety practices. After an intensive review, which resulted in changes and improvements within the airline — and the industry — regulators found the airline fit to fly. Nevertheless, when the airline resumed service some three months later, its stock price had plummeted and its fleet was operating well below capacity.

"Poor safety performance equals poor financial performance" leaves little room for argument. Moreover, the industry at-large — airframe manufacturers, engine manufacturers, unions, insurers, regulators and the airlines — can pay a price too. The public can demand that government impose sweeping new regulations that would offer a *perceived*, but not necessarily an actual, improvement in safety, while resulting in *real* increases in costs and complexities for everyone. Thus, valuable resources could be diverted from where they could have the most positive influence on real safety.

Safety is a competitive advantage. A highly successful international airline recently conducted a survey of its customers. The survey showed that about 25 percent of the respondents chose the airline over its competition because of convenient flight schedules; another 25 percent preferred its generous frequent-flyer program. But the most significant finding was that about 50 percent selected the airline because of its excellent safety record. Safety is a competitive advantage that improves the airline's financial performance and stock values.

Safety is free. Implementation of a successful safety program costs money, but tremendous financial benefits often are the result of an airline functioning at peak safety levels. An effective safety program, for example, can lower workers' compensation expenses and aircraft-insurance premiums.

Costs avoided through safety programs are on one side; *benefits gained* are on the other side.

The CEO of a large, successful and safety-minded helicopter service openly states that safety increases the company's financial bottom line. For every dollar invested in its safety program, the company calculated that it receives eight dollars to nine dollars in savings. And because the safety program is credited with saving the company millions of dollars, the CEO says, "Safety is free, because the benefits are greater than the costs."♦

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Managing for SAFETY

Flight Safety Foundation

ICARUS COMMITTEE BRIEFING

A BRIEFING FOR AIRLINE SENIOR MANAGEMENT

JULY 1998 NO. 6

FOQA — Possibly the Best Safety Tool of the 21st Century

The U.S. Federal Aviation Administration (FAA) has said that an effectively managed flight operations quality assurance (FOQA) program can provide the highest possible level of safety management, and is potentially the best safety tool of the 21st century.

FOQA programs obtain and analyze data recorded in flight. Their objectives are to improve flight-crew performance, air-carrier training programs and operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design. During the past two decades, many non-U.S. airlines have used this technology to identify baseline criteria for everyday operations and to identify and correct adverse trends.

Flight Safety Foundation, under contract to the FAA, published in 1993 — based on the experiences of FSF's international membership — the first major study to call for the implementation of FOQA in the United States.

Early flight-data recorders (FDRs) installed on airliners recorded only a few basic parameters by etching data onto a metal foil. In contrast, today's digital flight-data recorders (DFDRs) capture hundreds of parameters each millisecond.

Originally, FDR data were used for accident investigation. But FOQA programs involve converting digitally recorded flight data into accident-preventive safety information. First, the programs identify and count unwanted events — for example, approach speeds too fast at specified altitudes or vertical acceleration at landing too high. Second, and equally important, FOQA promotes trend analysis, knowledge building and decision making.

Used this way, the DFDR is an effective tool, especially if the data are combined with a confidential, nonpunitive incident-reporting system where pilots report less serious problems and incidents.

If you can't measure it, you don't know about it. If you don't know about it, you can't fix it. The heartbeat of an airline is the day-to-day line operations. FOQA allows operators to "feel the pulse" of line operations. Data can be downloaded and analyzed periodically, such as each night or every several days. With this stream of information, operators are positioned to make decisions based on data, not on speculation or hunches.

The data provided by a FOQA program help operators to evaluate the safety of flight operations. They help identify operational problems specific to airports used by that carrier or to the aircraft in its fleet. FOQA can become an essential ingredient in optimizing air-carrier training procedures and serve as a performance-measurement tool for company risk-management programs and for assessing training effectiveness.

Data support improvements. FOQA programs now under way in the United States have already had successes. One air carrier noticed an excessive number of unstabilized approaches at a hub airport. Pilots had often complained of air traffic control (ATC) problems at the airport, but the air carrier had no way of determining specific details of the problem and how it could be resolved. But with FOQA data, the carrier demonstrated that the ATC problem was real. The airport's instrument approach was redesigned, resulting in an immediate reduction in unstabilized approaches at the airport.

That same carrier learned that pilots were routinely receiving ground-proximity-warning-system (GPWS) warnings while being radar vectored to an airport surrounded by mountainous terrain. The ATC vectoring altitude provided sufficient terrain clearance, but the altitude provided insufficient clearance to avoid nuisance GPWS warnings. Again, FOQA data demonstrated that vectoring altitudes should be increased until flights were past that particular terrain.

