FLIGHT SAFETY FOUNDATION

AUGUST–SEPTEMBER 2002

FLIGHT SAFETY
DIGEST

SPECIAL ISSUE

Jerry Lederer: Mr. Aviation Safety

FLIGHT SAFETY FOUNDATION
SINCE 1947

Flight Safety Digest

Vol. 21 No. 8–9 **August–September 2002**

In This Issue

Jerry Lederer: Mr. Aviation Safety

About the cover: Jerry Lederer and his wife, Sarah (FSF Photo, 1994)

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially 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 850 member organizations in more than 140 countries.

Preface

Rarely does any organization have the opportunity to send 100th-birthday greetings to its founder. Flight Safety Foundation eagerly anticipates celebrating that milestone Sept. 26, 2002, with President Emeritus Jerome F. “Jerry” Lederer, “Mr. Aviation Safety.”

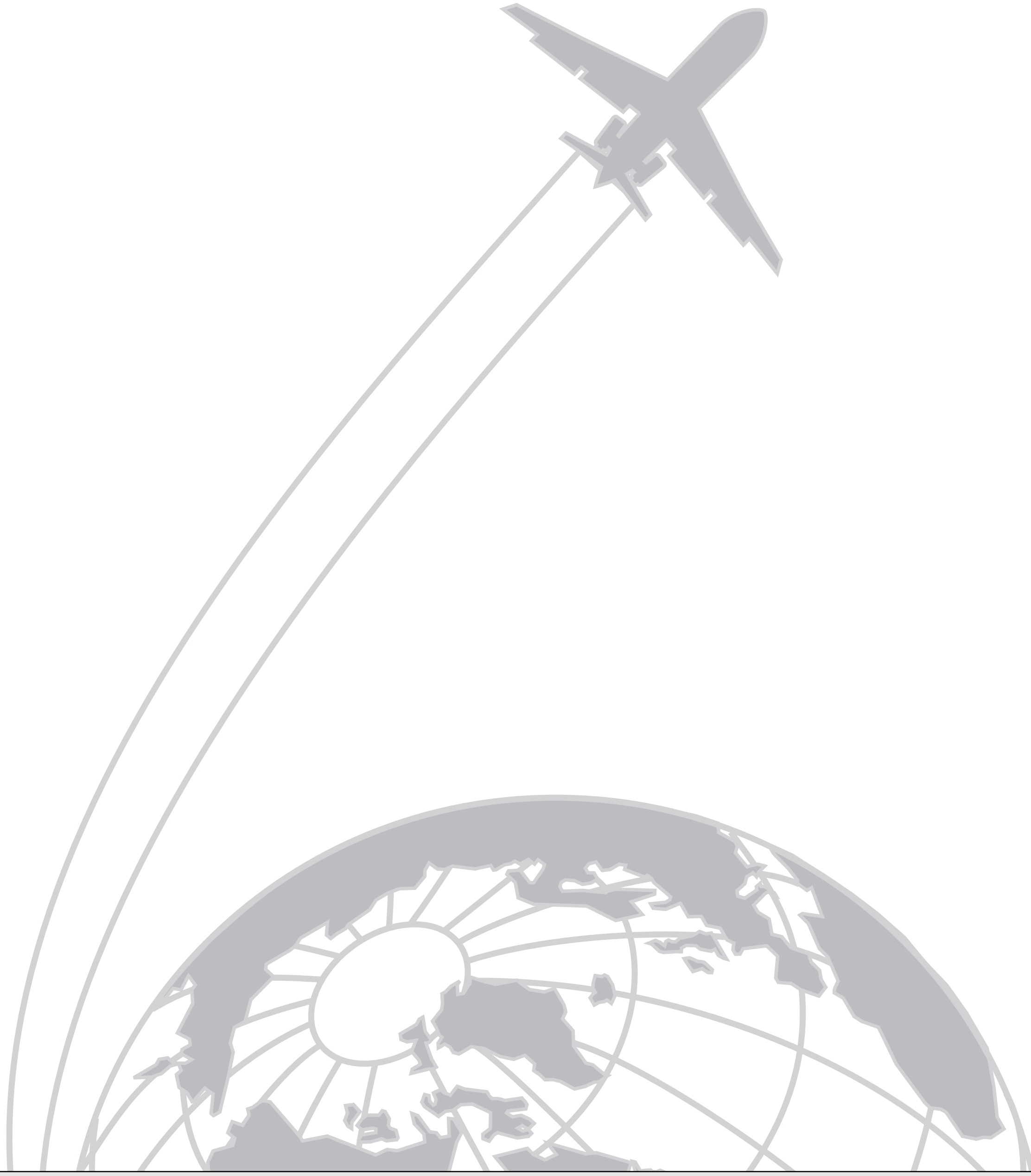
We have prepared this special issue of *Flight Safety Digest* to share some of what we treasure about Jerry with FSF members and his friends worldwide. While reviewing various historic materials, we have come to appreciate more fully why he inspires so many to give their best efforts to the cause of aviation safety.

We have encountered Jerry the visionary, the innovator and the great thinker. We have seen Jerry as a prolific writer, persuasive leader and aggressive advocate who, blending legendary tenacity and diplomacy, insists that we do the right thing for safety. And through the years, we have seen his wife, Sarah, supporting Jerry in both his personal life and his distinguished professional career.

Jerry’s passion for aviation safety still burns brightly. Frequent telephone messages from Jerry provide us with a unique connection to aviation’s past and to his recent safety insights on subjects such as how fuel lines in the space shuttle might be installed in coils to prevent load cracks and to reduce risks of fire; how alternate fuels such as hydrogen theoretically could help to mitigate post-accident fires; how passengers with dementia might be assisted during emergency evacuations; how brain-wave monitoring might help detect crewmember fatigue; how global warming might affect coastal airports, bird migration and takeoff/landing speeds; and why continuous transmission of aircraft flight data to ground stations might save precious time in determining the causes of accidents.

One regret is that the Foundation has few photographs documenting Jerry’s life. We know that on various occasions, Jerry generously lent his archival photographs to others. Most have been dispersed irretrievably among friends, relatives, museums, libraries, aviation historians, authors, journalists and documentary producers. Nevertheless, we hope that this publication will help aviation safety professionals appreciate Jerry’s extraordinary legacy.

— Publications Department Staff
Flight Safety Foundation



Editorial Note

Every effort has been made to publish accurate information. We would be pleased to add to our archives details, documents or stories that you wish to share about Jerry Lederer. Such messages should be sent to Director of Publications, Flight Safety Foundation, 601 Madison Street, Suite 300, Alexandria VA 22314-1756, U.S.

Personal Messages to Jerry Lederer

Personal messages may be sent to Jerry Lederer in care of the FSF Jerry Lederer Aviation Safety Library at the above address. All messages will be forwarded to him, but he may not be able to respond to each one.

Gifts to Library

Tax-deductible gifts to the FSF library honoring Jerry Lederer should be marked clearly “For Lederer Library” and sent to the same address.

Jerry Lederer Continues to Inspire Generations of Aviation Safety Professionals

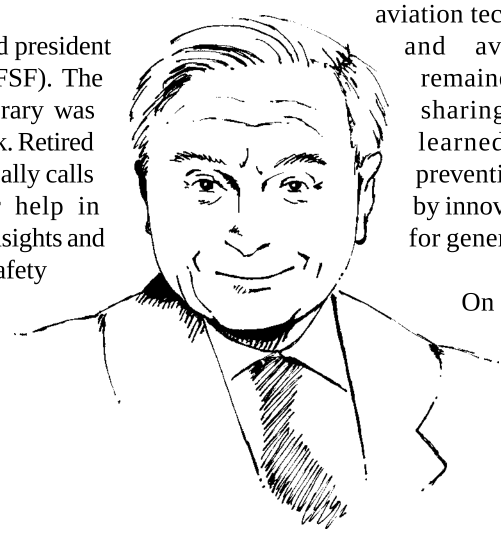
As his 100th birthday nears, the president emeritus of Flight Safety Foundation not only stays tuned to current issues, but frequently reminds FSF staff of lessons that must not be forgotten.

FSF Editorial Staff

Family members, friends and colleagues standing by to celebrate the 100th birthday of Jerome Fox "Jerry" Lederer on Sept. 26, 2002, face a formidable challenge: Agreement on the probable cause and contributing factors behind the achievements of his extraordinary life will be nearly impossible. The only consensus is that the twinkle in his eyes reveals not only megawatt energy and intellect, but abiding passion for the people, professional ideals and myriad pursuits that bring him joy.

Lederer is the organizer, first director and president emeritus of Flight Safety Foundation (FSF). The FSF Jerry Lederer Aviation Safety Library was established in 1989 to honor his life's work. Retired from the Foundation since 1967, he typically calls FSF staff several times a week for help in researching his latest project or to share insights and connections between current aviation safety issues and those of long ago. Admirers worldwide call him "Mr. Aviation Safety" and the "Father of Aviation Safety."

Born Sept. 26, 1902, Lederer is renowned as the innovator of many programs designed to save lives and reduce airline accident rates, and as an advocate of concepts that continue to prevent aircraft accidents.



Jerry Lederer

Stuart Matthews, FSF president and CEO, said, "Those of us who have been privileged to be a part of Jerry's life know him for his wit, creativity and inspiration in his tireless dedication to aviation safety. When Jerry began his career in aviation in the 1920s, pilots and airplanes were lost at an appalling rate, despite the skill of many pilots, because aviation technology and systems were rudimentary and aviation-risk-management principles remained largely unknown. Jerry's ideas for sharing widely and objectively the lessons learned from aircraft accidents — and preventing the loss of life and the loss of aircraft by innovative methods — have built a foundation for generations of aviation safety professionals."

On the occasion of the Foundation's 50th anniversary in 1997, Lederer was presented a certificate that "best describes our feelings for Jerry," said Matthews:

> Jerome F. Lederer was already a pioneering aviation safety specialist before he launched the Foundation

a half-century ago. His influence on aviation safety continues.

Born in 1902, Jerry, as he prefers to be known, has lived through the entire history of powered flight and changed it for the better. In beginning Flight Safety Foundation, and nurturing its evolution into a worldwide forum, he sowed the seeds for most of the Foundation's current projects and ongoing initiatives.

Jerry has also advanced aerospace safety in many other capacities, always maintaining the special qualities that brought him to the forefront of his field and kept him there: vision, creativity, imagination, humor and tireless dedication.

At this milestone in its history, Flight Safety Foundation honors Jerry Lederer, to whom it owes its beginning, its inspiration and many of its achievements.

Lederer organized the Foundation officially in 1947 and, until his retirement in 1967, he conducted many FSF research projects, international exchanges of accident prevention information, safety seminars and training courses for aviation accident investigators. He was concurrently, 1950–1967, the founder and director of the Cornell-Guggenheim Aviation Safety Center, which published *Design Notes* on safety in aircraft design, conducted annual global surveys of aviation research and recommended new subjects for research.

Throughout his life, Lederer has used his imagination to envision solutions to aviation safety problems. In speeches and articles, for example, he suggested methods for the worldwide exchange of aviation safety information, for counteracting complacency among pilots of highly automated aircraft, for real-time remote monitoring of pilot/aircraft performance via telemetry and for alerting flight crews to signs of fatigue.

Safety Takes Priority in U.S. Space Flight

After his retirement from the Foundation, Lederer was asked by the U.S. National Aeronautics and Space Administration (NASA) in 1967 to establish a new Office of Manned Space Flight Safety. Three NASA astronauts — Roger Chaffee, Virgil Grissom and Edward White II — had been killed when the oxygen-rich environment in their Apollo space capsule was ignited during a launch-pad test Jan. 27, 1967, at Cape Canaveral, Florida, and the safety of Project Apollo had come under review. From 1970 to 1972, Lederer was director of safety for all NASA activities.

Lederer said that at NASA, risk management involved technology that was far more complex than anything he had encountered in aviation. Although redundancy and backup

Jerry Lederer is sworn in as director of safety for NASA by Dr. George Mueller, associate administrator for manned space flight.

capabilities increased the probability of successfully addressing system failures, Lederer said that his experience with human factors, motivation and performance limitations also proved valuable.

"The most important thing I did was to establish ways to motivate everyone involved in the project to do a good job and to be rewarded for doing a good job," Lederer said. One such program involved distributing, to those who had served the program well, tiny objects that had been taken to the moon or on other missions aboard space vehicles.

At NASA, Lederer became acquainted with Dr. Wernher von Braun, one of the rocket scientists who guided the U.S. space program. Lederer won approval from von Braun with a remark during a NASA meeting in which there was concern about the consequences if falling spacecraft parts ever caused death or injury. Von Braun turned to Lederer and asked, "Do you have any ideas?"

Lederer replied, "Sure, I know how to cure that — everything we make, we mark 'Made in Russia.'"

He shared his knowledge, memories and experience in frequent lectures, speeches, papers and articles after his retirement from NASA, including as an adjunct professor at the Institute of Safety and Systems Management, University of Southern California; as a member of the Advisory Council to the Institute of Nuclear Power Operations; and as president of U.S. Air Mail Pioneers, an organization that studies and preserves the history of the U.S. Air Mail Service.

Awards Honor Lifetime Achievements

Lederer has received more than 100 awards, including the 1999 Edward Warner Award, one of civil aviation's highest honors, from the Council of the International Civil Aviation Organization (ICAO) "in recognition of his eminent contribution to the improvement of all aspects of safety in international civil aviation." In January 2002, he received the newly established Howard B. Drollinger Lifetime Achievement Award, presented by the Aero Club of Southern California.

Lederer often has said that the following words from an FSF Distinguished Service Award, which he received in 1967, best define his career: "For pioneering the flight safety discipline at a time when it was all but unknown, and for pursuing the objective of safer flight with a singular dedication, wisdom and courage. His belief in, and application of, the sharing of flight safety information and experience formed the cornerstone of the effort."

This Douglas airplane was typical of those that transported the U.S. mail in the 1920s.

Among the other awards Lederer has received are the NASA Exceptional Services Medal, the U.S. Federal Aviation Administration (FAA) Distinguished Service Medal, the Daniel Guggenheim Medal, the Amelia Earhart Medal, the Von Baumhauer Medal of the Royal Dutch Aeronautical Society, the Airline Medical Directors Award and the Aerospace Life Achievement Award of the American Institute of Aeronautics and Astronautics (AIAA). In November 1988, Lederer received the K.E. Tsiolkovsky Medal from the Soviet Federation of Cosmonauts. In January 2000, *Air Safety* magazine, published by Pakistan International Airlines, named him "aviation's man of the century."

When Lederer received the Wright Brothers Memorial Trophy in 1965, the citation read in part: "Aviation's extraordinary safety record to a significant degree is a result of the tireless and devoted efforts of Mr. Lederer. For 35 years, he has worked unceasingly to improve all elements of the flight safety spectrum and concentrated on making compatible the primary elements of flight — the man, the machine and the ground environment — to ensure maximum safety. In accomplishing this objective, he has taken the leadership in correlating, coordinating and improving the flight safety activities of the many varied organizations and agencies comprising world aviation."

As a reflection of his achievements, the International Society of Air Safety Investigators (ISASI) presents the Jerome F. Lederer Award to recognize individuals for their work in aviation safety.

Aeronautical Degree Leads to U.S. Air Mail Service

Born in New York, New York, Lederer became interested in airplanes as a child. He said that his childhood memories include attending an aviation tournament, the second to be held in the United States, in 1910 and seeing renowned aviator Glenn Curtiss.

Lederer earned a bachelor of science degree in mechanical engineering with aeronautical options in 1924 and a mechanical engineering degree in 1925 from New York University (NYU) and served as assistant to the director of NYU's Guggenheim School of Aeronautics. In that position, Lederer was responsible for erecting, calibrating and operating the school's wind tunnel, which generated air velocities of 40 miles per hour (64 kilometers per hour).

"Only two other universities or colleges gave degrees in aviation at the time because there were very few aeronautical engineers in those days," Lederer said. "One of my graduating colleagues in school, taking the course with me, refused to go into aviation because he felt it had no future."

He worked as an aeronautical engineer for the U.S. Air Mail Service in 1926 and 1927. As the only engineer for the world's first system of scheduled air transportation, he was responsible for modifications to aircraft, writing specifications and approving the reconstruction of accident airplanes.

While working for the Air Mail Service, he met Charles Lindbergh, a pilot flying for an airline based in Maywood, Illinois, where Lederer also worked. In May 1927, Lederer inspected Lindbergh's Ryan M-1, *The Spirit of St. Louis*, at Roosevelt Field, New York, on the day before Lindbergh's historic nonstop flight across the Atlantic Ocean. Lederer and Lindbergh became friends and maintained contact until Lindbergh's death in 1974.

During his time with the Air Mail Service, Lederer also published his first aviation safety bulletin. The service experienced many

Jerry Lederer at age 25.

accidents and, as a result, accumulated a stockpile of salvaged wings without serviceable fuselages. He said, "My first safety newsletter was addressed to the pilots and said, 'If you do crash, please fly between two trees and take the wings off and leave the fuselage intact.'"

Accidents, Safety Bulletins Set Important Precedents

In 1927, he became a consultant to airplane manufacturers and an insurer. In 1929, he was employed as chief engineer for the company that later became Aero Insurance Underwriters, at the time one of the world's largest aviation insurance companies. From 1929 to 1940, Lederer's responsibilities, in addition to evaluating aviation risks, included reducing losses through safety audits and educational programs, and disseminating loss-prevention information in aviation safety newsletters.

"Our safety bulletins were widely acclaimed in the United States and overseas," he said. These bulletins were early models for FSF safety publications.

Commercial aviation was growing rapidly by the late 1930s and falling increasingly under national regulation, including safety regulation. On June 30, 1940, a government reorganization at the direction of President Franklin Roosevelt combined functions of the Civil Aeronautics Authority and the Air Safety Board — which had quasi-judicial power for investigating accidents, determining their probable cause and making recommendations for accident prevention — into a new Civil Aeronautics Board (CAB). The CAB had authority to conduct safety rulemaking, adjudication, investigation and airline economic regulation with its five-member board and administrator reporting to the U.S. Congress and President Roosevelt through the U.S. Department of Commerce, but with independence from the U.S. Secretary of Commerce. Functions of the CAB Safety Bureau included safety rulemaking and accident investigation.

From 1940 to 1942, Lederer served as director of the CAB Safety Bureau. He had been in this position about one month when a Douglas DC-3 accident occurred in August 1940 during a thunderstorm near Lovettsville, Virginia. Three crewmembers, one airline employee and 21 passengers were killed, including U.S. Sen. Ernest Lundeen of Minnesota; the aircraft was destroyed. The CAB, in its final report, said that the probable cause of the accident was "the disabling of the pilots by a severe lightning discharge in the immediate neighborhood of the airplane, with resulting loss of control."

Lederer said that during this investigation, a report had reached the U.S. Senate about what were alleged to be hazardous stall characteristics of the DC-3. Thus, the CAB was under pressure to ground all DC-3s, which at the time carried about 90 percent of passengers and cargo in the United States. Lederer borrowed two DC-3s from local air carriers, and the airplanes were sent to Langley Field, Virginia. Aerodynamics of the DC-3 were re-evaluated as the CAB considered, and then rejected, the stall theory in the Lovettsville accident. Changes in DC-3 pilot training later were implemented, he said.

In 1942, Lederer was appointed director of training and head of the administrative section of the Airlines War Training Institute, which trained about 10,000 U.S. Army pilots, 35,000 maintenance technicians, navigators and radio operators for the Air Transport Command. As part of the effort, he later said, "We wrote and published 15 books in 15 weeks. One was about survival in the event of a crash in the jungle, in the ocean or anywhere else they had to go. An aircraft carrier [ship] had to wait until we got that survival book published before it could go off to do its job."

Late in the war, Lederer was appointed to the U.S. Strategic Bombing Survey in Europe, which analyzed how effective the strategic bombing campaign had been in hampering Germany's manufacturing capacity during the war.

Accident Generates Concept of Foundation

Lederer said that the Foundation had its genesis in a Lockheed Constellation accident that occurred in July 1946, near

Reading, Pennsylvania. Five crewmembers were killed and one crewmember was seriously injured; the aircraft was destroyed. The CAB, in its final report, said that the probable cause was "failure of at least one of the generator-lead through-stud installations in the fuselage skin of the forward baggage compartment, which resulted in intense local heating due to electrical arcing, ignition of the fuselage insulation and creation of smoke of such density that sustained control of the aircraft became impossible."

Lederer later said, "One of the baggage containers had a glass-wool lining, and this became saturated with hydraulic fluid. An electrical connection sparked and the insulation caught fire, causing the plane to crash." The investigation and hearings into the accident generated a meeting in New York of aviation safety specialists, several of whom were familiar with the newsletters that Lederer had published for the insurance company. They suggested that such publications would be valuable for the entire aviation industry.

Lederer organized a meeting, held at the Institute of Aeronautical Sciences (now AIAA) in New York, that resulted in support from industry organizations to help create a foundation to disseminate safety information that would transcend competing commercial interests and national borders. The new organization was named Aircraft Engineering for Safety, but shortly afterward merged with a group studying cockpit design, and adopted the other group's name in 1947: Flight Safety Foundation.

The first seminar conducted by the Foundation was organized in 1947 and had eight attendees from the United States and Canada, Lederer said. One year later, the seminar had an attendance of 50, and the Foundation's reputation and attendance grew in the following years. Lederer said that the support of his wife, Sarah, and the work of Gloria W. Heath, the first employee of Aircraft Engineering for Safety and a longtime FSF employee, were important in the development of the Foundation.

Lederer developed many FSF programs that continue today: annual International Air Safety Seminars (the 55th to be held in Dublin, Ireland, in November 2002); aviation safety research projects; and several scheduled publications examining various aspects of aviation safety. At the Foundation, Lederer also organized, in 1948, the first civilian aircraft accident investigation course conducted by a private organization, using as instructors his former colleagues at the CAB.

About 1950, when Lederer became director of the Cornell-Guggenheim Aviation Safety Center, he remained a director of the Foundation and halved his working time between them. That same year, the Crash Injury Research (CIR) program, which had been established in the 1930s by Hugh DeHaven and which had been supported with funds from Cornell University Medical School, came under the official oversight of the safety center; CIR was renamed Aviation Crash Injury Research (AvCIR).

DeHaven and Howard Hasbrook, assistant director, had been severely injured in separate aircraft accidents in which their aircraft had been destroyed; they shared an eager inquisitiveness to discover why they had survived. Most importantly, their work provided guidance on how to build crashworthy airplanes; they participated in many accident investigations and conducted the first "survivability" analysis of aviation accidents.

About 1956, AvCIR was relocated to Phoenix, Arizona, and about 1959, AvCIR became a wholly owned subsidiary of the Foundation. Many helicopters and airplanes were crash-tested at the Phoenix facility to enable manufacturers to improve their designs and to provide better protection to aircraft occupants. A remarkable crashworthy fuel system was developed for aircraft that later was incorporated into U.S. military helicopters. The name was changed about 1962 to Aviation Safety and Engineering Research (AvSER) in keeping with a broadened focus, but also to make it "less scary" to the public, said Harry Robertson, a former AvSER engineer who led the development of the crashworthy fuel system.

Meanwhile, Lederer was appointed in 1956 to U.S. President Dwight D. Eisenhower's seven-person Aviation Facilities Investigation Group, which organized the FAA and modernized air traffic control.

Jerry Lederer and C.R. Smith, president and CEO of American Airlines, celebrate Flight Safety Foundation's 10th anniversary.

In 1967, Lederer retired from the Foundation, and because the Cornell-Guggenheim Aviation Safety Center's mandate to help make aviation transportation as safe as trains had been accomplished, said Lederer, he retired from the safety center and soon after, the safety center closed. AvSER had a 35-person staff when it was sold in 1968 by the Foundation.

Aviation safety remains a subject of major public interest in news media worldwide. In the Foundation's early years, however, reluctance to communicate publicly about airlines' efforts to improve safety was common. Over time, the Foundation developed methods of carefully communicating factual information about safety problems and solutions.

Sarah Lederer Sets Example as Social Worker, Community Leader and Aviation Safety Supporter

The wife of Jerome F. 'Jerry' Lederer shares fond memories of her career in government service, community leadership and worldwide travel supporting Flight Safety Foundation's legendary president emeritus.

Sarah Lederer protested that she hardly knew Jerome F. "Jerry" Lederer when he proposed marriage 66 years ago. But their whirlwind courtship was just long enough to set the breathtaking pace of a life together immersed in romance, challenge and adventure. Now 90, she has been honored not only for contributing significantly to her husband's work — especially his prolific writing — but for her professional achievements and public service.

She is now retired with Jerry after a career involving positions as a social worker in New York, New York; a vice president of the New Rochelle Board of Education, New York; a member of the board of commissioners of the New Rochelle Municipal Housing Authority; a regulation writer for the District of Columbia Redevelopment Land Agency in Washington, D.C.; and president of Leisure World, a community of 20,000 senior citizens in Laguna Hills, California. The Lederers have two daughters, Susan Lederer and Nancy Cain, who has two daughters of her own.

Born Sarah Bojarsky Nov. 5, 1911, in Morgan City, Louisiana, she was the only daughter among six children. When she was six years old, her family moved from their home in Berwick, Louisiana, to Memphis, Tennessee, and then to Los Angeles, California. After her early education in Los Angeles, she earned a bachelor's degree in classics at the University of California at Los Angeles.

Her plan to pursue a graduate degree in social work changed when she met Jerry. They married on Nov. 1, 1935, in Poughkeepsie, New York. In the late 1930s, she was a social worker in the New York City neighborhood of Harlem, and also learned to fly at Teterboro Airport in New Jersey and at Schrom Airport in Greenbelt, Maryland. Between 1940 and 1944, the Lederer family lived in Washington; Larchmont, New York; and New Rochelle. During World War II, she was deputy director of the motor corps and captain of the rescue squad for American Women's Voluntary Services in Washington.

The Jerry Lederer family in 2001 — from left, Susan, Sarah, Jerry and Nancy.

During 24 years in New Rochelle, Sarah's professional work included obtaining replacement housing for local families displaced by federal highway construction programs. She also held leadership positions in the League of Women Voters at the city, county and national levels; the Woman's Club of New Rochelle; the New York State Congress of Parents and Teachers; and the Fatt Calfe Dinner, an annual event that focused on historic preservation, community commemorations and civic fund raising.

When Flight Safety Foundation moved from New York to

"Safety was a hard sell in those days," Lederer said. "That's the biggest thing I had to overcome." Nevertheless, Lederer said that he did overcome the reluctance to discuss safety "by diplomacy, by not putting out things that would scare the public."

Risk Management Becomes Industry Focus

Accident rates in civil aviation improved dramatically during Lederer's lifetime. In 1926, when he began work for the Air Mail Service, one in every four commercial aircraft pilots

Sarah Lederer, June 1937.

Washington, D.C., in 1967, she joined the District of Columbia Redevelopment Land Agency, writing regulations for urban relocation programs related to highway construction and other government actions. She also traveled extensively with Jerry on behalf of the Foundation, and throughout her life, she reviewed Jerry's draft articles and speeches about aviation safety and provided critiques, which he often cited among reasons for his success. Those who have known the Lederers as a couple also note the extraordinary degree to which Jerry took delight in Sarah's pursuits and interests and encouraged her, whether flying airplanes for enjoyment or volunteering for wartime civil defense.