The carrier also learned, through analysis of the same FOQA data, that pilots were performing the GPWS escape maneuver, but not performing it in accordance with established procedures. The issue was brought to the attention of the training department for resolution.

The engineering departments of several airlines use FOQA data for fault diagnosis, engine-health monitoring and fuel-usage tracking. One large carrier estimates that it saves US$750,000 annually on one long-haul international route, by identifying specific aircraft that have an exceptionally high fuel-burn rate, thereby being in a position to adjust those aircraft's airframes and/or engines for greater efficiency. For the proven safety benefits, as well as demonstrated cost savings, the chairman of this airline praised FOQA as being "the most valuable management tool we have."

Pilot support and trust are essential. Successful FOQA programs have the support of the carriers' pilots, and if pilots are represented by unions, union involvement is essential.♦

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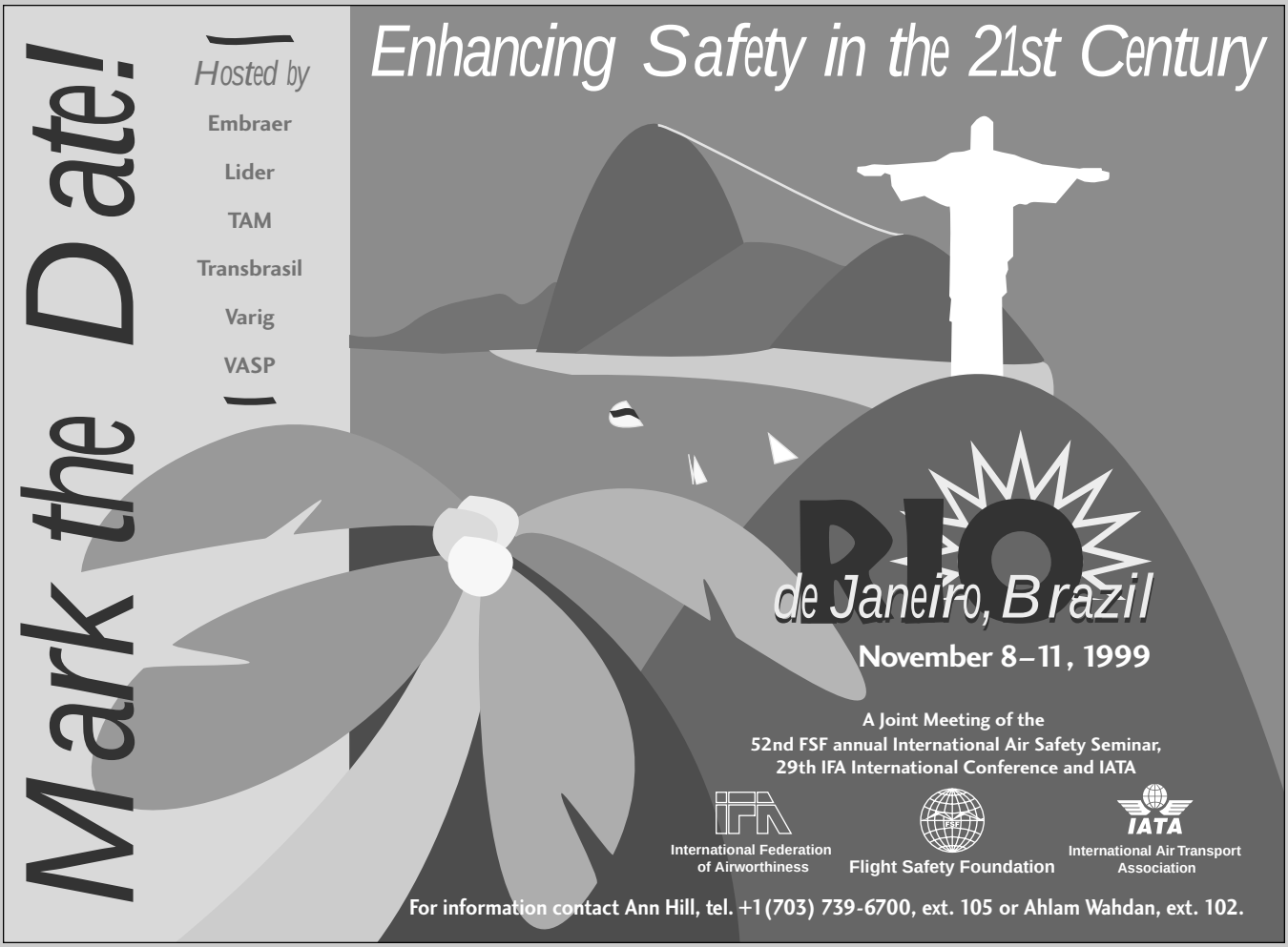

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