"Sarah, my wife and mentor, has survived trials, tribulations and many, many joys with me," Jerry said. "I appreciate having her around me all the time because of her persistence in my work in the past and right now. Without her, I probably would not be where I am now. She is full of ideas, very able to criticize my writings and to make useful suggestions. Sarah has been an ideal helpmate in my work and in aviation safety."

In 1974, following Jerry's retirement from the Foundation in 1967 and from the U.S. National Aeronautics and Space Administration in 1972, the Lederers moved to Laguna Hills. Sarah was elected to leadership positions in a Leisure World homeowner association and in the Golden Rain Foundation of Laguna Hills, a group of homeowner associations. In these positions, she provided fiscal and policy management, liaison to local schools and liaison to projects of the League of Women Voters.

Sarah has enjoyed, and has shared with Nancy and Susan, her appreciation of opera, piano and professional baseball. She received numerous awards for her work and public service, including a special FSF citation in 1997 on the Foundation's 50th anniversary:

> Sarah Lederer has been a conscientious source of support and inspiration for her husband of more than 61 years, Jerome "Jerry" F. Lederer.
>
> While Jerry nurtured his dream of encouraging the sharing of aviation safety information, through the birth and growth of Flight Safety Foundation under his leadership, Sarah has played an essential role in the achievements and recognition that we are celebrating.
>
> With abundant intelligence and insight into the cause to which Jerry dedicated himself, Sarah has always been at Jerry's side or with him in spirit, sharing the difficulties and the victories.
>
> Sarah shares with her husband the golden light that shines on those who have contributed to the safe keeping of human life through the Foundation's work.
>
> At this milestone in its history, Flight Safety Foundation honors Sarah Lederer for a lifetime of love, companionship and enthusiasm with our treasure, Jerry.♦

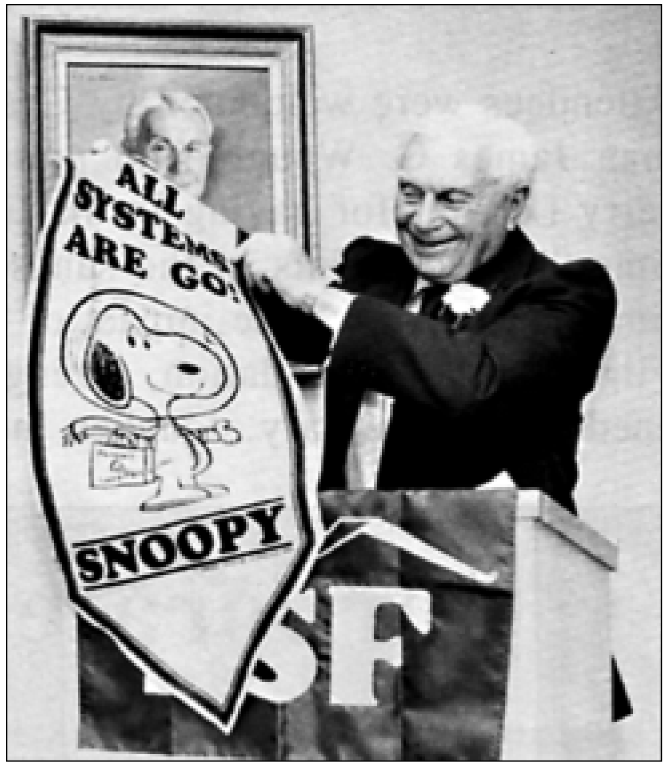
was killed each year. In 1964, Lederer wrote, "Today an airline pilot can secure life insurance at the same low rate as the floorwalker of a department store or a piano tuner."

Lederer's background in aircraft insurance influenced the terminology with which he thought, and spoke, about his field.

"Risk management is a more realistic term than safety," he said. "It implies that hazards are ever-present, must be identified, analyzed, evaluated and controlled or rationally accepted. Accepting the premise that no system is ever absolutely risk-free — or conversely, that there are certain risks inherent in every system — it becomes an absolute necessity that management should know, understand and take responsibility for the risks that it is assuming."

Lederer has written one book (*Safety in the Operation of Air Transport*, Norwich University, 1939) and hundreds of papers and articles. His government service has included participation in the investigation of train collisions and ship collisions, and the evaluation of nuclear powerplant safety.

Throughout his life, Lederer has enjoyed camping, sailing and canoeing, and he estimates that he has traveled many thousands of miles on canoeing trips between northern Quebec, Canada, and New York City.♦



During Jerry Lederer's tenure at NASA, Charles M. Schulz's Snoopy was the astronauts' mascot, and they presented this banner to Jerry. He presented his keepsake to the FSF Jerry Lederer Aviation Safety Library during dedication ceremonies in 1989.

Chronology Highlights Life of Jerome F. 'Jerry' Lederer

The following events comprise milestones in the life of Jerome F. "Jerry" Lederer, president emeritus of Flight Safety Foundation:

- Born Sept. 26, 1902, in New York, New York, U.S.;
- Received a bachelor of science degree in mechanical engineering with aeronautical options in 1924 and a mechanical engineering degree in 1925 from New York University;
- Worked as an aeronautical engineer for the U.S. Air Mail Service in 1926 and 1927;
- Beginning in 1927, became a consultant to airplane manufacturers and an insurer;
- In 1929, began working as chief engineer for the company that later became Aero Insurance Underwriters;
- Served 1940–1942 as director of the Safety Bureau, U.S. Civil Aeronautics Board;
- During World War II, served as director of training and head of the administrative section of the Airlines War Training Institute and participated in the U.S. Strategic Bombing Survey in Europe;
- Organized Flight Safety Foundation in 1947 and retired in 1967;
- Served concurrently, 1950–1967, as director of the Cornell-Guggenheim Aviation Safety Center;
- In 1956, served on U.S. President Dwight D. Eisenhower's seven-person Aviation Facilities Investigation Group, which organized the U.S. Federal Aviation Authority, now the Federal Aviation Administration (FAA);
- In 1958, served on the Jet Implementation Panel of the International Civil Aviation Organization (ICAO);
- Served as director of manned space flight safety (1967–1970) and as director of safety (1970–1972) for the U.S. National Aeronautics and Space Administration;
- Beginning in 1972, served as an adjunct professor at the Institute of Safety and Systems Management, University of Southern California; and,
- Received more than 100 awards, including the 1999 Edward Warner Award from the Council of ICAO and the 2002 Howard B. Drollinger Lifetime Achievement Award, presented by the Aero Club of Southern California.♦

Safety Innovations, Solutions Show Contemporary Relevance

Excerpts from some of his best-known writing provide insight into the concerns and perspectives of Jerome F. 'Jerry' Lederer.

FSF Editorial Staff

Jerome F. "Jerry" Lederer, president emeritus of Flight Safety Foundation (FSF), envisioned solutions to aviation safety problems throughout his career and retirement years. In speeches and articles, he suggested methods for worldwide exchange of aviation safety information, for counteracting complacency among pilots of highly automated aircraft, for real-time remote monitoring of pilot/aircraft performance via telemetry and for alerting flight crews to signs of fatigue — to name a few examples. Following are excerpts from some of Lederer's papers, articles, stories and solutions, and a few comments by others about him.

In "Loss Prevention in Non-scheduled Civil Aviation" — presented to the National Aircraft Production Meeting of the Society of Automotive Engineers in Los Angeles, California, Oct. 13–15, 1938 — Lederer said, "Human nature is so constituted that improvements in design are employed not to achieve safety but to take advantage of the greater utility which such improvements usually afford. A pilot may obtain an airplane with which it is possible to get in and out of a very small airport. Instead of considering this an emergency operation, he takes advantage of the design to actually operate regularly from such airports. This is a foible of human nature and is very much to be commended for its effect on design but its effect on accidents is not favorable, except indirectly. Improvements in design usually make flying easier or make it more useful, thus inducing more people to fly. The mileage flown per accident seems to increase with greater use; hence the indirect influence of improvements on safety records. However, on the basis of number of airplanes per accident, the future seems pessimistic. It must be admitted that the human element creates a greater hazard than the airplane itself."

"Strange as it may seem, a very light coating of snow or ice, light enough to be hardly visible, will have a tremendous effect on reducing the performance of a modern airplane. Although this was known in Canada for many years, only in the last three years has this danger been recognized here. It occurs only when the ship is on the ground, and makes takeoff dangerous. To avoid this danger, the airlines cover the wings with tarpaulins, or they make certain that all ice is off before the airplane is allowed to depart." (From "Safety in the Operation of Air Transportation," a lecture under the James Jackson Cabot Professorship of Air Traffic Regulation and Air Transportation at Norwich University, April 20, 1939. Quoted in U.S. National Transportation Safety Board [NTSB] *Aircraft Accident Report NTSB/AAR–93/02, Takeoff Stall in Icing Conditions, USAir Flight 405, N485US, La Guardia Airport, Flushing, New York [U.S.], March 22, 1992.*)

Lederer's 1939 book *Safety in the Operation of Air Transportation* — published by Norwich University, Northfield, Vermont — was written to show the relationship between technological developments and safety at a time when other books in the field focused on advances in aircraft speed, payload, range and efficiency. The following examples in the book reflect timeless safety principles or show how far aviation safety has evolved:

- "To discuss safety in air transportation is difficult because it is so intimately connected with human nature and weaknesses. … It is unfortunate for the sake of safety that human nature is so constituted that instead of using a device as a safety measure we like to use it to increase our efficiency."

- "Undoubtedly, our airlines are not yet as free from danger as are our railroads and it may be some time before they are. But, on the basis of passenger miles flown, it is safe to say that traveling in an airplane operated by one of the airlines approved by the Civil Aeronautics Authority is no more hazardous than traveling in the ordinary passenger automobile."

- "There is, therefore, an economic limit to safety in terms of equipment. But we are willing to risk riding in these [twin-engined transport] airplanes because we believe that the airplane personnel is so organized as to take every reasonable precaution to see that the engines will not fail on the takeoff, that the airplane is taken off in such a way as to reduce that critical period [of risk of failure of one engine] to a minimum, and, if any doubt exists regarding the safety of the flight, the airplane will not be permitted to take off at all. … Whatever the equipment lacks in safety is assumed to be restored by adequate organization and managerial policy to achieve safety. … The ability to maintain altitude with a full load on one engine was probably the greatest factor in advancing the safety and reliability of the modern airplane. … Since there were 1,246 powerplant failures of minor and major degree in 1936 and 1937, the need for multi-engined equipment for safety is obvious."

- "With the introduction of high-speed ships [aircraft] came the necessity of more thorough training of pilots because less time was left to think or to react in emergencies."

- "In the early days of scheduled transportation from 1922 to 1925, one pilot was killed for every 10,000 hours of flying. Most of the fatalities were caused by bad weather. The pilot would take off ignorant of the weather ahead because of lack of adequate weather stations. If the weather at his point of departure and at a few points along the route happened to be good, he would risk the flight. In fact, in the early days the airmail operations were based on the slogan, 'The mail must fly.' This slogan probably caused more deaths than any other policy in aviation."

- "Although pilots are able to fly successfully by instruments in bad weather, the airlines have mutually agreed that no such flying should be undertaken, either over the top or through clouds, if the distance between available landing areas is greater than 100 miles. This means a maximum of about 40 minutes of flight on instruments. If there is any indication that the pilot will have to fly on instruments greater than this distance with unlandable weather below him, the flight is not undertaken. This is a safety policy of the first magnitude, which should be credited to conservative and cooperative airline executive policy."

- "The flight analyzer, a recording barograph which automatically records altitude, the operation of the automatic pilot, the time and frequency of radio transmission, and vertical acceleration, is another aid which standardizes and controls flight operations, supplies proof that the trip was flown as planned, and indicates proof of the rate of climb and descent in case passengers complain. It can be made to record many other flight factors."

"'The mail must fly.' This slogan probably caused more deaths than any other policy in aviation."

- "Initial developments inside laboratories with a few months in the field on experimental airplanes cannot possibly compare with practical tests made on rigorous airline schedules day in and day out through all four seasons."

- "Safety is defined as freedom from danger or risk, but wherever people come in close contact with an object which under human control moves fast, or is associated in any way with kinetic or potential energy of high value, such as an automobile, a train or an airplane, the public must realize that it is practically impossible to achieve absolute freedom from risk. Conversely, whatever freedom from danger does exist is obtained through careful maintenance to preclude failure of material and through a high degree of control while the vehicle is in motion. No matter how many safety devices are installed in a machine, adequate maintenance and proper control achieved by organization remain the essence of safety."

- "It is unfortunate that much of the necessary, careful maintenance procedure and flying control has been obtained only through sad and costly experience. The lessons from these had to be, and continue to be, intelligently and immediately applied to avoid recurrences [of accidents]."

- "Another instance, also in the early days of the airmail, is worth noting. A steady series of accidents had occurred, in every case the pilot being killed and the ship destroyed without leaving clues as to the cause. Finally, one crash occurred in which the investigators found that the pilot had inserted a metal pencil of the common automatic variety through a bolt hole in a fitting which connected the control stick to the control assembly. The investigators concluded that the bolt which had been there had sheared in flight and the pencil was the only object that the pilot had to replace it. The pencil, too, broke off and fell out while the pilot was too low to adjust [for] the trouble again, and he crashed. Evidently, the cause of this accident and of the previous similar accidents was the weakness of that bolt attaching the control stick to the control assembly. When this was discovered, the bolts in every plane were increased in size, eliminating [that] bolt failure as the cause of [other] accidents. It is unfortunate that many pilots had to lose their lives before this weakness in equipment was discovered."

- "Standardization of equipment reduced the maintenance problems and created greater opportunities for the airlines to exchange mutually useful information regarding the safe operation of their ships. The establishment of semi-annual maintenance meetings to which all the airlines sent representatives to discuss maintenance problems was one of the greatest cooperative ventures for safety in the recent history of transportation."

- "Another airline is studying methods of reducing danger from birds striking the windshields in flight. Following several cases of considerable damage from striking birds, reinforcements in the windshield posts were made to reduce the seriousness of these collisions. Another airline is using bullet-proof glass."

- "The gradual adoption [by airlines] of conservative practices by mutual agreement, coupled with more certain methods of forecasting weather, has enormously stimulated safety, especially in winter."

- "Serious accidents, especially if they cannot be adequately explained, awaken the fear against flying which is inherent in most of us. This means loss of passenger revenue, idle airplanes and curtailment of business growth. Furthermore, the investigation to determine the cause of a serious accident may often cost more money than the value of the equipment lost."

- "Accidents are costly because they involve loss of personnel, loss of equipment, discouragement of passengers, expensive investigations, the threat of idle equipment and higher insurance costs. Conversely, an airline that builds a reputation for safety and dependability will find its costs lowering due to greater use of equipment and personnel, and in every way stands to gain economically through safety."

- "To overcome this dangerous tendency [paying pilots for each hour flown], the airlines, in the bad winter months, pay the pilots according to a fixed scale regardless of the amount of flying they do. They have thus, through economic means, eliminated the psychological pressure to go through bad weather. The psychological aspects of safety are as important as maintenance and operations."

- "Besides experience, the pilot should have a clean record, with no accident of a serious nature within the previous five years, unless the accident could not be attributed to him. But even if he should be the victim of a series of accidents through no fault of his own, he would probably not be hired. There is no reason for denying him a position except that he is running in bad luck, and why take a chance?"

"The fixing of responsibility is as important for safety in airline operation as are good equipment and trained personnel."

- "Forms fix responsibility. The fixing of responsibility is as important for safety in airline operation as are good equipment and trained personnel. In a well operated airline, no move is made without having it recorded on a form. … Verbal orders can be forgotten, there is no verification of their issuance, and they reach only a limited number of people."

- "The meteorologist assumes that the worst conditions will prevail and so informs the pilot and dispatcher. This philosophy of preparing for the most unfavorable conditions in doubtful weather, being humble in the face of uncertainty, is highly important in achieving safety."

- "The recently established [Air] Safety Board should also have a marked influence in spreading the gospel of safety by reason of its independent studies of accidents and the recommendations which follow."

- "The future should bring an accelerated record for safety because of refinements in powerplant construction, such as direct-injection carburetion; improvements in cowling and in fuel and oil installations to reduce fire hazards; stall warning indicators; use of anti-stalling devices; improvements in wing sections; improved performance with partial powerplant failure; better undercarriage structures; more accurate altimeters or terrain clearance indicators; radio static elimination; larger airports with clearer approaches; advances in our knowledge of vibration prevention; continuous research in structures, aerodynamics, meteorology, and metallurgy; improved methods of orientation and navigation; and especially study of pilot psychology and fatigue."

In "Loss Prevention Programs in Civil Aviation" — presented to the Air Transport Design Session of the 16th Annual Meeting of the Institute of the Aeronautical Sciences, New York, Jan. 26–29, 1948 — Lederer said, "The airline safety record by any yardstick appears well within magnitudes of safety acceptable to the public. Nevertheless, the airlines have a moral obligation and, as long as there are newspapers, a financial incentive to continue to make it safer. … An immense amount of aviation safety literature has been prepared. There are pamphlets, posters, motion pictures, safety codes and books. They are almost always directed at the pilot. He is subjected to a continuous bombardment of safety signs and slogans. By and large, they reflect the weaknesses and deficiencies in design or especially training which he is asked to overcome. … Perhaps some of the money and energy being spent on improving the pilot might give greater value if directed toward the design engineers, the instructors and even management. They certainly are no less human than pilots and therefore should eventually succumb to a safety program directed at them."

Around 1950, Lederer wrote the Pilot's Code [see page 45] and the Mechanic's Creed [see page 44] to embody values and responsibilities of the two professions. He later wrote in an Air Mail Pioneers publication, "The creed was adopted by the U.S. Air Force Military Air Transport Service and was posted on cockpit doors and pilot ready rooms."

In "Observations on Flight Safety" — presented to the Society of Automotive Engineers Annual Meeting in Detroit, Michigan, Jan. 8–12, 1951 — Lederer said, "Our answer to the problem of securing information on near-accidents is to have a place where personnel can confess without being ridiculed or punished or [required to] publicly cast [a negative] reflection on fellow workers. A flight engineer not so long ago related how the pilot and copilot, in using the checklist preparing for an approach, had neglected to read the gauge to get the hydraulic pressure. It was not the flight engineer's function to read the hydraulic pressure but as a matter of curiosity he did, because the gauge was of a new type; much to his surprise, it read zero pressure. He immediately informed the captain, who declared an emergency. A safe landing was made but the results could have been disastrous. He discovered that the captain was responding to the challenges on the checklist by habit rather than by actually checking the instruments and controls. He could not tell this to management without crossing the captain. The captain did not consider that it warranted further attention. … Pilots are hesitant to report near collisions with other aircraft for fear of the punitive action that might follow. But such statistics on near-accidents should be known if accidents are to be reduced. A way should be found to confess without jeopardizing one's career. Information on potential accidents is often obtained by casual gossip. … For example, a captain checking his [instrument landing system flight] path under [ceiling and visibility unlimited] conditions found that [the flight path] was considerably in error; the cause was determined to be some disturbance in the ignition system. At that time, few if any pilots realized that such disturbance could throw off the ILS [cause erroneous indications] even though the instruments would indicate normal functioning. In a casual way, he mentioned his trouble to a fellow pilot a few weeks later. Eventually, it got around to management. Such important information should not be allowed to migrate, it should be propelled. … The industry often prefers to move slowly in safety matters and for good reason. The government does not have to live with the safety measure as the airline does. The airline may not have the personnel required to service properly a safety device; it may have had unfortunate experience with previous hasty adoption of a safety measure; it may lack the manpower to study the numerous safety ideas that are always being advanced; it may have huge sums invested in the old way of doing things with a good record [so that] it may not be convinced on a safety measure; and there is always the point that if only limited funds are available for safety, who has the wisdom to decide with certainty where it should be spent most profitably to obtain the greatest safety."

"A way should be found to confess without jeopardizing one's career. Information on potential accidents is often obtained by casual gossip."

In handwritten notes after an address titled "Infusion of Safety Into Aeronautical Engineering Curricula" before the Third International Conference of the Royal Aeronautical Society of Great Britain and the Institute of Aeronautical Sciences of the United States, Brighton, England, Sept. 3–14, 1951, Lederer wrote, "I had to show that mistakes in design were being made. I used topics from [Cornell-Guggenheim Aviation Safety Center] *Design Notes.* Nowhere did I use the word 'American,' but the *London Times* next morning published on page two 'American Engineers Make Mistakes,' in bold type. Christopher Clarkson, the British air attache at the Washington [D.C., U.S.] embassy offered to meet with the editor to make amends but I felt it would prolong the agony. It took two years for me to live this down! Very embarrassing!" In the address, he said, "Anyone venturing into this complex field should do so with great humility and restraint, but a beginning should be made if for no other reason than that others can either build upon it, or tear it down, and in doing so establish a science of accident prevention in aviation."

In "Reduction of Aircraft Accidents" — presented to the Air Research and Development Command Flying Safety

Conference, U.S. Air Force, Baltimore, Maryland, Sept. 15, 1954 — Lederer said, "When an engineer comes across a design problem that might, with further attention, be made functionally simple to maintain or operate without the need for literature or extraordinary precautions, he is often prone instead to put another page in the operations or flight manual, hoping that it will be read. … If he drops a pencil [in the college laboratory], there is no danger of jamming a control. So that on top of being literate, the engineer is poorly oriented by his college training for an adequate appreciation for good human engineering. … The rapid growth of the aviation industry has required experienced talent to be spread very thinly [among] young engineers that have been brought in. It is hardly considered intelligent to repeat errors made in the past, but with pressure on the engineer to produce, [errors] may be excusable so far as the individual is concerned, but not from the standpoint of the organization. When the thoroughly competent designers who have learned their safety lessons by sad experience are moved up to higher administrative posts, they often leave a void in which the upcoming generation must learn again the sad way."

"Most flying operations involve routine procedures. This leads to the grave danger of complacency. … Safety is an outgrowth of good management. It requires active encouragement of the top echelon of management. Complacency is overcome by constant supervision, constant pressure. Therefore, it is better to stress the proper way to accomplish a job rather than to show mistakes; the positive approach, rather than the negative. The exception is where emphasis is needed to combat the special safety problems created by complacency. Because air safety is so complex and its problems are so changeable, this requires shifting emphasis by an alert management. The tools at hand may be humor, grim incidents, random checks by high authority, but most importantly, close, constructive personal contacts between well qualified specialists (who may be supervisors) thoroughly sold on safety and the people with whom they are dealing."

In "The Progress and Challenge of Air Safety" — presented Dec. 9, 1954, to the Nederlandse Vereniging voor Luchtvaarttechniek, Netherlands — Lederer said, "It is an honor for an American to be asked to speak on air safety in Europe, especially in view of your longer tradition of carrying passengers by air than ours in America. But safety should have no international boundaries. … I should like to say that I do not consider myself an expert in air safety and I believe there are no experts in this phase of aviation. Safety covers too broad a field and the art of aviation changes too rapidly for any person to consider himself to be an expert. The best one can hope to be is a good student of the subject."

"Safety covers too broad a field and the art of aviation changes too rapidly for any person to consider himself to be an expert. The best one can hope to be is a good student of the subject."

In an undated paper (circa 1957) "Problems in Promoting Air Safety," Lederer said, "While in one way the threat of litigation tends to subdue the circulation of safety proclamations, in another way, litigation impels management to keep abreast with the state of the art. Backwardness and omissions in adapting safety measures furnish ammunition to the opposing lawyer for accusations of negligence. Judgments based on negligence can run into millions of dollars. However, some managements are more alert and progressive than others in seeking and accepting safety developments. The less progressive are often blamed for placing costs above safety. I am more inclined to feel that complacency or lack of information at the top management level is the cause of most deficiencies that may exist. I cannot bring myself to believe that responsible management is less morally conscientious than myself or this audience. I prefer to believe that where backwardness exists, it is due to either lack of recognition of the importance of adapting a safety development or honest differences of opinion of the kind that persist between pilots themselves as to standard color for lights to warn of propeller malfunctioning."

In "Une Initiative Americaine," dated April 3, 1959, Lederer said, "As a member of the ICAO Jet Implementation Panel, the director of Flight Safety Foundation was surprised at the progress that had been made to plan for and implement the elements necessary for safety in aircraft operation. Unfortunately, this was true mainly of the technically progressive nations that have always been so oriented. The governments of many technically undeveloped nations are properly concerned with providing minimum social services for their people — schools, highways, hospitals — but apparently fail to recognize that funds provided to facilitate air operations will enable them to accelerate their economy and thereby expedite the provision of improved social services to their people. … [The Foundation's] main objectives are to combat complacency (which often is the outgrowth of a good safety record), to refresh the memories of pilots and mechanics to safety lessons they may have forgotten, call their attention to new techniques and plead with them always to remember their tremendous responsibility to their fellow men. … The fact that the Flight Safety Foundation has requests for one million bulletins per year from airlines indicates it fills an important gap. The Flight Safety Foundation enjoys a freedom of expression and a liberty of action which is often denied a government organization or an industry association."

In "Observations on Safety" — presented to the Radio Technical Commission for Aeronautics Meeting, Atlantic

City, New Jersey, Oct. 15, 1959 — Lederer said, "A proximity-warning device or collision-avoidance system would be a partial antidote for the uncertainties of air traffic control, at least for en route operation. Furthermore, in many parts of the world there will be no air traffic control complex for a long time; therefore, a proximity-warning system or a collision-avoidance device seems enormously desirable. The problems inherent in developing an anti-collision device are tremendous, especially if the perfect device is demanded. Perfectionists find no solution for any difficulties and find a difficulty in every solution. The search for perfection may lead to unnecessary development delay and to collisions. Only 8 percent of collisions are head-on. Why wait to solve the head-on problem if 92 percent can be avoided? On the other hand, the device should not create more hazards than it eliminates."

In "Airports and Safety" — presented to a symposium called The Issues and Challenges of Air Transportation, sponsored by Connecticut General Life Insurance Co. Nov. 1–3, 1961 — Lederer said, "The number of landings per fatal accident has improved in the past 10 years about tenfold. The absolute number of fatal accidents, as distinct from the rate, continues to be serious because the number of landings in 10 years has more than doubled. In respect to the airport and the operators of aircraft, about 30 percent of all accidents in transport operations occur in the approach-and-landing phase. A very high percentage of these can be attributed to inadequate facilities at the airport. … The problem of the landing aircraft can be attacked by giving the pilot the aids he needs during the critical time of landing so that even if he is an expert, he will be less prone to undershoot or overshoot. As a body, the professional pilots indeed are experts, else they could not have established a safety record which provides life insurance at the same rate as a chess player. However, they represent a cross section of the population, with all the human frailties this implies: Their competence will vary; they have good days and bad days. It is not sound to assume that all pilots are continuously at their peak performance. Automatic all-weather landing systems should improve the situation where airports and aircraft are equipped with these devices after their reliability is proven. Airports are also used by less expert pilots flying without sophisticated instrumentation. Both the sophisticated [pilot] and the ordinary pilot will continue to depend on proven aids and flight-oriented [air] traffic controllers to reduce the possibility of pilot misjudgment."

"It is not sound to assume that all pilots are continuously at their peak performance."

In 1962, Lederer presented the Daniel Guggenheim Award Medal Lecture during the American Society of Mechanical Engineers (ASME) Aviation and Space Conference in Washington, D.C, "Perspectives in Air Safety," which included the following excerpts:

- "Civil aviation cannot exist without being safe. … The worldwide air transport system is a technical triumph of the first magnitude."

- "Even in the case of a public carrier, however, the law cannot attempt to protect the passenger against every risk without closing the frontiers of progress. To encourage engineers and designers to exercise their imagination and ingenuity in the design of aircraft, the civil air regulations are phrased in broad objective terms. This provides considerable latitude for the designer and results in variations in safety. By and large, the industry continues to offer improved aircraft and equipment. Many manufacturers and airlines are not content to comply with the letter of the law; they go far beyond it voluntarily, to follow the 'intent' of the law in adopting safety devices and procedures. Others hew strictly to the letter of the law or regulation. Because of this, one may find that designers have improved safety in one respect and not in others. An example is the regulation which requires that passenger emergency-exit markings shall be illuminated with an emergency power supply independent of the main electrical system. This is done to assure that, if a crash occurs in darkness, the occupants have an independent source of light. In most air transports, each light has a separate battery to power it, but the regulation does not specifically demand this discrete protection, so one may find only one battery supplying all the emergency lights — and this one battery located in the nosewheel well of the airplane, the place most likely to suffer disintegration in a crash! The *letter* of the regulation but not the *intent* of the regulation has been satisfied in this case."

- "People will live or die on the basis of decisions made by engineers or by the superiors to whom they submit their plans. The pressures which militate against safety, the urgency to meet a design deadline, fear of competition, production problems, and financial commitments tend to distract the engineer from his responsibility for the safety of the public. The engineer with a conscience and a sense of public responsibility will meet many occasions and situations where his convictions and principles will be put to the test. A thorough study of the total cost of risk in terms of insurance, lost revenue, legal expenses, public acceptance and other losses, has never been made. It might help alter the emphasis on performance and assist the engineer in resolving his dilemma."

- "The infrastructure of aviation never seems to catch up with the needs of the aircraft. It has been common in the past for each new generation of aircraft to be operated under conditions not even entirely satisfactory for the aircraft they replaced. … The personnel and financial requirements of the aviation infrastructure compete with roads, schools, hospitals, housing and industry. Operational efficiency and safety suffer as a result. … The civil airspace is not a fitting place for political antagonism, rather it is a place for harmony, cooperation and coalition."

- "The Flight Safety Foundation expects to revive its dissemination of specific information on lessons learned. It started this in 1948 but had to abandon it because some felt its reports might fall into hands that would use them against the organizations which supplied the information."

- "It is not unusual for many years to pass before a proven safety device is adopted. … These lags perhaps result from the need for technological statesmanship, for the ability to recognize the total value to the industry and society of accelerating the adoption of a seemingly costly device or standard procedure. This is a more charitable view than ascribing lag to the egocentric attitudes of decision makers."

In "Reflections on Human Factors" — presented to the Aviation Contractors Safety Conference Jan. 28–30, 1964, in Virginia Beach, Virginia — Lederer said, "My reactions to the material I scanned [in preparation for this presentation] was first a feeling of inadequacy to deal with the subject of human factors in view of the massive tomes of knowledge which have been produced especially in the last few years, and secondly, a feeling of satisfaction that so many fresh, capable thinkers were devotedly engaged in this field, producing much more information than I had time to read. … Then I reflected on my slowness in helping to spur the development of human factors as such and this line of thought led to other opportunities I have missed in the development of air safety. … In regard to other fields of human factors which I missed, I reconcile my conscience and my pride by rationalizing that a large part of my efforts from the late 1920s up to the war [World War II] were devoted to trying to influence men's attitude towards safety in design, operations and maintenance; to show them that skill alone will not save them from trouble; that judgment, alertness, apprehension or foresight are also necessary, and especially a sense of responsibility to one's fellow men. This is dealing in human factors in a broader sense than what we have in mind today when human factors is mentioned."

In "Safety Briefs on SST [Supersonic Transport]" — presented to the Society of Automotive Engineers National Aeronautic Meeting, New York, New York, April 27–30, 1964 — Lederer said, "To this day it has been estimated that fewer than 15 percent of the world's airways are geared to jet requirements. The funds to install, maintain and operate ground support equipment have not been made available. Jet aircraft are flying in some areas of the world where ground support is barely good enough for DC-3s. Jet pilots are required to orientate themselves on approaches to airports by nondirectional beacons. Folios of reports are available which list the deficiencies of ground support in all areas of the world. The problem is mainly one of economics for the less wealthy nations of the world. Hospitals, roads, schools and other social services have priority over aviation. … A considerable number of jet accidents have remained unexplained. In some cases, the reasons may be known to the bureaucracy of the nation where the accident occurred. The information has been withheld, perhaps, for political purposes, for pride, or for some other reason of policy. … The huge investment, the many innovations in SST, the unexplained subsonic accidents support the need to improve methods to determine accident causation. … Essential information should be obtainable, not only by flight [data] recorders alone but, as in missile flight, by telemetering the data to the ground. The vast amount of telemetered data need not be retained more than a brief period unless an accident occurred. The data then would be available for accident analysis. Satellites might be used to transmit telemetered data."

"Aviation history is studded with ideas that were not accepted, later to be regarded as indispensable. The flight data recorder is a good example."

In accepting the Wright Brothers Award from the U.S. National Aeronautic Association on Dec. 17, 1965, in Washington, D.C., Lederer said, "The outstanding lesson to be learned from the open-mindedness of the Wrights is that civil aviation should not arbitrarily reject a proven device or technique. Aviation history is studded with ideas that were not accepted, later to be regarded as indispensable. The flight data recorder is a good example. … In brief, expeditious recognition of proven techniques or devices and a means for monitoring discipline will accelerate a rise in the level of safety. A corollary to this is to expedite the exchange of accident prevention information, especially the information learned from incidents. … But there are several developments on the horizon which promise to improve transport safety by several orders of magnitude: The installation of modern navigation and approach aids in underdeveloped areas, and the automatic approach devices, if successful, should reduce the fatal accident rate by perhaps 30 percent. The prospects of preventing fires following a survivable type of crash are good, and they should cut fatalities at least another 50 percent."

In an untitled paper presented during the Canadian Industrial Safety Association Conference in Toronto, Ontario, Canada, Sept. 18–19, 1967, Lederer said, "In my position [as director of manned space flight safety for the U.S. National Aeronautics and Space Administration (NASA)], I must attract scores of technical specialists to help with the complex problems of space. Specialists in structures, chemical engineers, civil engineers, reliability experts, test pilots and many others. The word 'safety' carries no romance; it is the absence of danger or risk, and as I said before, it denotes only a small segment of the total problem — protective equipment. Furthermore, the word 'safety' implies protection of lives. Many activities involve great risks of prestige and resources with minimum or no risk to life. Unmanned space operations fall into this category. The phrase 'loss prevention' covers both life and property. But to attract the kind of required talent, and for logical reasons, the word 'safety' is being supplemented by the phrase 'risk control.' This rings with challenge, with measurement, with analysis, with action, with status. In discussing this concept with Dr. Wernher von Braun and his staff, the phrase 'risk management' was proposed as a better alternative. Either one is a more satisfying definition of the true responsibilities of a safety engineer than 'safety,' I feel."

At the same conference, Lederer said, "[Systems safety engineers] must learn from the experience of others because they will not live long enough to make all the mistakes themselves. Preconceived opinions and intuitive judgments are often proven to be wrong when weighed against the cold hard facts of service experience."

"Systems safety engineers must learn from the experience of others because they will not live long enough to make all the mistakes themselves."

In "Ideal Safety System for Accident Prevention" — presented to the Symposium on Air Safety, sponsored by the *Journal of Air Law and Commerce* at Southern Methodist University, Dallas, Texas, April 22–24, 1968 — Lederer said, "Negligence results from attitudes, the most important single factor in reducing losses. Complacency, carelessness, incapacity, arbitrary rejection of suggestions because of pride, apprehension or suspicion, deliberate departure from accepted good practices (which occurs even in the face of excellent training), the nature of pressures exerted on management and by management in design and operation hinge on attitudes — attitudes of individuals, attitudes of society, attitudes of the government, of shareholders or industry associations, of unions and even of the man who sweeps the hangar floor. … Over the years which I have been engaged in aviation, nothing has given me more gratification than acceptance by mechanics and many pilots of codes prepared for them."

In his keynote address to the Government-Industry System Safety Conference at Goddard Space Flight Center, Greenbelt, Maryland, May 1–3, 1968, Lederer said, "Several problems remain to be solved before a lunar landing can be made with reasonable chances of safe return to Earth. Longitudinal vibration, powerplant reliability, space suit modification and lunar landing techniques are among the prominent subjects receiving concentrated attention. Time is a major factor. Once basic research is done, however, time schedules are not undesirable restraints if they are within manpower capabilities. Establishing a target date induces tight organization, drive and spirit; it creates momentum, compels identification and attention to significant factors, establishes motivation. It acts as a goad to a goal. The target was set by the White House seven years ago and was recently reemphasized in a presidential address at Houston [Texas]. However, the loss of time as a result of the [fatal Project Apollo space-capsule] fire of Jan. 27, 1967, has left its mark. The lessons of the fire have, of course, been learned. Corrective action has added some 2,000 pounds to the weight of the spacecraft and this, too, creates problems. Apollo will be operated with reasonable assurance of success even if a new target date has to be set."

On March 16, 1969, Charles A. Lindbergh, known worldwide for his 1927 solo flight from New York to Paris, France, wrote the following letter to Lederer, who was then director of manned space flight safety for NASA: "You have written that I should not bother to acknowledge the items you send from time to time, and probably I will usually take you up on this (with many unstated thanks) because my mail piles up in amounts that I simply can't cope with in the hours I devote to it. But I am so impressed by, and interested in, your paper on 'Risk Speculations of the Apollo Project' [see page 65] that I can't resist writing and telling you so. Anne and I have both read it with fascination. I have always felt that risk should be related to objective, and you have handled this relationship beautifully."

In "Human Error Will Persist — Can Its Effects Be Minimized?" (*Flight Operations*, 1976) — Lederer said, "Management is monitored. Congressional oversight committees monitor the [U.S. Federal Aviation Administration (FAA)], the FAA monitors the airlines, the media also monitor the aviation industry by publicity given to accidents. But day-to-day cockpit performance has not been monitored until fairly recently. Several airlines now use flight [data] recorders for this purpose. It is done with the consent of the flight crews under carefully controlled conditions which accentuate lessons learned while punitive measures are eliminated. The results have benefited safety. … It is a tribute to the cooperative attitude of managers of aircraft (pilots) that a form of acceptable flight monitoring has been evolved on several airlines. It would appear to be the way of the future to intercept unaware, unintentional or deliberate departures from good practice before they become fatal. Incidentally, this was proposed at an air safety conference way back in 1937."

In a January 1978 paper, "The Flight Safety Foundation: Early History," Lederer said, "At its peak, the Flight Safety Foundation had 65 employees." He said that the Foundation's accomplishments to date included the following:

- "The Foundation initiated collection and dissemination of mechanical-malfunction reports in 1947, now accomplished by the U.S. Federal Aviation Administration;
- "Spurred the acceptance of flight data recorders, anti-collision lights, crash/fire/rescue training, use of simulators in accident investigation and standardization of pilot training;
- "Initiated an anonymous pilot reporting system in 1964; [and,]
- "[The FSF] staff has received more than 50 individual awards for contributions to aviation safety. FSF has been called the 'conscience of the industry' for quietly disseminating aviation safety imperfections and uncertainties with remedial suggestions."

Lederer said, "The Flight Safety Foundation has a long history of safety research and investigation, both under government grants or contracts and confidential projects for its members. A unique research and study capability exists because the Foundation enjoys its freedom of action and of communication in a completely independent and objective environment. Some of the past funded research activities of the Flight Safety Foundation are:

- "Crew complement evaluation (CAB);
- "Cost of general aviation accidents (FAA);
- "Weather as a contributing factor in air transport accidents (U.S. Weather Bureau);
- "Synthesis of aircraft crash/fire/rescue and evacuation technology (FAA);
- "The communication of weather intelligence to general aviation (U.S. Weather Bureau);
- "Survey of occurrences involving loss of control of swept-wing aircraft (FAA);
- "Economics of safety in civil aviation (FAA);
- "Cost-effectiveness of using arresting gear for air transports (FAA);
- "Revision of medical standards for airmen (FAA);
- "Psychological requirements for air traffic controllers (FAA);
- "Near-collision study — Project SCAN (FAA);
- "Project GAPE — General Aviation Pilot Education (FAA);
- "Technology for detecting clear air turbulence (FAA);
- "CAPTACS — terminal area traffic control (FAA);
- "Effect of runway grooving on general aviation aircraft (NASA);
- "Study on cabin evacuation (FAA); [and,]
- "Safety aspects of operating passenger helicopters from the roof of the Pan American building (New York Airways)."

"Flight Safety Foundation publications [11 scheduled periodicals at the time] are designed to enhance the effectiveness of the safety efforts of its members," he said. "Information contained in these publications supports management safety programs. Publications offer both original and reprint material, and are themselves reprinted in magazines and flight operations publications throughout the world."

The Foundation's two annual meetings — the International Air Safety Seminar and the Corporate Aviation Safety Seminar — "bring together world leaders in aviation to share and exchange the best and latest operational and technical information relating to aviation safety," Lederer said. "In addition to the annual seminars, the Flight Safety Foundation also holds a number of workshops for pilots, flight crews and flight attendants. Notable among these recently was a four-course workshop dealing with approach-and-landing accident prevention, aviation safety program management, aircraft accident investigation and human factors in accident prevention."

Advocating "positive safety management," the Foundation offered aviation safety assistance programs (ASAP), which comprised "operations and safety surveys to provide management with a confidential appraisal of the performance levels of safety and efficiency in its aircraft operations," he said. "By sending highly qualified review teams to those companies requesting such a survey, the Foundation helps to uncover major and minor deterrents to safe operations and offers suggestions as to how to rectify them and prevent recurrence."

On April 21, 1982, Lederer presented a Wings Club Sight Lecture in New York, New York, "Aviation Safety Perspectives: Hindsight, Insight, Foresight." The following examples from the lecture were often cited in his articles and lectures:

- "[Aviation pioneers Orville Wright and Wilbur Wright] installed the first flight data recorder, automatically operated, on the first [powered aircraft] flight [on Dec. 17, 1903]. It recorded engine revolutions, distance through the air and duration of flight. … Several airlines have used [flight data recorders] to detect departures from good practices before they result in an accident, a very important safety measure."

- "One in every six airmail pilots was killed in the nine-year history of the U.S. Air Mail Service. … From the standpoint of safety, the Air Mail Service showed among other lessons the danger of exerting injudicious management pressure on pilots, a lesson that needs reiteration. It also emphasized the differences in ability of pilots to manage risks. … Good airmanship was conceived as a combination of skill and judgment. Now it embraces resource management."

- "Incidentally, two members of the Wings Club were involved in the very first formal course in aircraft accident investigation. This was conducted by the Flight Safety Foundation at Mitchel Air Force Base [Hempstead, New York] in 1948. R. Dixon Speas was one of the lecturers; Ms. Gloria Heath was the project manager."

- "Advances in micro-electronics and sensory devices are expected to enlarge the scope of [ground-proximity warning systems (GPWS)] and [minimum safe altitude warning systems (MSAW)] in relation to the entire approach-and-landing procedure. The pilot will know his position in space with increasing accuracy in reference to terrain. Avionic developments of the near future will provide a form of extra-sensory perception for the pilot that should improve safety by an order of magnitude. … The reliability of digital electronics and the associated memory systems should add several magnitudes to the safety and efficiency of flight by providing prompt access to critical information."

In "Safety Science in Aviation" — presented during the First World Conference on Safety Science in Cologne, Germany, Sept. 24–26, 1990 — Lederer said, "Safety could be strengthened, in my opinion, if the presidents of the airlines involved in an accident would be required to describe in person their safety policies and their implementation [of policies] at the hearings of the accident investigation."

In 1995, NTSB Chairman Jim Hall closed his speech during a seminar of the International Society of Air Safety Investigators by paraphrasing the following ideas, which he attributed to Lederer: "It is impossible to say that safety in air transportation is, has been, or will be achieved by any one specific piece of equipment, by experience alone, solely by conservative [investigative] policy, by [solid] research, by virtue of good organization, or because of government regulations. All these elements, cemented together by [investigators] imbued with a spirit of apprehension combined with a deep sense of responsibility for the safety of the flying public, have brought about our present laudable air safety record and will continue to improve on it."

Congratulating Lederer in 1997 for receiving the Aerospace Life Achievement Award of the American Institute of Aeronautics and Astronautics, U.S. Rep. Randy "Duke" Cunningham of California said, "You have made outstanding contributions to your industry and to the welfare of the people of the United States of America, and have truly earned the title, 'Father of Aviation Safety.'"

In another congratulatory letter for the award, U.S. Rep. Brian P. Bilbray of California said, "As an aerospace pioneer, you have demonstrated the American spirit to create a world that is safer for everyone. As an engineer, you have transformed the unimaginable into the standard. Your determination and dedication reflect your allegiance to the highest standards of public service."

Dr. Assad Kotaite, president of the Council of ICAO, said while presenting the 1999 Edward Warner Award to Lederer, "Safety has been the primary goal of ICAO since 1944 and it has also been the fundamental goal of Jerome Lederer, who has often been referred to as 'Mr. Aviation Safety.' From the very beginning of his career with the U.S. Air Mail Service in 1926 until now, Mr. Lederer has spared neither his time nor his efforts to make aviation safer."

In 2002, Lederer said that 14 million Americans have Alzheimer's disease, and he wondered about their safety when flying. "How do you remove them quickly from an airplane involved in an accident?" he said. "They quickly forget instructions."

The Skygod.com Internet site, on its page of great aviation quotes, in 2002 quoted Lederer as saying the following:

- "Every accident, no matter how minor, is a failure of the organization."

- "The alleviation of human error, whether design or intrinsically human, continues to be the most important problem facing aerospace safety."

- "Of the major incentives to improve safety, by far the most compelling is that of economics. The moral incentive, which is most evident following an accident, is more intense but relatively short lived."♦

Jerry Lederer: His Own Words

In 1994, at the Lederer home in Laguna Beach, California, FSF staff recorded on audio tape more than 17 hours of Jerry's recollections. Some of Jerry's favorite memories in this oral history provide us with a more complete picture of this extraordinary man.

—

FSF Editorial Staff

Early Years

In 1910, there was a big aviation display at Belmont Park in New York. Quite a few people there became very famous, Glenn Curtiss and others. That event got me interested in aviation; I had a sort of hankering to get more into it.

Jerry Lederer at age 5.

I was fortunate as a boy to grow up in New York City at a place called Washington Heights. I used to spend my time camping in the woods on Manhattan Island, a very beautiful place full of forest and empty spaces.

When I was about 12 years old, some buddies and I built a log cabin on Manhattan Island, which stayed up for three years, before some guy got in there and tore it down. We also used to play in a house built on top of a hill that belonged to Mr. Audubon, the famous artist who painted birds.

One friend and his brother had a canoe on the Hudson River near where we lived, and that got me into canoeing. I have gone about 20,000 miles by canoe. If you can canoe on the Hudson River, especially in bad weather, you can canoe most anywhere. Our main objective was to run rapids. One of our delights was to get behind a ferry boat and ride the wave from the paddle wheels; it was like riding rapids.

One Sunday afternoon, another fellow and I went out in his 15-foot cedar canoe to ride the waves, and a boat called the *Shady Side* came up from the southern part of Manhattan along Fort Washington Point. The tide there pulled us under the overhang of the boat. So we were trying to push off the side of the boat with our paddles, and we did not have very much time. The boat's paddles were coming towards us. Then the canoe turned over and we went down. I was not afraid, but the only thing I could think was how it would be to have my head cut off by a paddle wheel. When we came up, the boat went on; I guess the crew did not know that they had hit us.

A *New York Times* reporter was among the people out for the afternoon, and somebody gave him my name.

The next day, there was an article in the newspaper about these two kids who were hit by a boat and narrowly escaped death. I took one half of the canoe home with me that day, and I told my mother that a friend had been hit by a boat, and that I wanted to keep it as a relic of our past friendship. This hung in my little room, where we lived, and that was all right until about a week later when my mother went to the butcher shop to buy some meat. On the counter was the newspaper article, and she happened to read it. She was so mad that she would not talk to me for about a month.

We also used to go up the Hudson River as far as Albany, camp along the way, and hitch a ride with barges, hang on to them at night or put our canoes on board, and go up to Bear Mountain, a very famous resort. We would stay overnight and come back the next day. Later we began running rapids in the Adirondack. From the Adirondack, we went into Canada and used to spend two and half months — college vacations — in Canada. We paddled several times from northern Quebec down to New York City.

We were just four kids, and we each had our own wooden canoe one summer. We had gone to Northern Canada to shoot rapids and to paddle down to New York City. We had to take along our own food to last three months.

One day we came across an abandoned Indian settlement or camp. One log cabin had a lot of rifles all over the place, maybe a dozen. And we found one bullet. So I gave the rifle to the fellow who I thought was the best shot in my group. I left a note at the cabin saying that we had borrowed this gun and that we would give it back at the next Hudson Bay Co. trading post, which was about a three-week canoeing trip. We thanked them in advance and stuff like that, and gave them my name.

Henry Foote and moose.

The guy with the rifle [Henry Foote] shot a moose from a moving canoe at a distance of about 100 feet [30 meters] the next day. We were so anxious to get meat, we could eat it raw. I didn't but the others did. You could feel your strength coming back as you ate the meat.

On the way up to the next Hudson Bay post, the guy turned over in the rapids and lost the gun, so we were not able to return it. A year later, we were in the same area, and we were going by a huge Indian camp when a white man paddled out to us because we had double paddles. Nobody used double paddles except the Eskimos, so we were distinctive. The man said, "Any of you fellows go by the name of Lederer?" I raised my hand. He said, "Well, Mr. Lederer, I was with the Royal North-West Mounted Police [now the Royal Canadian Mounted Police] last year. I am now married to the daughter of the chief of this tribe. We found your note about the gun, and now we want to get the gun back. I followed you last year, the best that I could, for about four weeks and I lost you. We knew that you were Americans, but you walked across the border [illegally]."

Jerry Lederer far right.

We had our canoes built in Canada, and to take them across the border at a checkpoint would have meant paying an import tax.

Jerry (far right) and his companions portaged their canoes and gear during trips.

We had no money, so we had sneaked across the border at night the year before and then paddled down to New York City. So I asked how much he wanted for the gun. And he said [US]$25. We did not have any money, so we told him that we would send him a check when we got home, which we did. I do not know if you should call being pursued by the mounted police an honor. But this was one case where we were pursued by them and they did not get their man — until the second time.

The University

The principal of George Washington High School [in New York] told me that New York University College of Engineering was offering scholarships, and said that I ought to try for one. He had arranged my appointment. To get a scholarship, I had to appear before a body of three or four professors who asked me a lot of questions. They wanted to know my background, high school marks, outside activities. I told them about canoeing — things like that satisfied them, but they wanted to know more.

Then they asked me what I thought about the New York Yankees baseball team. Well, I would not have known a Yankee from anything because I had given up playing baseball when I was about nine years old. Fortunately, I had ridden the subway to the interview, and the man who was sitting across from me in the subway car had a *New York Times,* and the headline was "Babe Ruth Sold to the Yankees." I would not have known Babe Ruth from a hole in the ground. But when the professor asked me about the Yankees, I said, "Babe Ruth would do well by them." That satisfied them that I had an interest in current sports. If I had not answered that way, they probably would not have given me the prize scholarship.

Anyway, I entered the College of Engineering at New York University in 1920. I graduated in 1924 with a bachelor of science degree in mechanical engineering, aeronautical options. Then a professor asked me to stay on for a year as his assistant, so during that year I erected and operated the first wind tunnel at New York University. It was a four-foot [1.2-meter], 40-mile-per-hour [64 kilometer-per-hour] wind tunnel that we got from the Curtiss Co. My job was to erect it and calibrate it, and then run it for a professor. I did that for a year, and I got $12 a week. I received a full mechanical engineering degree in 1925.

When I went to New York University, I figured that I would go through engineering school there, and then go to Massachusetts Institute of Technology — MIT — to take the aeronautical course. Fortunately, the man who ran the aviation course at MIT opened the aviation course at New York University. My professor took the seven highest-rated students in mechanical engineering for this course; about a dozen had applied for it, and I was lucky enough to get in among the seven.

In 1925, Alexander Pacz, a Hungarian expert in metallurgy who had invented aluminum silicon alloy, asked me to accompany him on a three-month trip to Europe to see how the Europeans were using his alloy in various enterprises and automobiles. It paid for my first trip to Europe, and I was very much impressed. When I came back to the United States in 1926, I started to look for a job in aviation, but aviation was not much of an industry.

I took a job as a surveyor for the West Shore Railroad of New York. It was a nice job, out in the open all day in the most beautiful part of the Hudson Valley. I liked the job and I did not want to give it up, but I had to go back into aviation.

Flying

In regard to learning how to fly, I wanted very much to do this, and while I was in college, I tried to get into Naval aviation. But when I went for my physical, they turned me down on account of my eyes. Later on, when I got into industry, I was so busy that I never got the time to do it, although I did take some flying lessons and made three or four trips. Then I became so immersed in what I was doing for accident prevention that I did not take any more lessons.

Air Mail Service

At what is now Teterboro Airport in New Jersey, I went in 1926 to the Whitman factory where de Havilland Airplanes were built for the U.S. Air Mail Service. I could not get a job there because they were going out of business pretty soon. I happened to read an article in [*Aviation*] magazine [a forerunner of *Aviation Week & Space Technology*] about a new facility being built at Maywood, Illinois, by the Air Mail Service to maintain and rebuild the de Havilland airmail planes. So I wrote to the man in charge and asked him if he needed an aeronautical engineer. He wrote back that he did, and said, "Come on out." So my first job in aviation was with the Air Mail Service in Maywood. We used the British de Havilland 4, Liberty-powered biplane.

Jerry Lederer.

I drew specifications for new parts and developed test methods for new ways of operating the airplane. I put out my first safety bulletin when I was with the Air Mail Service. We had a lot of crack-ups, of course. We had a great number of spare wings but no spare fuselages. So my first safety bulletin addressed to the pilots said, "If you do crash, please crash the wings first. Go between two trees and take the wings off. We have plenty of wings but no fuselages." My first safety bulletin — I wish I had a copy of it.

Pilots Pressured

The main reason for the terrible fatality record in the U.S. Air Mail Service in the early 1920s was psychological pressure put on the pilots to fly regardless of weather. The Post Office Department had to prove to a really skeptical Congress that airmail was reliable and, therefore, pilots were told not to let weather interfere with a scheduled flight. After about two years, the pilots called a strike — not for money but for safety — to rebel against the idea of flying regardless of weather.

The way that they resolved this was by an agreement. If the station master at the airmail field ordered the pilot to fly regardless of weather, the pilot would then invite him to take a trip around the airport in the front cockpit of the de Havilland mail plane. This would expose them to the same hazards as the pilot, and acted as sort of a buffer between the pilot and the pressure to fly regardless of weather.

Human Factors

When we lost all those Air Mail Service pilots in the early 1920s, the usual cause of death was a fire following a crash. We lost one in every four pilots in the first two years of the operation. That was before I went to the Air Mail Service, but I inherited the problem. To find out what caused the fires, the Air Mail Service in 1926 sent [several] de Havilland airplanes to McCook Field in Ohio [now Wright-Patterson U.S. Air Force Base, Dayton], where they would be studied. We built a concrete ramp with a concrete wall at the end of it, then put these ships under full power and let them go down the ramp into the wall. We took slow-motion pictures of what happened. [This was the industry's first crashworthiness test.]

These de Havilland airplanes had water-cooled Liberty engines and an exhaust pipe that went down the side of the fuselage. The pictures showed that when the airplane crashed, the fuel spilling out of the tanks — which were carried up front in the fuselage — would go onto the hot exhaust manifold and start the fire. We did away with the hot exhaust manifolds and, in place of them, put small aluminum-finned exhaust cylinders on each one of the engines. The fins made them run cool. These were further away from the crashed fuel tanks. We made quite a few more tests, and there was no fire.

So I ordered one set that we put on a de Havilland. The test pilot flew this airplane for a week during our daily hours of work. He said that the performance was much better too, so I ordered 20 sets, and we started to put them on airplanes. But right away, we had to remove them — the reason being that when the pilot flew at night, the flames coming out of the short exhaust stacks blinded the pilot and he could not see ahead. That was my first lesson in human factors. Very embarrassing because I ordered 20 sets and had to send them back.

Several safety lessons emerged from this experience:

- In conducting operational tests include — if feasible — the entire operating regime of the object under test. Our tests at Maywood [Illinois, the base of operations] had been made in daylight, not at night.

- Continually question assumptions used to arrive at a decision. I had assumed that the Army had fully tested the new stacks.

- Be sure to consider the human factors aspects of a design before changing it.

- Before changing the configuration of an aircraft or any part of it, determine why it was designed that way in the first place.

Statistics

It is very difficult to measure safety; there is no one really good way. If you put it on the basis of accidents per number of flights — which is what many are doing now and much better than some measures — the automobile is probably the safest form of transportation, because you get into and out of the automobile every day.

A story I often use is: Statistics are like a bikini bathing suit, what they reveal is important, what they conceal is vital. I tell another story about the woman who had triplets in the hospital, and her friend said, "It must be a very unusual incident to have triplets, is it not?" The woman said, "Yes, people tell me that there is only one chance in 80,000 of having triplets." And her friend said, "One chance in 80,000! When did you find time to do your housework?"

By the way, I do not believe too much in statistics. To give you an idea why: In 1922, the U.S. Air Mail Service won the [Robert J.] Collier Trophy for flying a full year without a fatal accident, but in that same year, we had about 740 forced landings. So, how safe was it?

Charles Lindbergh

Charles Lindbergh was flying for an airline from Maywood. He came into my office early one morning carrying a parachute. He wanted to show me this very strange thing about silken parachutes. He had bailed out the night before, flying from St. Louis, Missouri, to Chicago, Illinois. His reason for bailing out was that he was caught in bad weather, and his fuel supply ran out. Someone had changed the tanks in his airplane without telling him. He had 20 gallons [76 liters] less than he usually had. He bailed out successfully, although the airplane kept circling around, and he was afraid of being hit by the airplane.

The reason that he brought the parachute to me was that it was full of great big brown holes. It appears that the field that he landed on was covered by grasshoppers. Grasshoppers exude a juice that burns through the silk — in those days, parachutes were made of silk. I believe that was his second jump or third jump while flying the mail around 1926. He was very quiet and very modest, but very observant — and a nice guy to be with.

The afternoon before Lindbergh made his famous flight nonstop from New York to Paris, I went out to the field and I looked the airplane over. I did not have too much hope that he would make it. He did not ask me to look at the airplane. I just went out because I was a friend of his, and I wanted to see it, to look the situation over.

Years later, the Port Authority of New York asked me to check out the roof of the Pan American Building in New York to schedule helicopter landings. During lunch at the Wings Club, Lindbergh came in and sat with us. I invited him to come to the roof. Lindbergh was a very practical sort of a guy. He was tall, and the way he checked out the wind situation was to take a handkerchief out of his pocket and hold it as high as he could, let it drop down and see what that wind did to it. And that was a pretty good test in those days.

Jerry consulted on the design of this Studebaker.

Lindbergh usually was very stiff. He spoke only those words which he had to. When his son was with him — you have never seen such adoration as that boy obviously had for his father. As the father grew older, he [the father] became much less stand-offish. He relaxed a little, and he was easier to talk to.

Another time that I was with Lindbergh was on the evening before the Apollo 11 launch to the moon. I asked Lindbergh to talk at a cocktail reception. He did not talk very long, but he talked to the point about how important this launch was, and said things that would give the people a feeling of being very important. That was the last time I saw Lindbergh.

Amelia Earhart

I had lunch with Amelia Earhart one time. She impressed me very much, like Charles Lindbergh did. She was very quiet, sort of thoughtful, and she gave the impression of being very competent.

Consulting

When the airmail operation was awarded to Boeing Air Transport System, I decided that since Lindbergh had crossed the ocean and made a big splash in aviation [New York to Paris, May 20, 1927], there was a tremendous interest in new airplanes. I decided to become a consultant [and to leave the Air Mail Service in June 1927]. I formed a company known as Aerotech, a term widely used by many other aviation companies. We were fairly busy. I put an ad in *Aviation Week,* and we got quite a few responses.

While I was still with the U.S. Air Mail Service, an airplane flew into Maywood, Illinois — a small cabin monoplane, the world's first cabin monoplane I believe, and it had very odd wheels that looked like baby-carriage wheels to me. Don Luscombe wanted me to look at the structure of the airplane, analyze it and get it certificated by the [Aeronautics Branch of the Department of Commerce]. After I started my consulting business in Davenport, Iowa, in 1927, then I made, I think, 48 changes in the structure of this airplane. We got it certificated, and Charles Lindbergh later bought one.

[Luscombe had hired a self-taught designer, Clayton Folkerts, to design the two-place Monocoupe that could be marketed to businessmen. But the Aeronautics Branch of the U.S. Department of Commerce had begun to require an Approved Type Certificate requiring commercial aircraft design to be analyzed and tested. Jerry was hired to verify Folkerts' data and the aircraft's structural integrity, and ATC no. 22 was awarded in 1928 — then the Monocoupe 22 model was born. Jerry would later design the four-place Monocoach.]

The Velie automobile company was quite prominent in the Midwest in those days. They built Velie roadsters, touring cars and an ordinary passenger car. I had one, and I liked it very much.

The problem was [that] in order to produce the quantity of these Monocoupes [Luscombe's airplane] that was demanded by the public, we had to have a factory. Velie decided to get out of the automobile business, and turn his factory over to the building of airplanes. So I was involved in converting an automobile plant into an airplane plant. That was a rather interesting assignment. I guess it was the first time that ever was done in the history of aviation and automobiles.

Velie also put a lot of money into the engines to power the Monocoupe. They put the Detroit Air Cat engine [the engine used in the Mono 22, the first of several Mono models] — it was not a very reliable engine, from my point of view — in the ship and sold them that way. I always had my fingers crossed about how reliable the engines were. [The Velie engine, built of aluminum, was a good match with the airplane, and Luscombe's operation became Mono Aircraft Inc., a subsidiary of Velie Motors.]

Much later, when I lived in New York, my license as an aero mechanic expired. I went out to Roosevelt Field [Long Island], where the Bureau of Air Commerce had offices, and said that I wanted to renew my certificate. They told me that I did not have any practical experience in welding or anything like that, so they would not renew my certificate. But they had a Monocoach, a four-place airplane for their inspectors, out on the ramp. This was an airplane I had designed for the Velie Monocoupe Co. The demand for the Monocoupes became so great because of Lindbergh's flight.

I found a lot of maintenance faults with it. So I went back to the office and gave the information to them, and they gave me my certificate.

Close Call

A fixed-base operator in Maywood, Illinois, had been a World War I pilot and ran a pretty good operation. He had built a single-engine monoplane for a doctor, and the doctor had brought it back, saying that he had a vibration in the airplane and that he did not want to accept it unless the vibration was fixed. The operator called me one evening and asked me to come up the next day to see what was wrong with the ship that caused it to vibrate. I agreed to do this.

I had been traveling and that same evening, my host had a big party. She served me a special piece of cake with a really nice, sweet, white creamy layer, which I ate. I later learned that an ingredient in the cake could be a powerful laxative. Next morning, I went out to Maywood to see the airplane.

Jerry Lederer designed this four-place Monocoach for Mono Aircraft Inc.

I found that the reason for the vibration was the absence of a steel tube, where they had put in a door. They had taken the steel tube out, and put a door in without replacing the mechanism to take the place of the steel tube that they had removed. I told the operator what to do to fix it. Then I agreed that I would go up and certify whether or not there was vibration, so that the ship could be delivered back to the customer. But I was having stomach trouble at the time.

They welded a steel tube where I told them to weld it. The airplane was fixed. The chief pilot took off and checked the airplane, so it was all right. Then a pilot for the Department of Commerce took it up on behalf of the government and said that it was OK. Then it was my turn to go up with the operator, but I was in the outhouse [toilet]. As he passed by the outhouse to get into the airplane and take off, he told me that he would take a short spin around, come back and pick me up.

While I was in the outhouse, I heard the airplane crash. The operator was killed. I found that the front spar of the wing was 50 percent under strength, and in the high angle-of-attack maneuver which he had done, he pulled back the stick and broke the wing off. So that was one of my close escapes from death. Had I not had stomach trouble, I would have been killed because I would have been up with him.

Designing Airplanes

I did some other consulting. Another job was a Wallace Touroplane. This was a four-place cabin monoplane with folding wings, and I did the stress analysis of that and got it certificated. Another airplane that I worked on was known as the Air King, built in a place called Lomax, Illinois. I designed the airplane, a two-place, Wright-powered biplane and watched it being built, which came out OK. They built quite a few of them, and then they went out of business.

The buyers were the ordinary private pilots in those days. People usually had learned to fly during World War I, and were looking for an airplane to fly around in, or anxious to get into aviation, from the point of view of having a good hobby. These airplanes cost maybe about $2,000 or $3,000.

In those days, you got hold of a big shed or a big hangar, and you painted the walls of the hangar white with whitewash, and that was your drawing board. When you wanted to design an airfoil, for example, you would draw it on the wall of the hangar, make the profile of the airfoil and make your measurements from that to build the wing. These were very primitive days.

Insurance

I went to see Aero Insurance Underwriters in New York looking for new business, and they wanted me to become their technical adviser for the whole Midwest, which I did.

As a technical consultant, they sent me to investigate the conditions of an airline that had a hangar in Maywood. Aero Insurance Underwriters had given me the [registration] number of the airplane. Only one airplane was insured. I went in the hangar and there were three de Havilland airplanes — all with the same number. That is where I met Lindbergh, and we became friends and kept in contact until he died.

Anyway, the company was impressed with my report, and they asked me to become chief engineer of Aero Insurance Underwriters in 1929. That is how I started in the aviation insurance business. I was in charge of accident risk analysis. I would go over the losses, and I learned a lot about what was happening in aviation that should not happen. I started writing a newsletter to keep our insured operators out of trouble. We reduced accidents. The newsletters made such a big hit that we used to send them by the thousands to airlines.

[Historical data show that insurance premiums in 1929, for most of the U.S. aviation business, totaled $4,017,619, with losses paid of $1,398,383. In 1928, premiums paid were $498,029, with losses paid of $144,858.]

But this was about 1930/1931 and during the Depression, my salary was reduced from $5,000 a year to $3,000 a year. I was very lucky. A lot of people were committing suicide — you know, no work, no income.

While chief engineer at Aero Insurance Underwriters, I had a staff of 200 part-time inspectors scattered over the country. I had a fleet of 17 airplanes for them to get around in. They became my eyes and ears; they would report back any dangerous situations that were developing in various parts of the country. We would send them out to inspect airplanes and to give us reports on how well the maintenance was going on the airplanes that we were insuring. We also would get ideas on how to reduce our wind-storm losses. We lost more airplanes in wind storms than we did in crashes.

In the 1930s, I spent all my time trying to reduce the losses of air insurance underwriters, sending out bulletins, doing a lot of traveling over the country, looking at risks for the insurance companies. For example, we insured the first Boeing 314 flying boat, which was used to fly from New York to Europe about 1938. This was insured for more than our entire income for the year from insurance premiums, so we were walking across a very tight rope. Anyway, one of my jobs was to go out and look it over and see if we should insure it. I did, and it was a good risk.

The insurance business was a very fascinating period in my life because of the problems it posed. Before any organization builds and flies its airplanes, it wants to know about insurance. So we were in on all the new developments that came along, long before they were in service. My job was to analyze the new risks and see if they were worthwhile taking.

Our main risk was insuring prototype airplanes. That was a big problem because they were something new and untried. But there was also good money there, if you did not have any losses.

Delta Air Lines

My company insured the Delta crop-dusting organization of Louisiana, which later developed into Delta Air Lines. Delta decided to try to get an airmail contract to fly the mail along the southern tier of the country in the 1930s. This was when the [U.S.] president [Franklin Roosevelt] canceled all the previous airmail contracts because of the hint of some kind of fraud in awarding them. Delta won one of the new contracts, and they planned to use Stinson trimotor airplanes.

When they read the fine print of the contract, they found that they had to cruise at about 100 miles [161 kilometers] per hour or faster to retain the contract. They asked me to come down to see what I could do to get the airplanes up to the speed that the government required. They gave me two airplanes, two pilots and a crew of mechanics.

We flew the airplanes up to Hartford, Connecticut, where the National Aeronautic Association [NAA] had an official timing course that would establish the speed of the airplane. We took off the radio antenna, took off the steps used to climb into the passenger cabin, improved the fairings around the wheels and so forth. After a few tests, we got the airplanes up to 101-plus miles [163-plus kilometers] an hour, certified by the NAA.

The Monocoupe.

With that document, Delta was able to begin its operation with the Post Office Department paying for the carrying of mail. When the airplanes got back, they probably reinstalled the radio antennas, the steps and some of the other things we had removed to gain the required speed.

Sikorsky

Through the insurance business, I met Igor Sikorsky in the 1930s. He used to show a gadget, one of these little helicopter things. This, he said, was going to be the future — his future. And then later on, he built the first helicopter. The last letter that Igor wrote was written to me. And in it, he prophesied his imminent death. He died that night [the same day that he wrote the letter].

AOPA

About 1938, I met Abbie Wolfe and Connie Wolfe during an aviation show in Miami, Florida. We got well acquainted, liked each other, and we spent a lot of time with each other in the ensuing years. Abbie Wolfe had the idea of starting an organization for private pilots, so he invited me to meetings he held with several wealthy friends in Lewisville, Pennsylvania. They met in his barn and discussed the reasons for organizing this sort of an association and how to go about doing it.

We probably met in the barn about five times before embarking on the idea of actually initiating the Aircraft Owners and Pilots Association, AOPA. We established the ground rules for the organization and what should be done to improve safety in aviation and help the private pilot with his problems in regard to flying. To organize the AOPA, J.B. “Doc” Hartranft, a private pilot, was selected. He seemed to be the right choice from the point of view of his motivation, his flying ability and his ability to organize such an effort.

Hartranft was appointed to head the organization and did a magnificent job in getting it started, getting a good reputation, and getting it to be what it is today. AOPA has done a very commendable job advancing the interests of the private pilot. I became [charter] member no. 21 because of my early association with the organization.

Wright Brothers

I used to meet Orville Wright every year on boat trips to aviation meetings conducted by the Institute of Aeronautical Sciences [now the American Institute of Aeronautics and Astronautics] in the late 1930s. The boat would leave Washington, D.C., and go all night to the airport [Langley Field, Virginia], so I got pretty well acquainted with Orville. He was a very quiet sort of a guy with a good sense of humor. We would discuss safety and things like that, and he was a very, very nice guy to know. His home in Dayton, Ohio, was full of ideas, too. Wilbur Wright and Orville Wright had the first vacuum cleaner that you could plug in on any floor. They also had the first stainless steel kitchen and, for some reason, they both had toilet seats in the shape of a saddle. I do not know why they did that.

They invented the first simulator. The reason they had to use a simulator was that the people in those days were riding bicycles and using sleds in the wintertime. People were accustomed to turning right by pushing the left foot forward and to turning left by pushing the right foot forward. In the case of a bicycle, you push your right hand forward if you want to turn left, and left hand forward to turn right. The controls of the Wright Brothers’ airplanes were the opposite. To turn right you pushed your right foot forward, and to turn left you pushed your left foot forward.

Civil Aeronautics Board

[In June 1940, the U.S. Civil Aeronautics Board (CAB) was established with authority to conduct safety rulemaking, adjudication, investigation and airline economic regulation. Functions of the CAB’s Safety Bureau included conducting safety rulemaking and accident investigation.]

Around 1940, I got a call from my friend E.P. Warner, vice chairman of the Civil Aeronautics Board, asking me to come down to Washington to take a job as director of the Safety Bureau. Dr. Warner was a professor of aeronautics at MIT and the most highly respected aeronautical engineer in the country at that time. So I talked it over with Sarah and my boss, who said, “Well, if you run out of luck, you can always come back to Aero Insurance Underwriters.”

Sen. Lundeen Accident

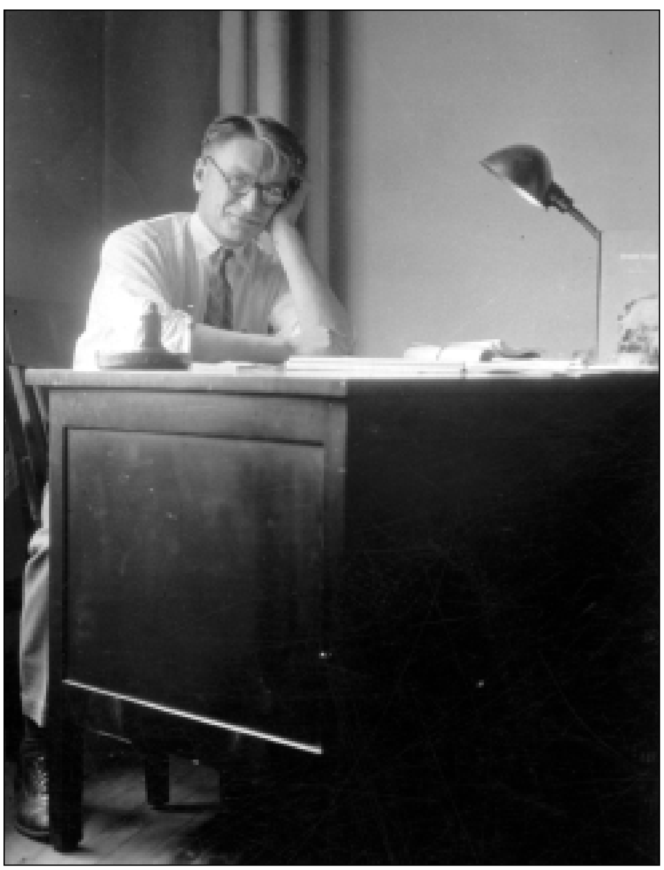
I had been at the Safety Bureau about a month when a Douglas DC-3 crashed over Lovettsville, Virginia, [August 1940] killing [U.S.] Sen. Ernest Lundeen [of Minnesota]. He was a well-known guy, sort of partial to the Germans during the war effort.

When a senator gets killed, all hell breaks loose. I was investigated by both houses of Congress because as director of the Safety Bureau, I was responsible for the accident. The airline industry had operated for 17 months without a fatal accident; that was the one reason I got into trouble. I had a pretty tough time, and it discouraged me about doing work for the government. I got my gray hair at that time.

There was a very severe storm at the time of the crash. Jimmy Doolittle had been flying through it in a light airplane, and we had him as a witness. He said that this was the worst turbulence he had ever encountered. On top of that, there was very severe lightning. We made tests to show that lightning can blind you for 30 seconds. So here was a crew — in very turbulent air, descending, being struck by lightning and blinded by lightning — that lost control [stalled] of the airplane — and they went into a farmer's field. We had three other DC-3 stalling accidents after that one.

The Senate Committee on Aviation was pretty mean. They tried to just put the blame on me for not doing things. But Sen. Lundeen, as I said before, was sort of pro-Germany, so I indicated that perhaps he might have been sabotaged … that maybe something else had happened. They did not want his name to be besmirched, so they ended the investigation of me right there.

From the Lovettsville accident, the only change made was the technique of operating the DC-3. We developed the wheel-landing system — tail high so that the airplane would not be flying near the stall, and the DC-3 came to be a pretty safe airplane. So I did not have to ground it, although the Senate Committee on Aviation kept on insisting that it be grounded.



Jerry Lederer.

Political Pressure

When I was with the Safety Bureau, I went to each member of the CAB to get a guarantee that they would not put any political pressure on me; they all agreed. But there were two exceptions. I had a letter from Eleanor Roosevelt [the wife of U.S. President Franklin Roosevelt] asking me to make Phoebe Omlie — a famous racing pilot and acrobatic pilot [who flew a Monocoupe] — the world's first female aviation accident investigator, and I told Phoebe that I could not do it on account of this promise. Had I done it for her, I would have had the flood gates open on me.

That was the only case of any political pressure on me, except around 1942, when I was asked to conceal facts in an accident report. We had found a tweed rag in the carburetor of a crashed airplane. The pilot of the airplane — a captain in the Colombian Air Force — was killed. I immediately notified the Federal Bureau of Investigation because it was a case of sabotage. The rag blocked the flow of gasoline, the engine suddenly quit, and he lost control of the airplane. They notified the State Department, then the State Department asked us not to divulge the fact that we had found evidence of sabotage in this ship because U.S. relations with Colombia were very strained. They were very pro-German, and war was imminent. So in the national interest, I had to conceal this information from the report.

Locks on Cockpit Doors

I had a request from J. Edgar Hoover, head of the Federal Bureau of Investigation, concerning signs of German sabotage just before World War II. The note said, "Please require a lock on the cockpit doors." So I put the order through, but most of the airplanes were already equipped that way.

Railroad Spike

Around 1940–1941, there was a railroad that bisected the Chicago Midway Airport, which at that time was one of the busiest airports in the world. I was director of the Safety Bureau, and I did not like the idea of having a railroad crossing an airport and being used by the public. So I wrote to the mayor of Chicago. I had no authority to do this, but I wrote to him saying that unless he did something about the railroad, I would recommend that the airport be abandoned for commercial aviation. I did not have the right to do this, but I did it anyway. And the next thing I knew, I got a letter from the mayor. He invited me up to see them pulling out the spikes from the railroad ties, and gave me the first spike that they pulled out.

Anti-collision Lights

ALPA [Air Line Pilots Association, International] told me that there was a growing nighttime hazard of Douglas DC-3s being overtaken by faster military airplanes that were being developed for World War II. There was a risk of collision because pilots could not distinguish the stationary tail lights of the DC-3s from city lights.

ALPA believed that the CAB ought to do something about it. So I started a project to test flashing lights. Some people in CAA [Civil Aeronautics Administration] did not think much of the idea and they were fighting me. The way I got wind of this was that my secretary was a friend of the secretary for the guy at CAA who was fighting me. We went ahead with the idea anyway.

American Airlines loaned us a DC-3. We had several different kinds of flashing lights made and put on the airplane — on the tail light and also on the navigation lights. The way we judged the best intervals of light/no light was to stand on the roofs of our houses at night and make notes while the airplane circled. We decided which lights would be the best ones to use. And that was how anti-collision lights evolved.

Flight Data Recorders

TWA [Trans World Airlines] and United Airlines installed very primitive flight data recorders on their Douglas DC-3s, and they each had some accidents. We found that flight data recorders were very useful in giving us information — airspeed, time, acceleration, etc. — that we would not have normally without a great deal of effort. Incidentally, that was a very bad position [as director of the Safety Bureau] for me to be in because every time an accident occurred, I would be investigating myself, asking, "Did I have the right regulation to prevent the accident?"

So I decided that it would be a good thing to have flight data recorders in all transport airplanes and to require them by regulation. The industry did not like the idea of having another device to maintain; having to change the recording paper, which might be a little bit difficult in rain; and having to decide the best place to put the recorder — in the aircraft tail, maintenance would be difficult — to keep it from being destroyed in a crash. The Air Line Pilots Association protested and said that this was just nothing but a mechanical spy that would tell lies about the pilot. I put through the regulation anyway.

A few weeks later, a United Airlines pilot was accused of flying too low over Fort Wayne, Indiana. We proved by the flight data recorder, however, that he was flying at the correct altitude. The pilot was a member of ALPA, and that persuaded ALPA that they should go along with the flight data recorder. The airlines were a little harder to convince. After I put the regulation through, World War II began, and airlines said that the war effort — the difficulty of getting the right materials — stood in the way of buying flight data recorders. CAB rescinded the regulation.

In the late 1940s, a University of Minnesota professor came to see me at Flight Safety Foundation. He had invented a much better flight data recorder, which was put in a fire-proof metal sphere that would float and provide protection. Based on this meeting in our office, he sold the idea, generally, all over the world.

Later, another University of Minnesota professor developed the idea of the cockpit voice recorder, which he had trouble selling because pilots would say, "All you would hear on our voice recorder would be a bunch of swear words, so what is the good of that?" Ultimately, both devices were found to be very useful in accident investigation. Those are the origins of the flight data recorder and the cockpit voice recorder.

Gliders for Troops

In regard to the use of gliders for transporting troops early in World War II, the Germans were doing this, the U.S. military was not. I was visited by Richard DuPont in about 1941, I guess it was. He was a great glider enthusiast. His reason for visiting me was to try to get enthusiasm for using gliders to transport troops in war. He had met opposition from the War Department because they felt that the public would not condone this very dangerous way of operating — of flying the troops [in gliders] — and he asked me to fly with him in a glider that would be snatched off the ground, flown around and then landed.

As director of the Safety Bureau of the Civil Aeronautics Board, I would be considered the supreme authority on safety in the country; presumably DuPont could use that influence to persuade the U.S. Army Air Service to get into glider activity. So I went to Wilmington, Delaware, and DuPont took the propeller off a Piper Cub, tied a nylon rope to the Piper Cub, and then extended the rope about 150 feet [46 meters] to two vertical posts; the end of rope was looped and draped between the posts.

An airplane with a tail hook would come along and snatch the Piper Cub off the ground, and we then would fly around. We did that. There was nothing to it. We flew around the airport once and landed, and there was no problem. During the war, the United States used gliders in the first invasion of France, D-Day. The gliders carried 33 troops each; some of them carried a small tank.

Gliders from England would be snatched off by a Douglas DC-3, fly over the English Channel, land somewhere in France that night, deposit their troops and then come back [by another tow] if they could. Most of them did not come back. About two years later, DuPont was killed in a glider crash. It never occurred to me at that time that the only nylon being made in this country — nylon rope, especially — was being made by DuPont.

Air Transport Command

When World War II started, the Air Transport Command [The Ferrying Command was created by the U.S. Air Corps on May 29, 1941, to fly aircraft to Great Britain. In June 1942, the group became the Air Transport Command.] was organized with a training system for pilots, mechanics, radio operators, navigators and loadmasters. I left the Safety Bureau and became the director of training for the Airlines War Training Institute.

I was not a member of the Armed Services in World War II. I was working [to train personnel] for the Air Transport Command. I put together the organization by selecting people who had proved to be very able in their fields. The navigator-instructors we got from navigation schools, especially Pan American Airways; radio operators we got from Pan American and another airline; flight engineer instructors we got from Pan American; and loadmasters we got from American Airlines and United Airlines. The training was done by the airlines on their aircraft at airline bases. We merely established the routine agenda of training. The Airlines War Training Institute also trained mechanics.

We trained about 10,000 U.S. Army pilots, 35,000 mechanics, navigators and radio operators. We had quite a job because some of the radio operators, for example, … were not educated and could not speak English. We had to give courses in English, courses in ordinary arithmetic, and to make textbooks that they could read and understand.

We wrote and published 15 textbooks in 15 weeks. And we were in a hurry for one of them about survival in the event of a crash in jungles, in the oceans, the Arctic and anywhere else that they might go. An aircraft carrier crew had to wait until we got that survival book published before they could they leave.

Airmen working with the Air Transport Command in Africa were making fun of the local customs. So I wrote a little manual that was very widely received and made the point that they should not kid these people because there are serious reasons behind all their little differences.

Women Pilots

I had a B-17 assigned to me for transportation [while director of the Airlines War Training Institute]. During the course of my travels, I went to one training base for B-29s in Texas, where they had a problem with the trainees fearing to fly the B-29s because of the engine fire record. [Jerry explained that the engines overheated because they were insufficiently cooled, the result of an underestimation of cooling requirements provided by the engine manufacturer to the aircraft designers.] The way they overcame that fear was by having a group of B-29s flown into the field by women pilots, WASPs [Women Airforce Service Pilots]. The women were brave enough to do this, motivating the men to go out and learn to fly the B-29s.

U.S. Strategic Bombing Survey

Late in World War II, I retired from the Airlines War Training Institute to get into other war activities, such as the U.S. Strategic Bombing Survey in Europe. The U.S. government wanted to know how effective its bombing had been on German industry, so they appointed a group to go over there to see what had happened. They asked me to serve on the part of the investigation about the effect of our bombing on the aluminum industry and the light metals industry. I had been in Germany in the early 1920s, and I had done work in connection with aluminum alloys at that time. The saddest part of this trip was that on the way back home, women would see us coming and would get on their knees with their babies in their arms, begging us to take them west because they were afraid of the Russians coming. That was a very difficult time in my career; I was not allowed to stop.

We learned that bombing of a factory was not always very productive because bombs would not damage the steel machinery very much, but would damage the brick walls and make the Germans in the area very angry. So they would all pitch in and build a factory again very quickly. The bombing of the oil industry in Germany was effective, because that reduced the amount of fuel going to the air force. We bombed the German transportation centers, their canals, railroads and bridges, and that kept them from putting their war materiel together.

National Business Aviation Association

The NBAA [National Business Aviation Association] is a very fine organization, which had its origin in my office at Aero Insurance Underwriters around 1946. At the end of World War II, when I went back to work for insurance companies, I took on as my assistant, Carl Kelberer to help me in my airline operations, a fellow who had been a United Airlines captain before the war. I had met him in Europe. He conceived the idea that the growing market for industrial use of airplanes by organizations deserved some sort of a method where they could express their needs. Other meetings were held, and he became the first director of the NBAA, but it had a different name — Corporate Aircraft Owners Association [CAOA]. And it went across very, very well. Now the NBAA is a recognized power in the industry and it does a very good job.

Airplane Stall Warning

When I was with the Safety Bureau, a man by the name of Leonard Greene [Safe Flight Instrument Corp.] came down to see me about the use of stall-warning indicators to warn the pilots of an oncoming stall. Stalls were the most frequent cause of fatal accidents in those days. He brought his gadget down to us and I had one of our men test it. We thought it was all right.

Jerry Lederer.

When I went to work for Aero Insurance Underwriters in 1946, one of the first things I did was to get them to agree to reduce the insurance rates on airplanes equipped with the stall-warning indicator. It helped to reduce losses. I also got insurance companies to put a reduced rate on airplanes equipped with fire extinguishers. Our inspections and other ways of reducing losses made us a pretty profitable organization. We also insured airlines, and we started the auditing system to determine what the airlines were doing from the point of view of safety.

I made one audit of an airline that was operating from Chicago and Oklahoma City. We did not insure the airline, but the president of the airline said that if I made a safety audit, he would give us the business. So I made the audit, and when I came back to his headquarters in Oklahoma City, I told him I had audited the airline, but I would not insure the airline. We did not want the risk. I showed him the photographs I had taken of mechanics refueling the airplane inside a hangar while smoking cigarettes. And I found a lot of other things wrong with the operation. He corrected them, of course, and after a while we did insure the company. That airline, by the way, was Braniff Airlines.

Flight Safety Foundation

After World War II, I went back to Aero Insurance Underwriters. They elevated me from chief engineer to chief engineer and associate manager. Flight Safety Foundation originated from a training flight accident that TWA had, where a Lockheed Constellation caught fire in flight and everybody except one pilot was killed. The hearings were held in New York and attracted quite a few safety people. About a week after the hearings were held, Harold Young, director of safety for Douglas Aircraft; Bob Knight, director of safety for American Airlines, who had been my administrative assistant at the Safety Bureau; and William Steiglitz, director of safety for Republic Aviation Corp., came to see me.

All were very capable people and very good friends of mine. They all knew about the newsletters I used to put out for Aero Insurance. They said that there was a great need to have this same kind of information for the entire industry, and they asked if I could help them to get it done.

When word got around that I was starting up [the precursor of] Flight Safety Foundation, some people said that I should not get into this stuff, that I would be sitting on a keg of dynamite, that it would ruin my career and that safety was not a saleable object — shows you how safety was a hard sell in those days. You mentioned safety and you scared people away. That is the big thing that I had to overcome — by diplomacy, mostly, and by not putting out things that would scare the public.

I was about to be without a job because Aero Insurance Underwriters was being closed down. I was offered a job by one of our competitors, but I was so interested in this new idea that I decided to stick with it. So I was given an office at the Institute of Aeronautical Sciences [now the American Institute of Aeronautics and

Astronautics] — free, no rent — and started Aircraft Engineering for Safety. The name was given to us by the president of the Institute of Aeronautical Sciences, who at that time was also the president of Sperry Corp.

A short time later, Dick Crane, who was a pilot, heard about what we were doing. In 1945, he and his friend Dave Morrison had organized the Flight Safety Foundation, which was doing nothing except studying cockpit layouts from the point of view of human factors. They wanted me to unite with them and do the work I was doing under their banner. They were doing very good work so I agreed. We then became Flight Safety Foundation. We had about four people employed on the basis that this was a very uncertain thing. Unless people had outside income, I did not want to hire them. Later I hired other people.

Laurance Rockefeller provided us with funds — I think it was $20,000 — and later helped the Foundation get more money. We were operating on nothing, although TWA had given us $1,500, and I think American Airlines had given us about the same amount. Then we had some money from United Air Lines. The highest salary I ever had with the Foundation was $8,000 a year, and the reason is that I had other income coming in. I also had organized the Cornell-Guggenheim Aviation Safety Center about 1950 [for Daniel and Florence Guggenheim] for the exchange of information on safety research worldwide. So I had salaries from the Foundation and from Cornell-Guggenheim, and I gave each organization about half of my time.

The idea of Cornell-Guggenheim Aviation Safety Center was to stay in business as long as airline flying was less safe than other means of transportation. It put out *Design Notes*, which showed the mistakes made in aircraft design that should not have been made. The year 1967 was when airline safety became safer than railroads or anything else, so Cornell-Guggenheim [Aviation Safety Center] passed out of business because it achieved what it was supposed to achieve.

Accident Investigation Course

Flight Safety Foundation presented the first course for civilian aircraft accident investigators at Mitchel Field, a U.S. Air Force base on Long Island, New York, in 1948. We put on a one-week school using as instructors my former associates at the Safety Bureau of the Civil Aeronautics Board.

Comfortable Seats

In regard to design in the 1950s, the safest airplane in airline operation was the Convair series. This also was the most comfortable airplane in which passengers and crew could ride because of the seat design. Before I ran one meeting, I asked the manufacturer's chief engineer to show how they had designed the seats to make them so comfortable. Seems they designed seats by having their personnel take their pants down and sit in plaster of Paris to make impressions of their behinds.

Rifle and Statistics

I was chairman of a Society of Automotive Engineers meeting at the Hotel Astor in New York. I had the approval of the hotel to carry a rifle onto the podium. I told the audience that the rifle had only one bullet in it, so if I fired it at them, there was only one chance in — I do not remember how many — of anybody getting hit by the bullet. If I were to aim at the ceiling, not at them, the bullet might ricochet off the ceiling, and the chances of anybody being hit would be even less. So statistically, they were very, very safe. They got the point.

Agreements

Flight Safety Foundation had agreements with the National Safety Council, for example, so that they would deal with ramp safety and industrial safety in aviation, while we dealt with operational safety. The same thing applied to the Society of Air Safety Investigators [now the International Society of Air Safety Investigators]. They would deal with accident investigations, while we dealt with operational safety. The Foundation has stayed pretty much out of the accident investigation field.

The whole field of human factors is the most important from the point of view of reducing accidents. One example would be fitness for duty: mentally, physically and emotionally, especially emotionally. Divorce or death of a family member have about the same effect.

Radar

During several Foundation seminars, speakers presented controversial topics, such as use of weather radar. Some airlines were very anxious to put radar on their airplanes. Most airlines turned the idea down, the reason being expense. When one airline installed weather radar, they discovered that they were saving money, because by avoiding turbulence, they had less wear and tear on bearings of engines and on instruments. They were able to make the ride much more comfortable for the passengers. Then every other airline had to follow suit. That is how weather radar started in the middle 1950s. The Foundation was asked to do initial promotion; instead, we worked very closely with airlines to tell people how others were using radar.

Flicker Vertigo

A friend gave me a book about the brain in [the 1950s], and I read how flickering light can cause you to go into a coma or unconsciousness or a trance. I began to look into it, and I happened to be in Holland when people told me about a private pilot landing a single-engine airplane. He was unconscious, and he had to be carried out of the cockpit. They found that the reason was that when he landed, he had the sun at his back, and the reflections of the rays from the propeller — about 15 flashes per second — had caused him to lose consciousness. I was told about how the Germans in World War II had used a flicker-light system to drive prisoners of war insane. When I came back from Holland, I put out a Flight Safety Foundation bulletin on this subject [1955]; the immediate effect was that the U.S. Army [researchers] at Fort Rucker, Alabama, immediately made tests on helicopter rotor blades, and they put out a rule that all helicopter pilots had to be tested for susceptibility to flicker vertigo. That was a good achievement.

AvCIR/AvSER

Back in my Safety Bureau days, I was visited by a man named Hugh DeHaven. He had enlisted in the Canadian Air Service during World War I, and he was training to fly in Texas. He had a collision in flight, which put him in the hospital for about eight months. Many of his bones were broken, and he had many other injuries; he wondered how he had survived. He figured that the human body must be much stronger than most people believed it to be, so he made a very complete study of this — people falling from great heights and surviving. It is a classic study.

I listened to DeHaven and for a while, I could not understand what he was driving at because, in those days, people regarded the body as being rather fragile. But I got the drift, and it appealed to me, so I tried to get my investigators to look into why people survived a crash, and why people were killed in the crash, because this had not been done before. So they did this, and we learned an awful lot about the design of wheels, the design of cockpits and measures to avoid being hit in the head by a sharp object — things like that.

We [Safety Bureau] used to feed all our information to DeHaven. I would read the nature of the accident to him, and he would tell me where the airplane design could be improved. And out of DeHaven's crash survival studies came the seat belts in cars, the dish steering wheel and inlaid instruments so that people cannot strike their heads against protrusions.

Howard Hasbrook became DeHaven's assistant, and later became a very fine accident investigator who made the very first analysis of why people were killed in an airline accident; he did a beautiful job.

Hasbrook, who was in charge of [aviation] crash survival for AvCIR [Aviation Crash Injury Research was operated in New York during the 1950s under Jerry's oversight as director of the Cornell-Guggenheim Aviation Safety Center.], liked horses, so he wanted to move AvCIR [in 1956] from New York to Phoenix, Arizona. We did not see anything against that, so he moved and put together a very respectable organization that had about 35 people when I retired from the Foundation in 1967. DeHaven ran the program, which was divided into two parts: aviation and automotive. Hasbrook headed the aviation end of it. The automotive part later was taken over by the Society of Automotive Engineers.

AvCIR became wholly owned by the Foundation [about 1959] and was [renamed Aviation Safety Engineering Research (AvSER) about 1962]. The federal government — the Federal Aviation Authority, the U.S. Army, the U.S. Navy and the National Advisory Committee for Aeronautics [the forerunner of NASA] — gave the [Foundation] funds to conduct crash-test experiments, crashing real airplanes and helicopters. All we were paid for was to do crash tests on airplanes. We put together fine reports that were used by the industry in improving the design of their airplanes.

AvSER also created a crashworthy fuel system [that was installed in U.S. military] helicopters. Harry Robertson was behind that development. We built fuel tanks out of plastic material that would not break. The fuel lines [were made of steel-braid-covered hoses with self-sealing valves] and the rigid hydraulic lines were coiled so that they would stretch when the helicopter crashed. We put valves in these lines so that when the lines broke, the valves would see to it that nothing flowed out of them. Those were the three most important things [for the fuel system]. AvSER crashed helicopter after helicopter — no fire. If you watch Indianapolis automobile races, the cars have tremendous crashes into walls and hit each other — with no fires. Same concept. The automobile racing people also turned to Robertson to tell them what to do.

Escape Slides and Airbags

Emergency evacuation slides originated while I was running an aviation safety meeting of the Society of Automotive Engineers in New York. Safety was held in such low esteem in those days that there were more people presenting the lectures than there were in the audience. One of the best contributions of Flight Safety Foundation to aviation was to make safety talkable and respectable. In the early days, "safety" was an obscene word because it scared people.

At that meeting, [TWA] Capt. [Robert] "Bob" Buck had just come from a tour of the South by car with his family, and he had noticed that the schools in the South had metal chutes from the third story down to the ground so that, in the event of a fire, the students could slide down the chutes to safety. He wondered why it would not be a good idea to use escape chutes for the quick evacuation of airplanes when they had a crash.

Otto Krishner, who was working with the Foundation on loan from American Airlines, thought that this was a very good idea. The next day, Otto went back to La Guardia Airport [in New York, New York], where American Airlines had a hangar and repair shops, put a sewing machine in the hangar, got a bunch of nylon and made the first chute.

The first airbag — now very common in automobiles — was demonstrated at a Flight Safety Foundation seminar around 1960. The inventor had come to my office with a plastic bag, which he proceeded to blow

Continued on page 37

Sarah Lederer: Her Own Words

Adventure

I met Jerry through a mutual friend. I was living in Los Angeles, and I reached adulthood and realized that I had seen very little of the world, outside of southern California. I had completed my college degree at the University of Southern California and I was working for the state relief administration as a supervisor in their relocation office. We were helping people who had to be moved to find other places to live so that areas could be cleared off and rebuilt. So I took myself to New York City, where every young aspiring American seems to go.

I was 22, and my friend told me about her friend by the name of Jerry Lederer in New York. She said that I ought to meet him, that he was just the guy for me. She was living in L.A. and Jerry had stayed with her and her husband when he was in the U.S. Air Mail Service. Jerry was helping her husband with an invention. That is how they got to be friends.

She wrote to Jerry in New York and told him that I was coming by train across the country. Jerry wrote to her and said he ought to meet me at the train station. Then he sent a telegram saying that he was sorry that he would not be in town that day, but that I should call him when I came to the city. I had to call this man who had been so nice to write a letter and then to send a telegram. So I called him.

Sarah Lederer.

For our first date, we went up to Bear Mountain. We climbed hills and down dales and jumped over streams and I guess he, being an outdoors man, was impressed with my feeling for the outdoors. We made subsequent dates, and three weeks after I met him he proposed. He wanted to marry me. I said, "I cannot marry you, I do not even know you that much." So we waited two more weeks before we got married in 1935.

He had made a date with a friend who was an attorney, and they were going off to do mountain climbing in the Adirondack. Jerry said, "Come along and we will get married on the way." So we stopped in Poughkeepsie, New York, and that is where we were married.

When we got back from the Adirondack, I took the civil service examination, passed it and got a job with the Department of Welfare of New York City. I had done social work in Watts in L.A., so working with the [poor] community was not anything new to me.

Jerry's secretary at Aero Insurance Underwriters was a flight instructoress. She said that she would teach me to fly in 1935. I had not soloed yet when Jerry left New York, so I took up flying again when we got to Washington, D.C., in 1940. I soloed in Washington in a Piper Cub.

Now the dirt runway at the field where I was flying ran down hill, and sheep were grazing on the field. Very often when you wanted to land, you would have to buzz the runway to get the sheep off of it, then go round again and land. I got a student pilot's license. Then right after I got it, we went to war. I never went out and actually made any great effort to fly because things were very upset in those days.

Taking those flying lessons — the few that I took and as much as I learned — was invaluable to me because from then on, I understood what Jerry was doing.

Marriage

There were just two paths in life that I wanted to follow. One was that it is up to a wife to keep a marriage going. That was my philosophy. And the other was, never do anything to alienate your husband from his family. I think that is what keeps a marriage going. This was not necessarily what I had pre-planned. Also keep a sense of humor, and work at the marriage.

I was young when we met. You are a lot more pliable and you roll with the punches a lot better when you are young because you are not set in your ways and you can change easily. I never have had that particular feeling that "this is the way I have got to do it" unless the situation involved something right or wrong. So I roll with the punches. What I do — if something adverse happens — is always analyze it and think, "Is there any good that can come out of this?" There is always some redeeming feature. And that is the way I look at things. Trying to find the good in it.

In the beginning and sometimes along the way, some things were especially difficult for Jerry. He had to face that the word "safety" was a dirty word. He had to sell it, and he did, he stuck to his guns. Jerry always seemed to be able to overcome obstacles.

When Jerry worked for the Civil Aeronautics Board, he had five bosses — the five members on the board. Jerry liked to get things done, and these fellows would get stuck on little things. He came home one day and told me, "They talked for a half an hour about whether they would put in the word 'but.' Here I have an office where I have got so many things to do, and I have to sit there through this harangue." This bothered him. He did not have the patience that it takes to sit around and talk about nothing, with so many important things to take care of — this rankled him.

Jerry usually gets along with people, and the people with whom he works usually like him, almost always. The people who worked under him adored him, they really did. They would do anything for him and I think that he inspired them. Because he was very quiet, and he would never say anything unkind to anybody at any time, things went very smoothly in his organizations. He was a diplomat.

Sarah and Jerry Lederer.

Bees

We used to spend a lot of weekends in Pennsylvania with Don and Brownie Luscombe, known for the Luscombe airplane. Brownie had a commercial pilot's license, so she and I would get in one of the Luscombes and go fly. We would go down to Atlantic City, New Jersey, for lunch for instance.

Another time in the late 1930s, Jerry had gone to Cape Cod, Massachusetts. Pat Gladney, my flight instructor, said "Why don't we fly up there this weekend?" I said, "That's great." So she got a Piper Cub at Teterboro Airport. We started to fly up. It is not very far from there to Cape Cod in any airplane except the Piper Cub. We stopped to refuel at a grassy field.

We taxied over to the hangar. It was a hot day so we left the airplane windows open, and then we went to the ladies room. When we came back, and the airplane had been refueled, we got in the plane, wiped the windows and took off. All of the sudden as we were getting off the ground, there was a buzz in the cockpit. Buzz, buzz, buzz. We looked, and the cockpit was full of bees. They had come in while the plane was being refueled.

Now that was not the most comfortable thing to fly. I did not know how many angry bees there were. In the first place, it was very noisy in the cockpit, and a lot of vibration disturbed them no end, as we could see. They were disturbed bees and we did not want them to take it out on us.

I happened to have a copy of *The New York Times* that I was taking to Jerry, so I just took it and started swatting them, one at a time, and finally got the whole bunch right up on the windshield. I counted them. There were 13. But let me tell you that was kind of a white knuckle bit of flying until we got them all out of the way, because any one of them could attack you. Dead bees make you happier than live bees in a small cockpit.

Washington

We returned to New York after the war, then came back to Washington and I became a social worker again. I ended up writing a whole set of regulations for housing and relocating people who had to move because of government action; for example, we were building a subway — all kinds of things.

This was an interesting experience though — writing the regulations. I very carefully went over all the regulations and I wrote them, and then they sent over a little snip of a guy, a young fellow who said, "Are you a lawyer?" I said, "No." Of course, then I was nobody. So he took the regulations and rewrote them. I had to take them back and it took me one month to get them back to comply with the law. That really happened.

He did not know that in our legal department, when they wanted to know something about the relocation regulations, they did not bother going to look it up. They came and asked me what the regulation was. And they went back with the [correct] information, so they called me the "Illegal Legal."

I was a member of the American Women's Voluntary Services. I was in uniform. We were a quasi-federal organization. We did not get paid, we were voluntary. We used our own cars, and we had a motor corps. I was deputy director of the motor corps and then captain of the rescue squad. We were given intense first aid training in case of a bombing. The only time I really got to use that training was during a Memorial Day parade, the last one held in Washington before World War II. It was an extremely hot day and people were fainting.

The motor corps had a bond rally, where all the big movie stars came and put on a big show in Washington. The president [Franklin Roosevelt] had a reception for the stars, and standing out there was Groucho Marx. And he said, "Why are you women not at the reception? You have got to go." I was standing right next to him, and he grabbed my hand and walks me right up to the White House door. I could not say yes or no, because he dragged me up there. He opened the White House door and pushed me in. And the Secret Service pushed me out.

Gen. Dwight Eisenhower was hero of the land at the time, and [his wife] Mamie Eisenhower decided that she wanted to join the American Women's Voluntary Services — that was a big thing. So, they wanted a picture of her in uniform. Well, my uniform was size 10 and that was the only one she could fit into. I was not wearing it at the time, because by that time, I was like this [pregnant] with Nancy. So I gave the uniform to Mamie. Later, I got a telephone message from Mamie, thanking me for the use of my uniform.

And then a few days later — being in the condition I was, I was no longer in the motor corps and could not do any rescuing — so they made me head of the personnel department — so I was confined to quarters. Mamie came into my office, and said, "In case you did not get my phone message or my letter, I wanted to be sure that I thanked you for letting me use your uniform." I was very impressed that she came in person.

Workaholic

Jerry, as you may know, is a workaholic. He just works and has never stopped working. If we were on an airplane, if we were on a train, he was working — reading, writing, whatever.

I believe that Jerry found Flight Safety Foundation most satisfying [of all his career experiences]. He had a lot to do with the formation of that organization. Air safety was what he was most interested in. His days

Sarah Lederer with Bessie Owen and her Beechcraft. Burbank Airport, California, October 1938.

were filled with air safety, and he would try to put into action all the ideas that he had. It was the one way for him to reach the goal of improving the safety of airplanes — and that is what he did.

At home, we did not have much verbalizing after dinner. Jerry would take over the dining room and he would work for several hours. He had a perfectly good office upstairs where he could go and work, but he wanted to be with the family. He wanted to be where we were — our daughters and me — to see what was going on. That is the way he did it.

Jerry had helped a lawyer with a case. Evidently Jerry's assistance was so great that the lawyer won the case based on what Jerry advised him to do. In gratitude, he sent us the first television in the neighborhood. It had a big 10-inch [25-centimeter] screen. But still I used to get I don't know how many kids coming over every day to watch *Howdy Doody.* I had to get new living room furniture, it all wore out. And you have no idea what it cost me in lemonade.

Our daughter Susan became a film maker. Our daughter Nancy became an environmental engineer with a doctorate in environmental engineering, and has two daughters.

I was asked the question, "Who is your hero?" I did not have to think. It is Jerry. I appreciate his ethics, his outlook.♦

Sarah and Jerry Lederer.

up and put against a wall. Then he got as far away as he could and ran against the inflated bag as hard as he could and, of course, he was not injured. We tried the airbag idea in our crash tests on DC-6s at our Aviation Crash Injury Research program in Phoenix, Arizona, but we found that when the airbags deflated, they would impede the passengers getting out of the airplane in a hurry, so we did not recommend the use of airbags for aviation. The Foundation's tests on fires and crash survival conducted at AvCIR were very important to aviation.

We used to collect information about the failure of evacuation slides and the failure of life rafts, and at the request of the Coast Guard, we put on quite a few seminars on sea survival. Gloria Heath wrote the first manual for the skippers of the ocean vessels that come to the aid of ditched airplanes.

Jet Airplane Implementation

When jet airplanes came, I was a part of the International Civil Aviation Organization's Jet Implementation Panel, which went around the world to determine whether it was safe to implement the operation of jet airplanes. We made recommendations — such as, when they were building a new airport in Paris, I noticed that the windows were ordinary window glass. And I told them that with the jets coming in, they had better strengthen those windows because there might be a blast from the jets.

When I got back, I wrote a pamphlet for Flight Safety Foundation on how jet operations would differ from the ordinary propeller-driven airplane operations.

Flight Engineers

Another event in which Flight Safety Foundation was involved: There was a very strong move to do away with flight engineers around 1960. Flight engineers, of course, were an extra cost to the airlines, and the design of the new cockpits was so much improved that the flight engineer would not be necessary.

Airlines — Braniff, American and United and other airlines — got together to give the Foundation something like $50,000 to make a study as to the need for a flight engineer. For example, we put crews in a flight simulator and created emergencies to see whether they could handle them. If they could handle the emergencies, then maybe they did not need a flight engineer.

We were expected to come out with the idea that maybe the flight engineer was not necessary, but that was a political situation, which we avoided by saying in our report, not that you did or did not need a flight engineer, but how to go about determining whether you needed a flight engineer or not. We escaped from a very tight political situation and did our job.

Bogus Parts

Around the early 1960s, a corporate manager of air transportation called me one day. He had ordered a bunch of bolts for fastening the wing of the Douglas DC-3 onto the stub wing. He decided to have the bolts tested in the company's laboratory and found that the bolts were under-strength, not up to specifications. I got Joe Chase [then editor of the *Aviation Mechanics Bulletin*] to take on this project to look into bogus parts. Joe was a very quiet guy. When he wrote a report, he said that we had found that a lot of these parts were being made out in Long Island City, New York, and in Italy in little home-built factories that tried to do the best they could, but the bolts were not up to specifications.

Aviation Mechanics Bulletin

By the way, about the *Aviation Mechanics Bulletin*: At first, Flight Safety Foundation sent them to the homes of the mechanics working for the airlines so that their families knew that their husbands or their brothers or other relatives were doing something useful. It would help the whole morale of the organization.

Washing Machine

Another meeting was in honor of the 25th anniversary of Jimmy Doolittle's famous flight to show that flying could be done without any view of the horizon, by using the artificial horizon and directional gyro that he and Sperry [Gyroscope Co.] had developed. This was probably the greatest single contribution to airline safety that ever occurred, even until now.

I got together a group of people who had participated in the design of Doolittle's research airplane — the wheels, the fuselage, the wings, the whole caboodle. Word got out that I was planning this meeting. I got a telephone call from Bendix [Aviation Corp.], asking me to put them on the agenda, too, because they had something to contribute.

Bendix was last on the agenda. Although everybody else had shown pictures of the airplane and the part that they had built, Bendix showed an ordinary washing machine. They said, "This was the washing machine used to wash Doolittle's underdrawers after he made this flight."

NASA Challenges

Around my retirement from Flight Safety Foundation in 1967, NASA [the U.S. National Aeronautics and Space Administration] had a big fire at Cape Kennedy. [Virgil Grissom, Roger Chaffee and Edward White II died Jan. 27, 1967, when the oxygen-rich environment in their Apollo space capsule was ignited during a launch-pad test.] They asked me to become director of the Office of Manned Space Flight Safety. I did not know what I was getting into, and probably would not have taken the position if I had known this would be the most complicated thing I could ever imagine. For example, the idea of getting to the moon by stages — and then taking off from the moon, and meeting another stage in flight to come back to Earth — was very foreign to me. If I had had anything to say, I would have said this was impossible — but it was done.

Project Apollo was amazing. The Apollo 11 vehicle had 5.6 million parts and 2.5 million systems, such as fuel systems and control systems. With reliability of 99.9 percent, you would expect 5,600 failures per space flight. You average about 35. But we had a lot of backup systems. It was considered the most difficult achievement of the 20th century. [Apollo 11 was launched July 16, 1969, with Neil Armstrong, Edwin Aldrin and Mike Collins as the crew. Armstrong and Collins landed on the moon in their lunar module, "Eagle." The crew returned to Earth on July 24 in their command and service module, "Columbia," after a successful mission.]

The first thing I did was hire very good people to work for me. Without my deputy, I do not think I could have done very much. He knew all about the politics of the organization, which is very important. The most important thing I did — which would have prevented the fire — was to establish ways to motivate the guy on the job to do a good job, and to reward the guy for doing a good job. I got that idea from Grumman [Aircraft Engineering Corp.], which was very good at getting the people involved to bring up their ideas. The idea was to improve motivation and morale.

Confessing Mistakes

The program manager for Project Apollo said that there were indications of some bad workmanship, and that we would have to do something to motivate the workers to do the best job that they could — with an awareness of their responsibilities to their country as well as to NASA.

He pointed to me as the man who should put through the motivation program. I asked him how many people I was supposed to motivate. He said, "400,000." That made me blink a few times. Then an incident at Grumman gave me the clue.

A Grumman inspector using a mirror was inspecting the inside of an Apollo space capsule, and as he was using the mirror, it slipped out of his hand, broke and many, many pieces fell into the bottom of the capsule. Knowing that it would take maybe three weeks to disassemble the Apollo capsule and that the cost would be hundreds of thousands of dollars to find the pieces of glass in the bottom, the worker immediately went to the supervisor and reported what he had done. Instead of punishing the man, Grumman had a philosophy that men who admitted their mistakes should be rewarded.

When the Space Shuttle Challenger accident was investigated, the reports said that, had NASA retained this philosophy, the Challenger accident probably would not have happened.

Discovering Mistakes

Along the lines of safety [in space], there was not much that I could contribute even if I knew how to do it, because it was very highly technical, some of it beyond my capacity. But I did manage to draw a safety organization together and give a greater focus to safety within NASA, especially the awareness program, to keep everybody alert to the fact that they should be constantly thoughtful about what they were doing from the point of view of safety.

We did not have smooth going in some areas. For example, in our first safety audit of Cape Canaveral, now called Kennedy Space Center, we were looking at everything and noticed the guy who was painting the various pipes at the center, to show whether they were carrying gasoline, kerosene, oxygen or other fluids. He was using the wrong colors. When we looked into this, we discovered that the reason he was using the wrong colors was that he was color blind. We put in a regulation that everybody who was employed by NASA had to have a color-blindness test.

Risk Management

In 1967, as director of manned space flight safety for NASA, I used the term "risk management" in place of the term "safety." Risk management means not only eliminating risks or reducing them, but also accepting risk on a rational basis. Risk management is a more realistic term than safety. It implies that hazards are ever present, that they must be identified, analyzed, evaluated and controlled or rationally accepted. It gets away from the ambiguity of safety as freedom from danger, a condition that rarely — if ever — exists.

Furthermore, the term risk management has much more psychological appeal than safety; therefore, it was more likely to attract the intellectual ability that we wanted at NASA. It served as more of a challenge to mental resources than safety because it stressed the uncertainties. It called for the need to explore all foreseeable options to assess a hazardous situation, and to put forward the options for management decision. This must include many considerations, such as schedules, environmental problems, societal relationships, and so forth.

The term is now very widely used in the aerospace industry and has spread to other technologies. However, the term safety should continue to be used for public reasons and for reporting purposes. Accepting the premise that no system is absolutely risk free — while conversely that there are certain risks inherent in every system — becomes an absolute necessity. Management should know and understand the risks that it is assuming, and providing a formalized system to develop this risk visibility is the mission of system safety.

Space Debris

[Dr.] Wernher von Braun was a very delightful person and a very good, advanced thinker. He was really the guiding light for the American space program. He was always afraid the Russians would get ahead of us, and that was what drove our whole organization.

One of the things that I was afraid of is that some piece of a space object would fall from space, hit somebody on the head and kill them, and that there would be liability. My staff said that this scenario had been covered by the country's leading statisticians, and that this was such a rare event, I should just forget about it.

About two weeks later, the newspapers reported that a part of a space object had fallen on the deck of a German steamer in the Caribbean. I got the staff together again, and this time they brought in the reports — statistical studies about the impossibility of anything coming from space and killing anybody on Earth.

Then space debris fell in Canada. A cow was killed in South Africa by space stuff. A piece of a space vehicle was found in some other part of the world, and a farmer wanted $25,000 for it. A big piece was found up in Minnesota. Then another piece fell on a ship in the Pacific Ocean. And I began to worry more and more about this. So far, nobody had been hit, but ultimately this was bound to happen.

But one day I went down to attend a meeting that von Braun was having in his office. They were discussing the same problem: What do we do if part of a NASA spacecraft comes down and kills somebody? What are the options? And he turned to me and said, "Do you have any ideas?" I said, "Sure, I know how to cure that. Everything we make, we mark 'Made in Russia.'" And that endeared me to him; he was a tremendous character.

Three Mile Island

When the nuclear power plant accident happened [March 28, 1979] at Three Mile Island in Pennsylvania, the man who was the head of all of the nuclear power plants asked me to meet with him. The whole idea was for me to tell them about the safety advances in aviation that could help them with their nuclear power plants so that another such accident would not occur. Well, I found out that the accident had occurred at 4 o'clock in the morning, which is the most likely time to have an accident because of fatigue [circadian rhythm]. I brought out that they had to do something about people working at night.

Anyway, the result of this whole meeting was the organization of the Institute of Nuclear Power Operations that same year, which focused on analyzing the way that nuclear power plants operate from the point of view of safety, making safety recommendations. They have done a very, very good job. They had an advisory panel, and I served on the advisory panel for about six years.

In regard to my part, I remember that Lockheed [Corp.] was given a contract to look at the various nuclear power plants from the point of view of human factors — what could be done to improve the human factors environment in order to have a safe operation. One picture that they took showed the use of different brands of beer cans to identify the levers used to operate a nuclear power plant, especially in emergencies. There were literally hundreds and hundreds of levers that all looked the same.

If an emergency occurred, a worker would have to stop to identify which lever should be used and which lever should not be used. By putting different brands of beer cans over the levers, people knew which lever to use for whatever exigency occurred. That is how primitive the human factors situation was in nuclear power plants. This has been greatly improved.

Jerry Lederer.

Communication

I have a feeling of satisfaction in being able to live in this era, and having everything go so well. That is about all I can say — a feeling of elation and satisfaction. The big thing is communication … increasing the speed of communication … it accelerates the creation of wealth. People can get together and discuss their ideas: new factories, new designs, new everything. That, I think, is the main benefit of communication.♦

Procedures in Accident Reporting

Jerome Lederer
Director, Safety Bureau
U.S. Civil Aeronautics Board
1942

The National Advisory Committee for Aeronautics Bulletin No. 576 deals with aircraft accidents and sets up a method of analysis which has been the basis for accident analysis since its issuance in 1936. In principle, it was followed by the Bureau of Air Commerce prior to that date. It is the method now used by the Safety Bureau in its analytical work. Any change would be likely to distort the pattern of statistical analyses and make comparisons with past experience impossible. We feel that any change in policy should be subject to the same careful study which preceded the issuance of the National Advisory Committee's Bulletin No. 576; that the industry should then be advised; and that statistical data issued after a change is made should have a note attached, warning against making comparisons with previous statistics.

The accident analysis form used in accordance with methods adopted by the National Advisory Committee breaks down the immediate and underlying causes of accidents in terms of percentages. To facilitate this system of recording the analyses of accidents, the Safety Bureau has installed a Keysort Card System by means of which some ninety-odd items entering into accidents are condensed on a card in such a way that every accident involving any one of these items can be segregated in a few moments. From the standpoint of group studies, this system offers many advantages.

Since many accidents consist of a series of events which terminate in the actual impact, it is often difficult to segregate the cause from one of these events.

In the field of reporting on individual accidents, we have a different problem even though the analytical thought through which conclusions are reached follows the same general methods. Under the Civil Aeronautics Act, we are required to report on the facts, conditions and circumstances surrounding the accident and the probable cause thereof. In making such a report, we therefore endeavor to state how the accident happened and why. The "why" is our conclusion expressed in terms of probable cause and contributing factors. Since many accidents consist of a series of events which terminate in the actual impact, it is often difficult to segregate the cause from one of these events.

Sometimes the cause clearly precedes the series of events. For example, the series of events may be a stall, a spin and the crash. The first of this series could not have happened had flying speed been maintained. The proximate cause, therefore, is a failure of the pilot. Back of that, however, is possibly one or more underlying causes or contributing factors. Inexperience, carelessness, recklessness, improper instruction, flight characteristics of the airplane or some other factor may be clearly developed from the evidence.

In other cases, the proximate cause is clearly found in the sequence of events rather than in a position preceding the sequence. The accident involving an aircraft of United Airlines at Salt Lake City in the fall of 1940 is a typical example. The evidence showed that the captain involved was guilty of definite errors in judgment prior to his decision to start an approach procedure. These errors were part of the sequence of events, but it was our decision that the proximate cause was the malfunctioning of the radio range. In effect, we said that had the range been functioning properly, the particular accident that did occur would not have happened even though the pilot had made errors prior to starting the let-down procedure.

Determination as to the probable cause of an accident is at best a controversial matter and as a matter of fact has been the subject of argument since 1935, when the Air Commerce Act was amended to require reports on fatal accidents. It has been our endeavor to stick to a practical pattern which establishes the proximate cause as the probable cause and sets up the underlying or more remote causes as contributing factors.

Determination as to the probable cause of an accident is at best a controversial matter and as a matter of fact has been the subject of argument since 1935, when the Air Commerce Act was amended to require reports on fatal accidents.

As an example of this, we will consider an accident which occurred at Boston in 1941. The pilot went up to perform aerobatics, entered what appeared to be a normal intentional spin and crashed. The investigation showed that his physical condition was impaired by an attack of the flu and by the fact that he had had two wisdom teeth extracted the day before. In this case, we gave as the probable cause: “intentional spin from which the pilot failed to recover.” The contributing factor was “impaired physical condition.” Incidentally, in this case, we might have had a second contributing factor — “bad judgment of the pilot in flying when in poor physical condition.” This conclusion was not reached because it would be based on an assumption that the pilot was able to properly evaluate his physical condition and we did not know that this was the case.

In determining the proximate cause, we endeavor to adhere to the doctrine of the last clear chance. The following examples will illustrate this thought:

In the first case, assume that an engine failed over terrain where a safe landing could not be made. In this case, the probable cause is engine failure, because the pilot, having no place to land, could not avoid the accident. In the second case, assume that the engine failed in the vicinity of the airport where the pilot has a clear chance to land safely. He allows the aircraft to stall and spin while making the approach. In this case, the probable cause is a failure of the pilot, and engine failure becomes the contributing factor. (A similar one is analyzed on page 8 of the National Advisory Committee report.)

In each of such cases, there may be other underlying causes which can be listed as contributing factors.

In reviewing the probable cause and contributing factors in accidents, our conclusions are checked against those arrived at by the Analysis Section. Any discrepancy results in further consideration by all concerned.

Any material change in the philosophy behind our present methods of developing facts would upset all of the statistical data compiled up to the present time. In addition, it would appear that the use of a general statement such as “inexperience of pilot” as the cause of a specific accident would fall far short of the requirements of the Act, which charges us with certain duties with respect to the avoidance of similar accidents in the future. Judging from the replies we have received from a questionnaire, the industry seems to approve of our present reports and conclusions.

The thought has been advanced that a probable cause should be designed to teach a lesson rather than to merely state our finding. This might in many instances give an untrue picture of the probable cause for the sake of giving the reader a lesson.

While our work in safety education is based on individual accident reports and group analyses, the reports themselves, educational though they often are, should not be designed for this purpose.♦

[FSF editorial note: This paper was presented to the U.S. Civil Aeronautics Board June 12, 1942.]

The Code of the Pilot

Jerome Lederer
Typewritten Manuscript
1951

The choice was yours. You are committed to the profession of piloting aircraft — with all the challenges and rewards that this implies — and to the obligation that you have accepted.

The meaning of "profession," other than the dictionary definition of "vocation requiring knowledge of some department of learning or science," is hard to define. This is because we are concerned with professional *attitudes* as well as professional knowledge. For the purpose of this discussion, we can define a "professional" as one who has mastered the knowledge required for his vocation and, in addition, is required to exercise independent judgment in exercising his knowledge. The aircraft pilot certainly meets this definition. He must have a specific type of knowledge; he must be able to analyze situations in the light of his knowledge and arrive at reasoned decisions.

Integrity is essential to professional conduct. When you visit a doctor for medical attention, when you seek the services of an engineer or an architect for advice on the construction of a house, when you retain a lawyer to help in drawing a will or for other legal advice, you are placing your safety and welfare in the hands of a professional person. Where the practitioner of these various professions has established a reputation for integrity, he commands your confidence. Integrity is your main guide because your own knowledge is not adequate to judge the value and correctness of his advice.

Your confidence in his judgment is based on:

- High standards to qualify, requiring thorough educational and training processes;
- Maintenance of proficiency; keeping abreast of new knowledge;
- Recognition of one's professional status by others who are qualified to evaluate one's work;
- Tradition of individual responsibility, of intellectual curiosity and activity, of service to individuals and society; and,
- Ethical standards of conduct, *self-imposed*, established by its practitioners; this means that he must always be critical of his own acts and competence in relation to those he serves or with whom he works.

Professionalism means to know your occupation so thoroughly and intimately that it becomes a part of your life. You feel you will never know enough about it, so you seek constantly to improve your knowledge and proficiency. In short, you wish to become a master of your profession.

Piloting modern aircraft in the service of your country or of its citizens has every element common to other professions, except one.

Flying is becoming ever more exacting, requiring strict compliance with proven good practice, careful attention to detail, continuous alertness. A pilot must keep abreast of new techniques and new procedures, just as the doctor, the engineer or the lawyer. His technical competence must also be coupled with integrity, else he become an outcast.

No other profession requires such constant vigilance as piloting an aircraft. Because of the precarious nature of his activity and his constant battle with the law of gravity, the aircraft pilot must be continually alert to any form of overconfidence, complacency, egoism, vanity, irresponsibility and impatience (see *Combat Crew*, May 1951). In all these respects he has much in common with other professional people who deal with the safety and welfare of the public. They must all guard against the same weaknesses. However, a pilot bears a unique additional responsibility because there is usually no other "expert" around to check his judgment and his action at the time he makes them.

No other profession requires such a combination of skill, judgment, art, with ever-changing techniques which must be mastered.

The pilot carries high responsibility for the safety of the public, just as do the practitioners of other professions, and the military pilot carries an additional moral responsibility: the preservation of a society.

The pilot meets every one of the demands of other professions, except one. Unlike the practitioners of other and older professions, pilots as a whole have not developed a written code of ethics. The doctor has his Oath of Hippocrates, the engineer his Canon of Ethics, the lawyer also has his Canon of Legal Ethics, even the aviation mechanic now has a Mechanic's Creed.

A code is useful to professional people, even though it may occasionally be honored in the breach, because it acts as a rallying point about which members of the profession can gather to measure their competence, to uphold their integrity and to confirm their importance to society. It spurs professional progress on a high plane of activity. It creates a climate which induces high respect from the public at large, and it acts as a guide to conduct which legal decrees or military dictums cannot supplant.

A code of ethics rests on the voluntary acceptance of broad issues of group acquiescence to specific principles of behavior.

Mechanic's Creed

Upon my honor, I swear that I shall hold in sacred trust the rights and privileges conferred upon me as a certified mechanic. Knowing full well that the safety and lives of others are dependent upon my skill and judgment, I shall never knowingly subject others to risks which I would not be willing to assume for myself or for those dear to me.

In discharging this trust, I pledge myself never to undertake work or approve work which I feel to be beyond the limits of my knowledge, nor shall I allow any non-certificated superior to persuade me to approve aircraft or equipment as airworthy against my better judgment, nor shall I permit my judgment to be influenced by money or other personal gain, nor shall I pass as airworthy aircraft or equipment about which I am in doubt, either as a result of direct inspection or uncertainty regarding the ability of others who have worked on it to accomplish their work satisfactorily.

I realize the grave responsibility which is mine as a certified airman, to exercise my judgment on the airworthiness of aircraft and equipment. I therefore pledge unyielding adherence to these precepts for the advancement of aviation and for the dignity of my vocation.♦

Flight Safety Foundation
Written by Jerome Lederer
Director, Safety Bureau
U.S. Civil Aeronautics Board, 1941

An examination of the codes, canons and creeds shows that they have these points in common:

- Moral obligation to those they serve;
- Obligations to fellow workers; and,
- Principles of conduct.

The common ideals, the common tradition, the common understanding of all airmen make a code of ethics unusually desirable and applicable.

The profession of aircraft pilot deserves a code. Here is one suggested for your critical examination (see "Pilot's Code," page 45). This is a suggested code. Think it over. If you have constructive criticisms, send them to the editor.

Ethics are not learned by teaching. They are inculcated by example and by experience. To a man of honor, "ethics come as naturally as good table manners."♦

Pilot's Code

- As a professional pilot, I recognize my obligations:
  - To the public, which trusts its safety to my skill and judgment;
  - To my fellow pilots, who mutually depend upon me to follow established good practice;
  - To my crewmembers, who look to me to exercise my best judgment and leadership;
  - To my co-workers, who constantly are striving for greater achievements and general overall improvement in aviation; and,
  - To my organization, which entrusts me, in the conduct of my flights, with moral and economic responsibilities.
- To discharge these obligations, I will at all times observe the highest standards of my profession.
- I never will knowingly jeopardize the safety of a flight by undertaking a risk to satisfy personal desires nor will I fly when my mental or physical condition might lead to additional risk.
- I will use all means at my disposal to assure the safety of every flight both as to my assigned duties and those of my fellow crewmen.
- I will continue to keep abreast of aviation developments so that my judgment, which largely depends on such knowledge, may be of the highest order.
- My deportment both on duty and off reflects my respect for my profession and for my country, and it shall be such as to bring credit to both.
- I pledge adherence to these principles for the advancement of aviation and for the advancement of my profession.♦

– Jerome Lederer, 1951

Current Levels of Aircraft Safety

Jerome Lederer
Director, Flight Safety Foundation
Cornell-Guggenheim Aviation Safety Center
1953

What is the significance of safety in a democracy?

Safety is not just the saving of life or the prevention of suffering.

Safety is not just the science of recognizing the consequences of an unsafe act or an unsafe design.

Safety is not just a means to preserve wealth or protect capital investments.

Safety is not just a means to reduce the costs of insurance.

Safety is not just a means to avoid interference with production or operational efficiency.

Safety is not just a means to escape public recrimination when disasters occur.

Safety is not just a means to win public acceptance of air transportation.

Safety has much greater significance than any or all of these. It is an expression of a way of life and of living which distinguishes man from animal, intelligence from ignorance; it is a manifestation of both our ethical and technical civilization. It is the evidence of our decency, dignity and consideration towards our friends.

If we respect the dignity of the individual, we do whatever we can to preserve his right to personal beliefs, to freedom of expression, to freedom from tyranny or injustice and from physical pain.

This is not to underrate the tremendous importance of taking risks. Life would not be worth living without some element of risk; danger often has an exhilarating effect.

The right to take risks is one of our freedoms — but only when the risk affects our personal safety and not, without their permission, the safety of others.

The Declaration of Independence holds these truths to be self evident: "that all men are created equal; that they are endowed with certain unalienable rights; that among these are life, liberty and the pursuit of happiness." We must not pursue our happiness at the expense of some other person's welfare. And this is an excellent reason to crusade for safety.

Safety is difficult to define and to measure. Its common definition is of a negative and defensive character — freedom from accidents. I would prefer to regard it in a positive light as an assault on danger, even though danger being a relative matter also is difficult to define.

The current levels of aviation safety can be given in many ways. There is no adequate yardstick by which its levels can be shown in a way to satisfy all viewpoints. You can take your choice of the many ways which I will describe. Your choice will depend on whether you work for aviation or for a railroad!

Social Significance

The level of aviation relative to other causes of death is seen in Slide 1. This might be termed the relative social position of aircraft in the community of accidents. With well over 25 million people flying the airlines and I guess (pure guess) another 10 million in non-airline types of flying, the record of aircraft is good. Its position fortunately is low on the scale, whereas automobile deaths are high (90,000 fatalities per year).

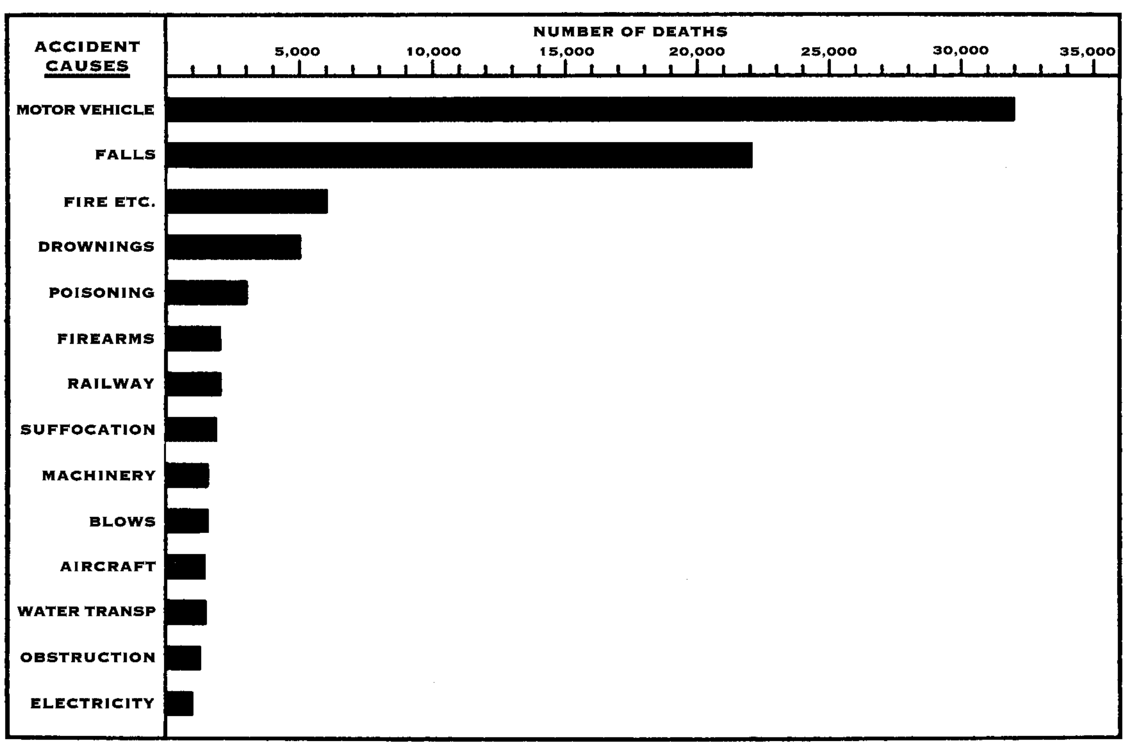
But as I have said on many previous occasions, statistics are like a Bikini bathing suit. What they reveal is important, what they conceal is vital. The great numbers of deaths on the highways are caused by great numbers of vehicles. If we exclude pedestrians who are killed, because we luckily have no pedestrians in the air, and consider only the occupants, we find that approximately one in about every 1,500 automobiles is involved in a fatal accident each year. If the average car is operated about 400 hours per year, this means one fatal accident in 600,000 hours. This is the same order of safety as the scheduled airlines and the corporation aircraft when flown by professional pilots. On the other hand, on the basis of passenger fatalities per 100 million passenger miles, automobiles are considerably less safe.

There are many other ways to show levels of safety. Ross McFarland has an interesting series of numbers on page 24 of his new book *Human Factors in Air Transportation*. On the basis of deaths per 100 million vehicle miles, automobiles look a lot safer than we know them to be (Slide 2, page 48). Slides 3 (page 49) and 4 (page 49), taken from Modley's* "Comparative Significance of Transport Safety Statistics," show how favorably aviation stands in reference to total deaths and injuries caused by trains and cars. Aviation provides rapid transportation with the least amount of human suffering.

Improvement Since the War

Slide 5 (page 50) shows how the accident record of the scheduled airlines has improved enormously since the war. But it appears to have stabilized since 1949. If this continues to be the case, it gives added significance to the tremendous effort under way to provide crashworthiness and increased chances of survival when accidents do occur. Remember that in considering fatal accidents we are dealing in very small numbers — four or five a year in over two million hours of scheduled flying — and about 30 reportable accidents of all kinds. This should be no reason for complacency. With perfection so close, we should strive to achieve it. But it is

* Rudolf Modley. A paper read at the Flight Safety Session. Institute of the Aeronautical Sciences, New York, January 31, 1951.



Slide 1

	Type of service				
	Scheduled air transport		Railroad passenger train	All buses	Passenger automobile and taxi
	Domestic	International			
Passenger-miles, millions:					
1946	5,948	1,101	64,673	72,000*	620,000*
1947	6,110	1,810	45,972	66,000*	670,000*
1948	5,981	1,889	41,185	66,000	710,000
1949	6,744	2,054	35,100	61,000	750,000
1950	8,003	2,206	31,800	59,000	810,000
1951	10,566	2,600	34,660	60,000	860,000
Vehicle miles, millions:					
1946	301	54	4,317	3,391	280,457*
1947	318	84	3,812	3,479	304,000*
1948	342	95	3,784	3,520	324,500
1949	344	102	3,567	3,384	419,000
1950	364	94	3,437*	3,383	466,000
1951	406	97	3,551	3,374	492,000
Revenue passengers, thousands:					
1946	12,213	1,041	790,130	9,422,407	
1947	12,890	1,360	703,280	9,548,100	
1948	13,168	1,373	642,781	10,060,933	
1949	15,081	1,520	554,506	9,357,036	
1950	17,651	1,676	486,241	9,302,054	
1951	22,635	2,030	483,834	7,748,000	
Passenger deaths:					
1946	75	40	116	140	15,400
1947	199	20	74	140	15,300
1948	83	44	52	120	15,200
1949	93	0	32	120	15,300
1950	96	48	184	100	17,600
1951	142	31	121	130	21,000
Passenger deaths per 100 million passenger-miles:					
1946	1.2	3.6	0.18	0.19	2.5
1947	3.2	1.1	0.16	0.21	2.3
1948	1.3	1.0	0.13	0.18	2.1
1949	1.3	0.0	0.09	0.20	2.0
1950	1.1	2.1	0.56	0.18	2.2
1951	1.3	1.2	0.41	0.22	2.4
Passenger deaths per 100 million vehicle miles:					
1946	24.9	74.0	2.7	4.1	5.5
1947	62.5	23.8	2.0	4.0	5.0
1948	24.3	21.1	1.4	3.4	4.7
1949	27.0	0.0	0.9	3.5	3.7
1950	26.4	51.0	5.3	2.9	3.8
1951	35.0	32.0	3.4	3.8	4.3
Passenger deaths per million passengers carried:					
1946	6.1	38.4	0.15	0.015	
1947	15.5	14.7	0.11	0.015	
1948	6.3	14.5	0.08	0.012	
1949	6.3	0.0	0.06	0.013	
1950	5.4	28.6	0.38	0.011	
1951	5.6	15.3	0.25	0.017	

Source: From various sources.[18–21, 24]

* Estimated.

Slide 2

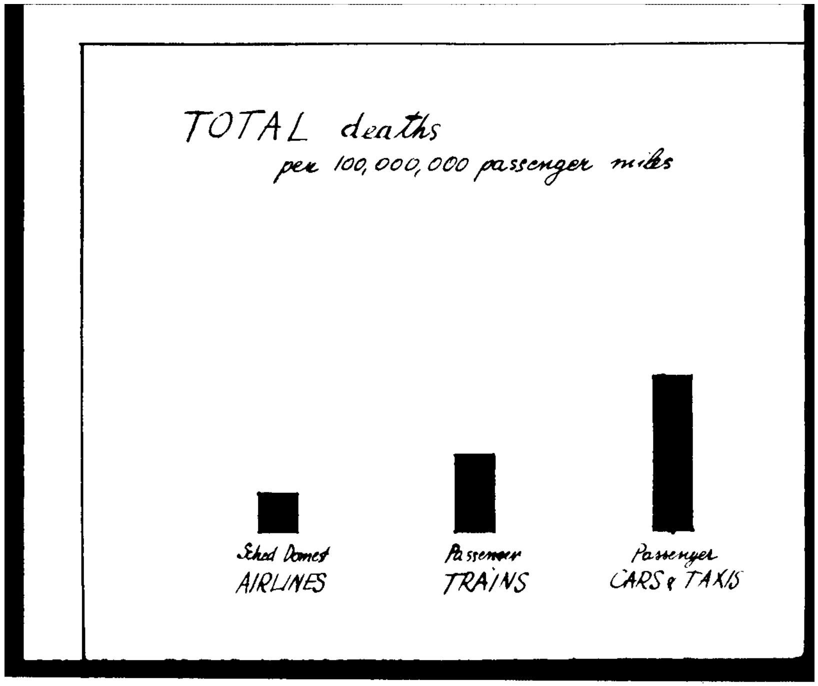
going to be relatively more difficult to improve on this already very favorable situation than to increase by design the opportunities for occupants of aircraft to survive an accident when it does occur.

Slide 6 (page 50), showing five years' cumulative accident rates, also shows very favorable safety progress when the yearly divergences are removed.

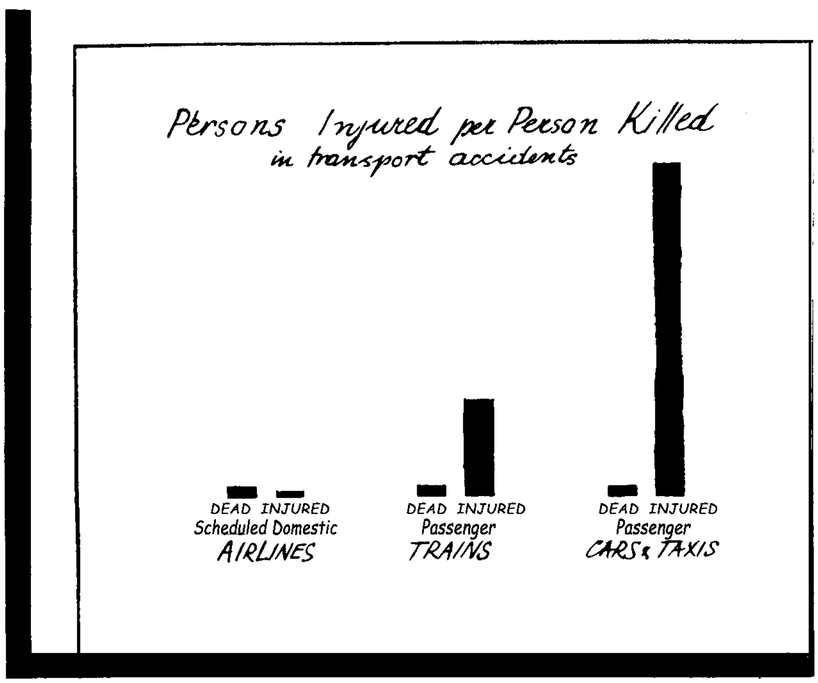
Insurance

Another way to measure safety is by insurance rates covering personal accidents.

A passenger of a scheduled airline can buy round-trip trip insurance at the rate of 25 cents for $5,000. This trip rate indicates that there is one chance in 20,000 of meeting death on a round-trip air journey. It is a lot better than that. First the owner of the policy vending machine gets a cut in the take, then the insurance company must use the remainder to pay its claims, pay its overhead and, if possible, the small underwriting profit allowed by state insurance regulations to provide incentive, pay stockholders, etc. I assume that the business is profitable because in recent years three competitors have come into this picture. Therefore, all in all, I would estimate that on the basis of 25 cents for $5,000 coverage, the calculated risk is more on the order of one



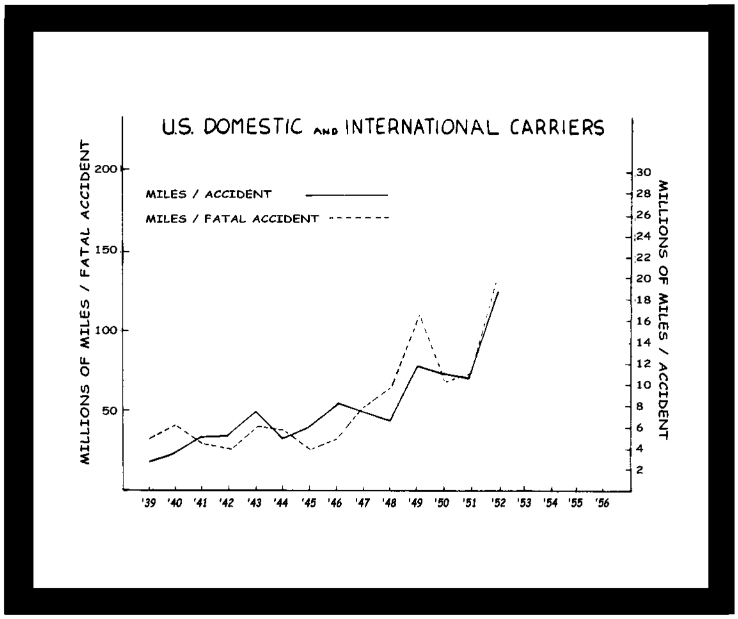
Slide 3



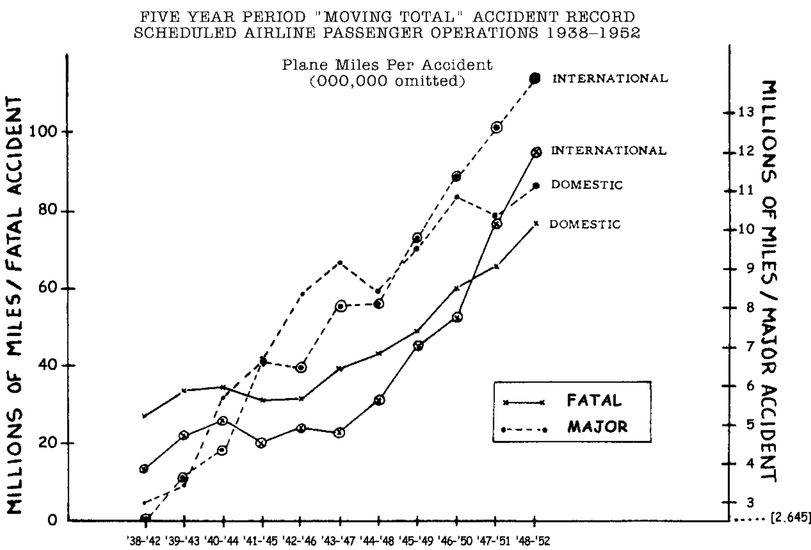
Slide 4

chance in at least 50,000 and possibly as high as 70,000. The annual accident rate for passengers flying scheduled airlines is now about $1.20 per $1,000 of coverage. In 1929 it was $10. An airline or private pilot can now secure accident coverage at $5 per $1,000; in 1929 it was $34, and for private pilots about $20.

Irregular air carrier operations enjoy a safety record on a passenger mile basis which varies considerably from year to year. It seems to be improving. The irregular carriers are now about where the scheduled airlines were before the war. Overall statistics can be very unfair because of the large differences which may exist between various airlines.



Slide 5



Slide 6

Non-air-carrier Flyers

Safety rates for other forms of flying, such as private flying or crop control, are not reliable because the exposure to risk is not accurately known.

I suppose there are some 50,000 single-engined aircraft in operation and they are involved in about 400 fatal crashes per year. This includes crop dusting and other forms of flying which border on stunts. It is unfair to paint with a wide brush because we may be unjust to categories of flying such as aircraft which are used as a business tool and which have an excellent record. It is also unfair to certain models which have much better records than others. Fortunately, the number of people involved is very small. But the figure of approximately one fatal accident per 100 single-engined airplanes is not impressive, especially when these aircraft are not highly utilized.

I cannot leave this subject of levels of safety without pointing to the economic necessity to improve the safety of agricultural flying. This is distinctly not a matter for regulation because public safety or passenger safety is not involved. Regulations are meant to protect the innocent. The crop control pilot risks only his own safety, and he realizes the risks he incurs.

The impact of agricultural flying on the economy and welfare of the world may well be of the utmost significance. It may be on par with the invention of the plow. But it is the most hazardous form of flying. Insurance rates on crop dusting aircraft for flight coverage are practically prohibitive. This includes helicopters. The rate for compensation insurance which the employers buy to protect the pilot runs as high as 20 percent of the pilot's pay, and this gives them very limited benefits. The helicopter fares better — the compensation insurance rates for pilots using helicopters are much lower. However, helicopters are not adapted to many types of agricultural flying. Here is an important field for research and education.

Personnel Safety

The fatality expectancy of the scheduled airline pilot flying at the rate of 1,000 hours per year is about 400 years, and some of those now flying appear to be immortal. We must not forget the forgotten man: the airline mechanic and other aviation employees. Slide 7 (page 52) is taken from "Accident Facts," published by the National Safety Council. It shows the frequency and severity of accidents involving the workers in various industries. In frequency, the airline record is relatively poor, understandably so because of the exposure to weather, difficult working conditions on the aircraft, numerous points of injury such as sharp cotter pins, rough metal edges, movement of heavy equipment, etc. The severity record is not bad now. It used to be in the lower fifth. Incidentally, in computing severity rates, a death is computed as equivalent to six years total disability for one man. The Air Transport Section of the National Safety Council is hard at work to improve this situation. And this brings us to the second part of my talk: overall efforts toward improvement.

Overall Efforts Toward Safety

The assault on danger covers a very wide front. Each sector is equally important. Constant pressure must be exerted against the enemy's line at all points to preserve the gains we have made. Our generalship has at times failed to recognize weaknesses in our ranks; and because we have many generals, our progress occasionally has been delayed by argument, economics, pride, until we are forced by an unhappy experience to consent to a safer course of action. The opposing side is led by one supreme commander who is an absolute dictator. He commands the utmost loyalty of his forces by great personal magnetism and attraction. His name is Gravity.

It is impossible to detail the manner in which our arms are deployed to overcome this enemy. Time is short and others after me will cover some of the principal salients such as the attack on fire, metal fatigue, midair collision and accident survival. Speaking very generally, we are developing two flank attacks: one is along the lines of technical research and development; and the other is being shaped to overcome some of our human and personal weaknesses.

An overall evaluation is further complicated by the many activities which aviation safety encompasses. For example, we might recommend shoulder harnesses in small private personal planes, but these would be difficult to fit to passenger seats in transports; and what is good for the airline may not be applicable to the private pilot.

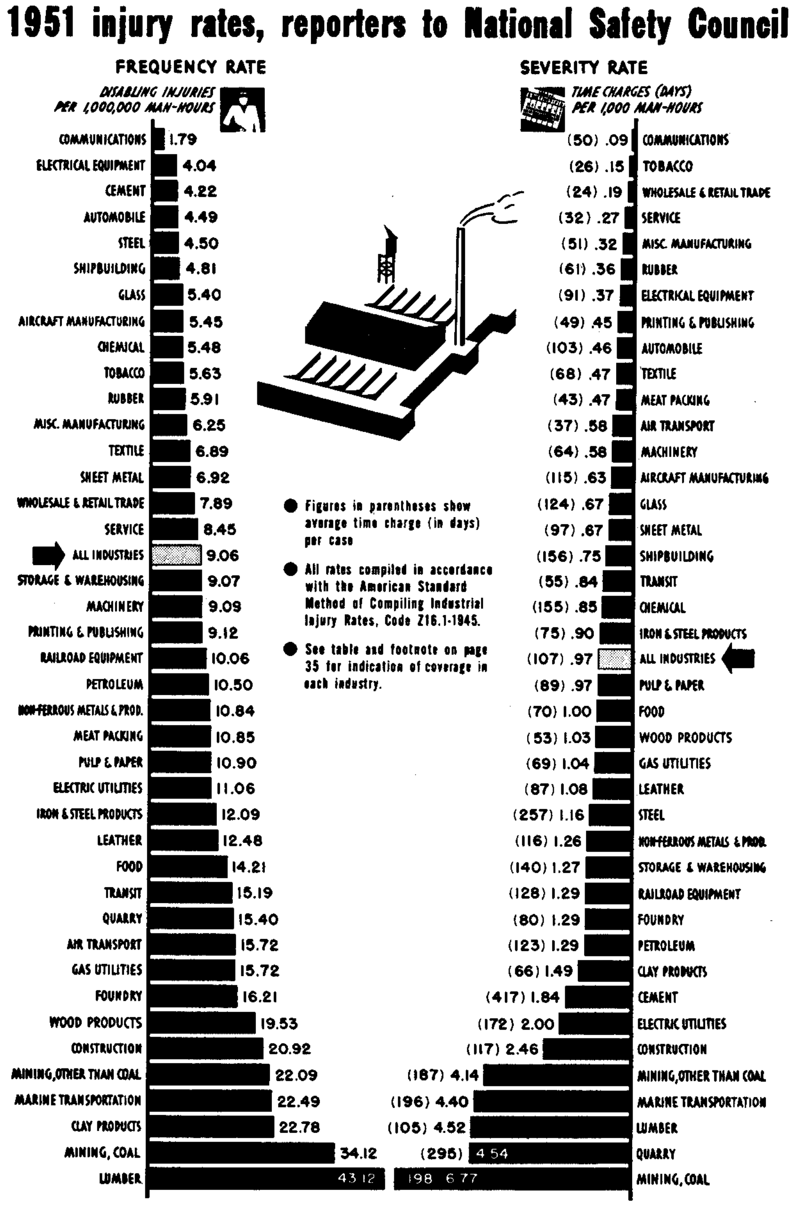
We must consider developments in management's attitude toward safety, the selection, training and supervision of man; the operational requirements and characteristics of the aircraft; the reliability, safety features and crashworthiness of the aircraft; the progress and the unsolved problems in combating weather, in communications, in aids to navigation, in airport design and management; and, very importantly, the problem of the approach and landing in instrument weather. I'll try to touch on some of these.

Management

Management is compelled to think in terms of economics, traffic and safety. Let us not fool ourselves by saying that every management considers safety as more important than the other factors. They are generally regarded as of about equal importance; some airlines favor safety a bit more than economy; all are understandably strong on building up traffic; some favor economy over safety in varying degrees at varying times, depending on the moods of management. This is equally true of manufacturers where competition, in terms of cost, producible range, payload and speed, has in the past sometimes been a greater consideration than reliability and safety. I am happy to report that never have I witnessed such interest in safety as now exists among both operators and manufacturers. However, to assure continuity of this effort, we should study the nature of organizational policies and procedures which call forth effective and safe behavior and the forces which seem to oppose adoption of safe policies and procedures.

Education

The Flight Safety Foundation and the Cornell-Guggenheim Aviation Safety Center are in the field of supplying information on accident prevention through design and operation. The thirst for the material is enormous. The Flight Safety Foundation alone publishes 5,000 bulletins every ten days covering operational problems. Its other safety literature brings the total yearly circulation to over 200,000 bulletins. One object of these bulletins is to combat complacency without creating resentment. The Cornell-Guggenheim Aviation Safety Center publishes its monthly *Design Notes*, which were intended at first only for use by instructors in universities where

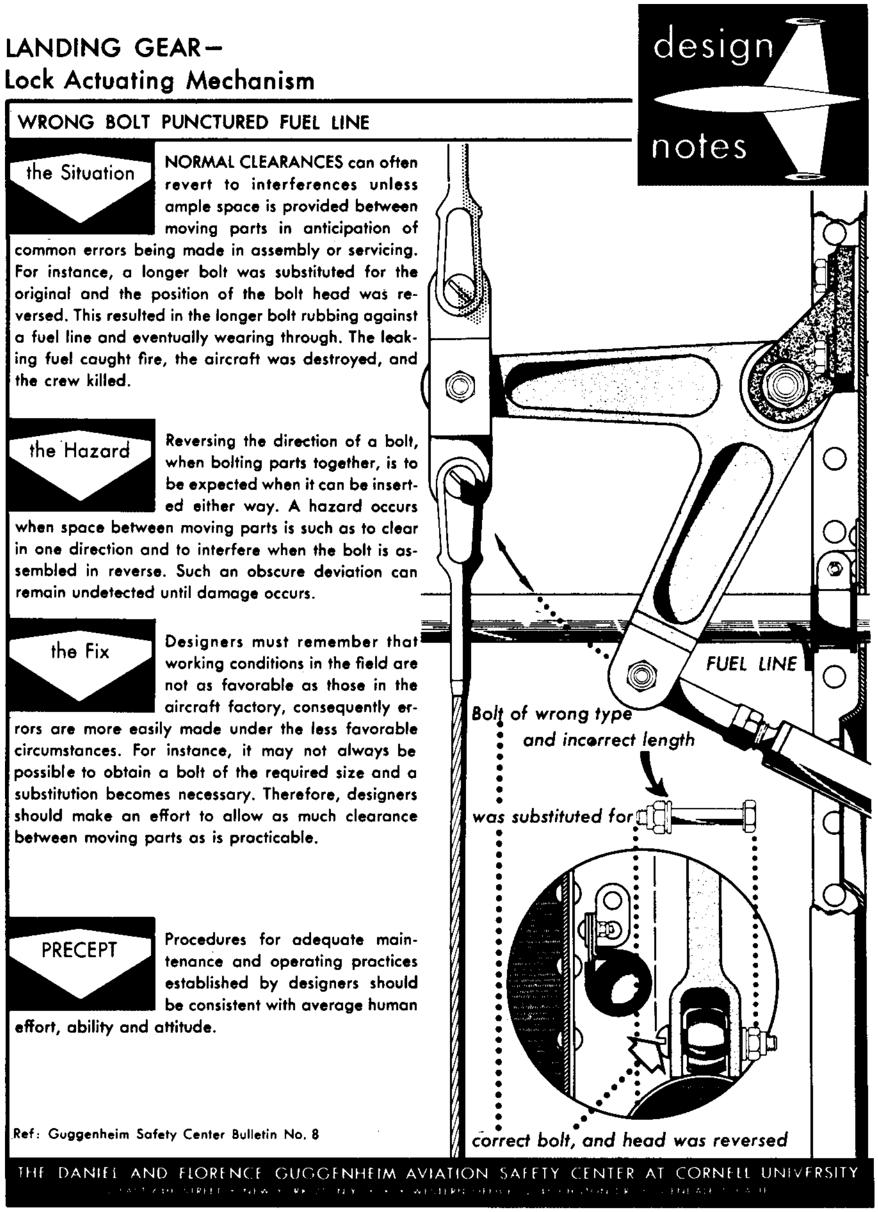


Slide 7

aeronautical engineering is taught. We have about 70 colleges in this program. The *Design Notes* (e.g., Slide 8, page 53) are expected to be integrated into classroom instruction to give students an appreciation of safety and its precepts. However, the demand from the manufacturers now far exceeds the requirements of the colleges, to the point where we supply the manufacturer with transparencies so they can make their own copies. One manufacturer makes 3,000 reproductions. These are only two of many indications of the current interest in safety. The ATA [Air Transport Association of America] and IATA [International Air Transport Association] have established committees to study safety and develop safety procedures which, from my observation, show extraordinary promise if they can crystallize their thinking in time before the design of new aircraft is too far along and if management buys their ideas. Many of the individual airlines have excellent safety refresher courses and great initiative in developing safety activities through research aids, flight simulators and special training of crews.

Industry Associations

The ALPA [Air Line Pilots Association, International] safety committees are well organized, sound, aggressive. Every issue of the *ALPA Journal* has excellent safety ideas. One issue outlines a plan of attack on that most important of all cockpit problems from the standpoint of the pilot: What will happen to me if I don't pass my next physical? The AIA [Aerospace Industries Association of America] is disseminating safety information and preparing codes of good practice. AOPA [Aircraft Owners and Pilots Association] has



Slide 8

established a safety foundation and is providing funds for safety research.

The NATA [National Air Transportation Association] and Flying Farmers, crop dusting organizations, provide much information on safety to their membership. The National Fire Protection Association is spurring the training of municipal fire departments in attacking airport fires. There is no need to outline the impact of Hugh DeHaven's work at Cornell on accident survival.

Nevertheless, oversights still occur and, of course, will always occur. The dearth of seasoned, experienced manpower in the design field, the growing drain on the time of experienced supervisors, are factors which require constant operational vigilance in spite of good intentions.

The educational efforts of government agencies such as the CAA or CAB, Coast Guard, Air Force, Navy, ICAO [International Civil Aviation Organization] are of a basic nature, yet not well known to various elements in aviation. I venture to say that very few airline operators know of the successful safety discussion groups organized by the CAA for private pilots. The CAB accident reports and special studies are now widely distributed where pilots can read them.

How many know that the U.S. Coast Guard carries on a continuous training program for overseas airline operators?

The NASAO [National Association of State Aviation Officials] gets safety back into the grass roots and has been especially instrumental in attacking the problem of "buzzing" by immature pilots.

I could go on endlessly describing all that is being done to achieve greater safety in aviation. No other industry has so many agencies working on its safety problems. This is the good side of the safety picture, but each element has interests which conflict with the safety interests of the other groups. The private pilot versus the airline pilot, the manufacturer versus the operator, the military versus the civil. Each must learn to give a little, to recognize the needs of the other — otherwise, the government must step in and do this by regulation. Some individuals and organizations cannot tolerate an externally generated idea in a field in which they consider themselves preeminent. It requires tact, understanding, persistence and clarity of exposition to secure their cooperation.

Research

Beyond this great educational effort is the immense amount of energy being devoted to the research on safety problems by our universities and research centers. Predominant in this field is the work being done in human engineering — fitting the machine to the limitations of the operator — and, equally important, work in the field of aviation medicine — heart troubles, aging, effects of high altitude, even space medicine.

A new approach to safety is being developed by Maurice Slud of the Cornell Aeronautical Laboratory. He is applying the concept of operational analysis to the whole system of air operations, knowing that safety is a result of a system, not of any one or two methods or ideas — or conversely, an accident results from a series of coincidental events, the omission of any one of which might have resulted in safety instead of danger.

The critical part of flight is usually the approach and landing. Recent developments may be expected to alleviate some of the hazards: The ALPA-ATA-CALVERT centerline approach system has been adopted by ICAO and the United States; the critical measurement of landing visibility from the standpoint of the pilot is under contract to Sperry; the development of rate of change concept to guide the pilot on the true course to the runway is under way — spurred here by Jenks of the CAA and in England by Calvert of Farnborough. The use of radar is the most promising aspect of collision prevention in congested areas; experimental verification of its value is under way. Radar for weather surveillance is also very promising. You will hear about aspects of accident survival, collision hazards, noise, fire and other safety research from others on this program.

Morale is important to safety. The larger airlines, where the problem is of greater magnitude, are planning programs which should improve management-employee relations, giving each a better sense of respect and consideration for the importance of the other.

To my mind, the present critical operational problems are: avoidance of midair collisions, safe approach and landing, accident survival, personnel attitudes towards safety, turbulence and noise. Critical design items dovetail with the operational problems and often create them: avoidance of midair collisions, for example, is one of the functions of vision from the cockpit; approaches and landings are linked inseparably with wing loading and controllability; accident survival must be considered in the detail design of the structure, the location of the fuel, etc.; reliability and safety characteristics are related to the knowledge and attitude of the designers on these subjects; noise, the most critical problem facing the industry, makes its insistent demands principally of the designer.

Simplicity of design of the cockpit, of the control system, of powerplants, etc., is chiefly a function of the designer. In satisfying the requirements of the purchaser, he should think in terms of the mechanic, the pilot, the cabin officer, and take advantage of the immense store of information on human engineering which is now available. However, the designer needs from the operator some guidance in arriving at compromises — he needs a system of weighted safety measures in the form of statistics, incidents and informed opinion to guide his judgment.

I hope I have shown that the current level of safety is good for scheduled airline flying and in the operation of privately owned multi-engined aircraft flown by professional pilots, and it appears to be improving. Much remains to be done to improve safety in other forms of civil flying. The educational and research programs in the field of air safety are well supported. The future holds tremendous promise. Civil aviation even now provides transportation with less human suffering than any other system of automotive transportation.♦

[FSF editorial note: This paper was presented to the Washington Section, Institute of the Aeronautical Sciences, at the Cornell-Guggenheim Aviation Safety Center at Cornell University April 7, 1953.]

The Work of the Flight Safety Foundation

Jerome Lederer
Managing Director, Flight Safety Foundation
Director, Cornell-Guggenheim Aviation Safety Center
1960

You may be puzzled about the distinction between Cornell-Guggenheim Aviation Safety Center and the Flight Safety Foundation.

The Cornell-Guggenheim Center deals mainly with broader aspects of safety and with safety research projects, whereas the Flight Safety Foundation deals with the more immediate safety problems and also conducts several research projects. For example, the Center may question the professional capacity of the emerging nations to control health measures in aviation, such as checking the water supply at airports, contagious disease control around airports, food contamination, etc. If this is so, the Flight Safety Foundation will try to take remedial steps through public health services, bulletins to flight crews to be careful about food, or other means.

The Center is the concept of Mr. Harry F. Guggenheim, and it is supported by the Daniel and Florence Guggenheim Foundation. The Flight Safety Foundation is supported by industry and a few dedicated individuals, such as Mr. Laurance Rockefeller.

The Center is controlled by a Foundation committee consisting of high government officials. The Flight Safety Foundation policy is established by a board of governors consisting of bankers, engineers, business executives and pilots who no longer have a direct interest in the commercial operation or manufacture of aircraft.

At the Foundation, we are often asked what we do to improve air safety. We find it impossible to answer in one short sentence. We are challenging the most unrelenting and unforgiving of our natural forces: the law of gravity (and its greatest ally, complacency).

The FSF deals in safety techniques and gadgetry and training problems. But far more important than these are the attitudes towards safety of the pilots, the mechanics, the cabin attendants, the managers who operate the aircraft and the engineers who design the equipment they operate. One of the main purposes of the Foundation is to strengthen the sense of responsibility of these people, to refresh memory by recalling hazards that may have been forgotten, to disseminate lessons learned from accidents and near-accidents, to prove the need for constant alertness, to draw attention to improved methods or new safety concepts, to dramatize respect for human dignity so that no one will knowingly jeopardize the safety of others; in short, to battle complacency, and we must do this without creating resentment, because resentment arouses resistance. Just as it is difficult for a preacher to prove that he has reduced sin, it is very difficult for us to prove that we have changed carelessness to diligence, ignorance to knowledge, distraction to attention, indifference to desire. These are our true objectives.

Bulletins are our chief form of communication. We distribute about 700,000 per year. Airlines distribute thousands to their pilots.

We have held very successful seminars where controversial safety problems are discussed in an atmosphere of quiet objectivity; where, for example, engineers and traffic controllers get to understand the problems of pilots and vice versa.

We also participate in safety meetings for private pilots, airline pilots and military personnel.

We conduct critique panels where inventors with new ideas can secure the reaction of pilots, engineers and management to their developments. Takeoff monitors, altimeters, fire detectors are some of the devices that have been subjected to these searching critiques.

We administer awards for distinguished service to air safety, for unusual performance by air crews in accidents or accident prevention.

We also try to act as a source of inspiration and moral support for safety-minded pilots, mechanics and others who need sustained encouragement to fight for safety. This is the reason for the creeds we have developed for mechanics and pilots.

We have no power to enforce — only to persuade, convince, refresh, inquire, educate.

The staff give many lectures trying to impress engineers with the importance of safety. Engineers compete for performance — for speed, payload, range — but competition for safety is not in the specifications. We try to suggest that safety be put on a par with performance.

The majority of aircraft manufacturers now have design safety specialists with whom we cooperate and exchange information of use to their engineers.

A major educational effort is to inculcate engineers with the need to consider human limitations in aircraft design both from the standpoint of maintenance and operation. This is done through lectures, by our *Human Factors Bulletins* and by direct "negotiations" with the manufacturers.

Another effort is to avoid repetition of design errors which have led to accidents or near-accidents. This is done by our *Design Notes* sent to all manufacturers but intended also for use at engineering colleges where designers of the future are trained.

A third educational effort is to introduce concepts of design for crash survival. Designers have been so engrossed in solving fundamental problems of performance and airworthiness that crashworthiness, until recently, had not been given the attention it deserves. This involves safety belts, seat design, elimination of sharp edges, structural deformation and energy absorption, etc.

A fourth educational service is a school we are conducting at our research center in Phoenix. This specializes in training accident investigators in the special art of determining why people are injured or killed in survivable types of accidents. This school is connected with the Aviation Crash Research Center. Here, on behalf of the Transportation Research Command of the U.S. Army, the Office of the Surgeon General of the U.S. Army and the National Institutes of Health, we investigate aircraft crashes and expect to establish a facility to crash aircraft under controlled conditions to determine what can be done to insure greater protection for passengers in an accident.

Special Studies

In addition to formal research, the Foundation conducts special studies as time and funds permit. In the planning stage is a study of private flying safety for the National Institutes of Health. Several others of these will be outlined:

- Landing accidents — The most significant project is a thorough study now under way of accidents that occur on the approach to a landing. Here the airlines are faced with a peculiar problem. The accident rate is reasonably good, but because of the expected increase in activity — and therefore exposure — this rate must be improved by about 50 percent by 1965 and 60 percent by 1970 if the number of fatalities is to be kept constant at, say, 200 per year — to put it coldly.

  The Foundation's study on landing accidents shows that 40 percent of all fatal accidents occur between the outer marker and the threshold of the runway. This study could be a powerful factor in supporting FAA's demands for funds to reduce landing accidents by new types of approach lights, precision radar, adequate runways, etc. We hope to extend the study to include cockpit procedures and teamwork on the final approach, the adequacy of weather reports in the last 30 seconds of flight and engineering analysis of numerous cases of undercarriage malfunctions and failures, the influence of psychological pressures to complete a flight.

- Bogus parts — Flight Safety Foundation found that critical airplane parts were being made in backyard machine shops. Large organizations, such as the airlines, were not usually affected because as a rule they buy from the original manufacturers or test the products they buy elsewhere. But this became a problem to many other aircraft operators. The parts resembled the original part only in appearance. The material, heat treatment, dimensions, etc., were not up to specifications. As a result of this study, Mr. Joe Chase prepared his famous study, "Bogus Parts." Many thousands of copies have been distributed, and it has been translated into Portuguese and Spanish.

- Safety yardsticks — We know of no fully adequate way to measure safety. The measure used by management may be different from that used to present a picture to the public. Passenger miles, hours, miles, flights, life expectancy are some of the yardsticks used; none is applicable for universal comparison of one form of transportation with another, or even one type of aircraft with another.

  By whatever yardstick used, the airline passenger record for safety is well within the normal risks of living. The man most exposed to the risks of passenger flying is the airline pilot. And over the years, his life expectancy as a scheduled pilot flying about 1,000 hours per year is approximately 1,500 years. There is no markup for his life insurance. The number of fatal accidents among the other group of professional pilots, those who fly in executive operations, is almost statistically insignificant.

- Reliability — Our Industry Advisory Committee has requested us to study the problem of reliability in the manufacture of aircraft accessories such as automatic pilots and altimeters. Like the story of the horseshoe and the nail, a small malfunction ran result in newspaper headlines.

- Controllers — In 1959, we completed for the Federal Aviation Agency a study of environmental factors which influence the efficiency of air traffic controllers.

- Midair collisions — An immense effort by the FAA is underway to reduce the midair collision potential. The airlines, in cooperation with the CAA and now the FAA, have instituted their own procedures, and results appear to be good.

  A quick review of midair collisions indicates that some of the results of the near-miss reporting program were not consistent with the history of actual collisions. For example, collisions rarely occur in instrument weather when aircraft are under ATC control. But the near-miss program reported 69 percent of the near-misses under ATC control and/or in contact with the control tower. Only 8 percent of actual collisions occur "head-on," but the near-miss program reported 34 percent.

  From 1948 through 1959 (12 years), the U.S. scheduled airlines were involved in 20 midair collisions, of which seven resulted in fatalities to occupants of the airline aircraft. There were seven midair collisions which were fatal to occupants of the other aircraft. Six midair collisions involved no fatalities. We estimate that there were 25 million airline flights in these 12 years, or about one collision in 1,250,000 flights. This is a good record.

  General aviation (private flying) has averaged about 15 midair collisions per year. In 1959, there were 12, of which 10 were fatal. The number of flights per collision is probably better than for the airlines.

  The total number of U.S. scheduled airline passengers fatally injured in these 12 years was 1,497 in 71 fatal accidents, of which 239 or 16 percent were involved in midair collisions.

  In these 12 years, midair collisions accounted for 506 fatalities in all U.S. civil aviation against a total of about 11,000 fatalities from all types of aircraft accidents, including collisions; therefore, about 4.5 percent of all aircraft fatalities have been due to collisions.

  Collisions do not necessarily increase with activity. The worst year for the scheduled airlines was 1949, with four fatal midair collisions. There were no fatal midair collisions in 1959 or 1952 through 1954. Miles flown increased over 200 percent from 1949 to 1959. The worst year for general aviation was 1948, when there were 30 collisions, of which 15 were fatal. The midair collision is so potentially catastrophic that even one is too many.

- Private flying — With a grant by the Link Foundation, the Flight Safety Foundation is conducting a series of seminars in cooperation with various states to encourage private pilots to learn how to retain control of their airplanes when they encounter instrument weather. This one factor of inadvertent flight into instrument conditions accounts for about 30 percent of fatal accidents in private flying. Automatic devices may also solve this problem. The AOPA [Aircraft Owners and Pilots Association] has attempted to correct the situation with its 180-degree-turn program, and there are other approaches such as the integration of instrument instruction with initial training of pilots. Successful experiments have been completed, under grant of the Link Foundation.

- Jets — Several thousand copies of our study "Problems in Jet Operation" were requested by airlines and many other agencies. Posters were prepared to deal with special maintenance problems posed by jets.

We foresee rapid aviation development in five different directions. There will be further and remarkable progress in the normal subsonic field. This includes the conventional fixed-wing type of aircraft cruising under 200 miles per hour as well as aircraft that will be cruising at high Mach numbers. Second will come the development of supersonic airliners, with all the problems they entail. Third will come the development of steep-gradient aircraft, made more practical, more comfortable and more economical to operate by the turbine engine. Fourth will be the so-called ground-effect machine which should open a new avenue of aviation adventure. Fifth will be the advent of space vehicles. In addition to the technical safety problems which these five separate developments will bring on, there are economic, social and political factors, domestic and international in character, which must be considered in monitoring and spurring safety development in these five areas.

For example:

- The future of labor-management relations, and relations between unions: This can influence morale, flight discipline, long-range planning.

- The changes in the size and character of population worldwide: Urbanization will have a powerful effect on aviation because of noise and greater danger from falling aircraft. The opening of remote areas and the awakening of backward nations will increase demands for transportation — more air traffic and more small-plane operation.

- New independent nations: The increase in the number of these, technically backward but with intense national pride, may create many problems for air traffic control and safety. These new nations may not recognize the importance of common control of the airspace. They may underestimate the importance of competent controllers and adequate equipment, and may not have trained technicians to draw from or cannot afford them. Political instability is a serious factor. If the military becomes the dominant factor in civil aviation in these new nations, it may create additional problems of priorities, red tape, unstable management of traffic control and of communication systems. ICAO [International Civil Aviation Organization] is the organization to prevent chaos in this area.

- Changes due to manipulation of natural forces: These will introduce several factors that may assist safety or change the pattern of operation. Nuclear power may offer unlimited range and reliable electrical units for ground facilities. The use of modified seawater to irrigate desert areas way alter climate and trade routes. Reforestation and agricultural advances may alter population patterns and culture.

- The new techniques in the art of mass communication and individual communication may improve safety: For example, will closed-circuit TV be used for in-flight inspection and for traffic control? Will TV be used in the cockpit to relay instructions to fix in-flight malfunctions? Will there be TV pictures of airports in the cockpit?

- The fear of flight which is inherent in man: One object of air safety is to keep fear forever dormant. The public is impressed by numbers of accidents, not by rate of safety, so that the safety rate cannot remain static even if it is good; it must improve in proportion to the increase in exposure (e.g., in air traffic) if public confidence is to be retained.

- The use of safety statistics: Officials responsible for the approval of safety budgets (in and out of government) often and rightfully demand statistics to support requests for funds — for example, "How many lives will it save?" Is this always a true criterion? Is it morally sound? Is the public willing to pay the cost of small increments in safety, or is the public willing to assume small risks in return for less-expensive transportation? If so, how much risk? What is "small"? Can such decisions be made by "majority" opinion?

- Does "safety" frighten the public? Aircraft operators often feel that a safety measure that is visible to the public breeds fear of flight. Is this so? Example: Marking the outside of the fuselage to show crash crews the location of emergency exits or, in nonpressurized aircraft, where to cut in to rescue passengers from a burning airplane without cutting fuel lines, etc. This has been opposed as being unsightly and frightening to the public.

- The effect of varying mores on safety programs and developments: Air safety should not recognize international boundaries. Safety lessons learned in the United States should be known in Australia, the Belgian Congo, Latin America and vice versa. But the mores of the various nationalities have an important effect on how the lessons should be presented. What are the taboos, fetishes, national characteristics which should be known and recognized to spread the safety gospel? Without this knowledge, it is difficult to tailor safety propaganda to the nature of the public to whom it is directed.

- Energy input versus safely results: Energy used to achieve safety measured in terms of funds, manpower or man-hours, etc., should be employed with optimum efficiency to prevent waste. This energy should be directed at the major problems.

This, then, is the picture of air safety from the standpoint of the Flight Safety Foundation:

- The record is good when professional pilots fly aircraft.

- The record of the nonprofessional could be enormously improved if he could retain control of his aircraft when he encounters instrument weather. This could be done by training and/or by automatic devices.

- The midair collision potential appears to be lessening; it is still serious. The problem is being strongly attacked by the FAA and industry.

- When crashes do occur, it is important to give occupants a better chance to survive by proper design of the structure, seats, seat belts, cabin and cockpit interior, and by the prevention of fire.

- There is as yet no adequate common yardstick to measure safety, but the public is more concerned with the number of accidents, or fatalities, than with rates. To keep this number constant, the safety rate has to be improved about 60 percent in 10 years.

- Until VTOL [vertical takeoff and landing] aircraft are common, the greatest stride in safety will arrive in transport operations when improvements are made to secure uniform high quality in the approach to a landing.

- The safety problems of the future should be considered in terms of the broad, technical, political, economic and social changes that are likely to take place.♦

[FSF editorial note: This paper was presented during a press briefing on aviation safety sponsored by the Cornell-Guggenheim Aviation Safety Center at Cornell University Sept. 30, 1960.]

Changing Concepts of Air Safety

Jerome Lederer
Director, Manned Space Flight Safety
U.S. National Aeronautics and Space Administration
1968

On February 6, appearing at a NASA Management Council Review, I said that "safety or risk management is embedded in all of NASA's programs and is everywhere ambient."

The success of the Mercury and Gemini programs, the successful launchings of Apollo V, November 9, 1967, and Saturn V, January 22, 1968, are, in my opinion, miracles of safety achievement — the flawless operation of 5.5 million parts! I argued before coming with NASA that its efforts to foresee and minimize hazards would raise the status of safety specialists in all of industry, that the nature of NASA's safety problems had attracted a wealth of unusual talent to this area, that NASA would set standards of safety which would be the goal of all technical activity.

Having been with NASA for seven months, I am more firmly convinced of this than before. Nevertheless, the Office of Manned Space Flight Safety, the Aerospace Safety Advisory Panel and the establishment of center safety offices reporting directly to the center director were set up in response to public and congressional uneasiness that not enough was being done to prevent accidents.

I should like, therefore, to take a few minutes to explain our present organization and what it is expected broadly to accomplish.

Dr. George Mueller, associate administrator for manned space flight, quotes Bob Hotz, editor of *Aviation Week*, that the technical challenge presented by the Apollo Program is equal in complexity to the combination of the building of the pyramids, the development of atomic energy and the design and operation of the supersonic transport all rolled together. Furthermore, it is unique in respect to ordinary requirements of safety organizations because its problems are not static, such as the operation of a factory or of a transportation system. NASA is operating a continuous series of research and development programs. We are dealing with enormously complex situations, pushing the frontiers of knowledge and design — dynamic and ever-changing, fraught with great risks. The objective to design, test and function with the highest degree of care is unusually difficult under these circumstances.

It differs in respect to military organizations, since they started with a basis of operational skills, as distinct from research. This means a type of discipline not recommended for research and development. NASA, on the other hand, started with R and D and is gradually assuming operational functions of ever-greater magnitude, combined with research.

What is the role of a safety organization in this vast complex of venture, risk, programs and people? The best we can hope to do is to pull together and support existing safety criteria, standards, procedures from each center or elsewhere for the use and benefit of the entire organization; search for gaps in these practices; complement and supplement the excellent safety activities already in existence; conduct surveys of center and contractor operations as a means to satisfy management that the highest degree of care is in fact being exercised, that complacency has not set in, that efforts are being made to improve safety; spur the search for areas that have not been considered; and establish plans to motivate the man on the bench, a key figure, to function with integrity-plus.

At this point, I should say that the concept of safety has changed from a narrow concern with industrial safety — that is, the prevention of accidents to workers — to the systematic concern with design and operational safety. Both are important. Workers must be protected; property must be conserved. Engineers have always been concerned with safety — it is part of their canon of ethics — but not until recently as a distinct technical discipline: systems safety engineering.

Systems safety engineering requires accident prevention to be carefully planned in a manner analogous to planning production scheduling, cost control, weight control, instead of being left to conscience, whims or intuitions and the random lessons of personal experience.

Systems Safety Engineering

Dr. Mueller has defined systems safety engineering as applied common sense. The advantage of establishing such a separate entity in engineering or design is that it can be defined in contractual terms, separately funded and therefore provides accident prevention with the possibility of competing on equal terms with schedules, costs, performance and profits. Systems safety engineering should overcome a safety problem created by a competitive economy where purchase orders are based mainly on costs and performance; a company cannot afford to lose business because of added costs, weight or devices that result from safety considerations. An executive of a large organization once stated that the amount of safety he builds into his airplanes depends on what his competitors do. The military services developed the concept of systems safety engineering. It was applied first by Boeing to the Minuteman missile. Its first application to aircraft is the Lockheed C-5A, although not in its conceptual or definition stage.

Among other requirements, it calls for specific attention to a large variety of design features, such as compatibility of materials, human factors, crash survival, the use of historical safety engineering data, even preparation of training programs as well as the thorough documentation and rationalization of trade-offs or compromises in design or procedures. Systems safety engineering happens to be coincident with a trend imposed on manufacturers by pressure of legal liability for the design and manufacture of products in full compliance with the state of the art.

Still in its developmental stages, it is considered a breakthrough in safety management. I refer you to Mil. Spec. 31330B for further details.

Risks must be accepted. Systems safety engineering places emphasis on the "calculated risk." In the words of Jimmy Doolittle, "calculated risks give mobility to the whole social structure. The phrase simply means a willingness to embark deliberately on a course of action which offers prospective awards outweighing its estimated dangers."

Systems safety engineering, though limited to hardware and procedures, is a manifestation of purposeful risk control or risk management.

Safety/Risk Control

Systems safety engineering places definite responsibility for safety on top management, as a contractual obligation. The dictionary definition of safety is freedom from danger. This is a very desirable goal but not realistic. It gives safety an impractical connotation; it is a sentimental term like being against sin or for motherhood. The word "safety" carries little appeal to the imagination. Until recent years, it did not attract many men of unusual caliber.

What the public really expects from safety is a tolerable accident rate, the elimination of negligence in the management of risky projects, the minimization of risk or the highest degree of care, resulting in a tolerable accident rate — but always with the objective of attaining freedom from danger.

The concept of the safety specialist is changing to another direction. As stated previously, a safety specialist has been considered to be a person who watches for and corrects a hazardous condition or trend, such as fire hazards or lack of guards on machinery. The concept was then broadened to include operational safety, then design safety.

Flight training hazards, cockpit design or an increase in, say, overshooting accidents in airline operations became the concerns of safety specialists. But these were men with different backgrounds from the specialists in environmental health and safety. Perceiving and correcting a hazardous condition is important but not so important as determining the management lapse which permitted the condition to exist. The specialist in loss prevention must treat the disease as well as the symptoms. Therefore, the safety specialist is rapidly becoming an arm of management; he functions as management's roving ambassador. The day will come when management specialists will sit on accident investigation boards along with the technical specialists. This is a newer area for the loss-prevention specialist.

Safety is becoming more than an abstract term to management. Its importance is brought home to management by its need to protect its public image, its prestige, by the heavy costs of lawsuits and by a growing recognition that an undesired event is a reflection on its competence to manage.

To satisfy all these varying concepts of safety, to attract imaginative people to this field and to recognize the role of top management in preventing accidents and conservation of its resources or deliberate assumptions of risk, the term "safety" is less descriptive of practical goals than the phrase "risk control" or "risk management." In the real world, we are concerned with safety, not so much as "do-gooders" but as managers of risks. The word "safety" tends to lull — the word "risk" tends to alert the senses. The word "risk" is lively, meaningful and challenging. The word "control" or "management" denotes the ability to identify, analyze, evaluate, measure, minimize and thereby control the risk — all the mental tasks that appeal to engineers or scientists. Above all, the phrase is realistic. "Risk control" rings with action, status, challenge and appeal to the imagination.

Public Pressures

Major developments in safety usually follow dramatic accidents. Then public sentiment demands correction. One need to look no further than fire codes for this. The disastrous Triangle Shirtwaist Fire of 1913 in New York, in which scores of girls lost their lives, was followed by standards in fire protection previously nonexistent. The sinking of the *Andrea Doria* and the burning of the *Yarmouth Castle* have had great impact on the revision of marine safety codes. The midair collision over the Grand Canyon resulted in the Federal Aviation Act and a tenfold increase in funds to provide for traffic control. The death of a very prominent person or dramatic attention to large numbers of unknown people killed in accidents has a similar repercussion. This is safety by "crisis management," which should be countered by systems safety engineering and expectable risk management.

When large numbers of people are killed in small units, the public seems to remain unimpressed until someone pulls all the information together to arouse public reaction. The line of demarcation appears to be dramatic death versus commonplace death or risks taken in concert versus individual risk.

In the early days of aviation, the public expected accidents to happen and accepted the risk. Not so today. This applies to space activities, astronauts. They may be willing to assume the risks, but neither the public nor Congress favors this if corrective action could have been taken.

All this leads to a point on which designers and engineers are seldom cognizant until it hurts. They have been trained to allow for every type of physical force in creating their designs. But they tend to ignore other less tangible but powerful forces such as public pressure or legal liability. Public pressure results in crisis management of accident prevention. Public pressure closed Newark Airport for about nine months following a series of three accidents in that vicinity in the early 1950s; it almost closed Kennedy International and La Guardia at the same time. It is a force which cannot be ignored. It compels designers and executives to reconsider trade-offs in design, such as redundancy and crash survival, against the desirability of using those weights or costs to improve reliability. Rational analysis may at times have to give way to public opinion if a program or a business or even a government wishes to survive. It is a fact of life which, like product liability, should have some constructive connotation. The best antidote is organized risk recognition, minimization and management as exemplified in design by systems safety engineering.

The designer bows to other non-Newtonian forces such as time constraints and costs. The forces of public opinion and legal liability are also beginning to be recognized as realities an engineer has to live with.

Legal liability is having a profound effect in technical affairs. It affects the free exchange of accident prevention information, the ability to obtain free and full disclosures of pertinent information during accident investigations. The reason for this comes from the ease with which such information can be used in lawsuits to collect for negligence against industry. Lawyers for plaintiffs have the power to subpoena company or associated records and can use government accident reports as sources for information and witnesses. Lawyers are adept in finding every scrap of evidence that can be used to argue negligence of pilots, engineers, mechanics, designers and other employees of government or manufacturers. At any one time, the FAA has $250 million in lawsuits to defend, and one of the large aircraft manufacturers has over $100 million in suits against it at most any given time. At public hearings on aviation accidents, there are usually more lawyers than technical people in the audience.

A corrective measure has been suggested: liability without fault. This calls for the payment of claims without trying to fix blame for negligence. It is being considered for automobile application in several states. Workmen's compensation insurance is an example of this concept.

Human Factors

There are several divisions of the discipline known as human factors: medical, physiological, psychological. It is intended to help design the machine, procedures and schedules to fit man's limitations; it also includes crash survival. This concept of air safety is relatively new, since World War II.

Medical, physiological and psychological standards were promulgated by the military services for the selection of pilots in World War I and have been developing ever since. But acceptance of a scientific approach to engineering for human limitations and for crash survival has come very slowly. The probable reason for this is that engineers gave priority to solving the basic structural and aerodynamic problems and let human problems be resolved by the intuition, personal characteristics and habits of whoever designed the seats, instruments, controls, windscreens, control and fuel systems, maintenance features and cockpit/cabin configuration. Thus, there are airline pilots who have had to go to chiropractors to get their spines straightened; cockpits have no place to put approach charts; there are unnecessary light reflections, sharp corners, lethal control wheels, toxic producing materials; there is constant need to combat Murphy's Law and a host of other oversights of human factors in design. These have led to accidents and fatal injuries. Improvements in human engineering have come slowly because of limitations in the training of engineers. They are trained to specialize in the world of materials and physical laws. Their laboratory work is not conducive to understanding the need for rapid analysis and fast manipulation of controls in emergencies. They are trained to learn by reading technical texts and to report their knowledge by preparing reports, and they often have the mistaken confidence that the operators of the vehicles they design or the people who maintain them have accepted literature as a way of life. This is not so for many very able technicians. Engineers tend very often to depreciate or push aside the contribution to safety that can be made by human factors specialists. Because we are humans, or think we are, we engineers are prone to use our own experience in place of scientifically derived knowledge of human factors. The old NACA [National Advisory Committee for Aeronautics], despite its magnificent achievements in the development of aviation, was not overly cordial to physiologists, psychologists and aeromedical specialists until the advent of space problems. The human factors specialists have themselves considerably to blame for reluctance to recognize the practical problems and trade-offs faced by engineers, for putting their knowledge in terms difficult to understand or use and for not doing a better selling job. A paper given at one of the annual conferences at the U.S. Naval Air Safety Center showed how dangerously lacking was this attention to human factors. This was followed by a study by Meister and Farr[1] made for the Office of Naval Research and reported in the *Journal of the Human Factors Society* for February 1967. The abstract says, "Designers appear to have little or no interest in human factors criteria or information and usually fail to consider human factors in their designs. Their analysis of design requirements is minimal and shallow."

1. "The Utilization of Human Factors Information by Designers," Bunker-Ramo Corporation.

Fortunately, under the influence of systems safety engineering, this new safety discipline will require organized attention. This will be a very desirable change in the concept of safety.

Pilot Error

Pilot error has undergone a considerable change in concept. It is the most controversial of human factors. Until a few years ago, the accident analysts based the probable cause of an accident on a stereotyped pilot who could do no wrong. This has changed. Errors made by pilots can be created by design (the misreading of the three-pointer altimeter and dangerous stall characteristics of certain aircraft are examples), by ignorance (inadequate training), by the environment (weather, navaids, airport conditions), by physiological and psychological reasons (vertigo is an example of both), as well as by acts of commission or omission such as flying while under the influence of alcohol or drugs, or failing to have current charts (i.e., true pilot error). The phrase "pilot factor" has replaced pilot error in much of air safety literature. This change is discussed in greater detail in "Human Factors and Pilot Errors," Eleventh Business Aircraft Seminar, Flight Safety Foundation, 1966. The recent CAB [U.S. Civil Aeronautics Board] publication "Aircraft Design Induced Pilot Error" gives excellent examples of design practices which cause pilots to make "errors."

Crash Survival

The Wright brothers had a considerable interest in crash survival. That is one reason why the engine on their first airplane was offset so that, in a crash, it would be less likely to land on their backs.

The human ability to survive crashes was also ignored in aviation until recent times. This concept was recently brought to wide public attention by Mr. Ralph Nader and Congress in regard to automobile design; it was not recognized as a separate discipline until Mr. Hugh DeHaven initiated carefully documented studies to prove that the body had unknown capacity to survive great forces when the forces were properly distributed. From his work, supplemented by Col. John Paul Stapp and others, was derived most of the current concepts in crash survival for aircraft and later for automobiles. It was difficult to convince designers that improvements were needed. One often heard the cliché "our airplanes were built to fly, not to crash." It took about ten years to raise the seat design loads from 6 g to 9 g!

The latest civil air regulations require more detailed attention to crash survival. The U.S. National Transportation Safety Board has a human factors unit for accident investigations with a flight surgeon attached to it.

The chances for surviving the impact of a crash have been vastly improved. Fire following a crash remains a major problem. An immense amount of development work is being conducted to evolve crash-proof fuel systems, fuels that will burn only in the engine. Explosion-suppression systems are being installed. But the new requirements were brought to a head by two recent airline crashes: safety by crisis management!

Crash survival is now one of the liveliest issues in design, spreading from aviation into the design of trains, boats, automobiles and spacecraft — an excellent example of change in concept.

This short exposition on change in concepts of air safety has covered the transition of health and environmental safety to another discipline: systems safety engineering. It also reports on the transition of a safety specialist from one who attacks symptoms to one who is an exponent of good management as well as the increasing influence of public pressure and product liability on engineering management and exchange of information. The change in concept of pilot error and the increasing emphasis on human factors in design are relatively newer concepts which should rapidly gain wider acceptance than in the past. The space program should have a marked influence on these developments.♦

[FSF editorial note: This paper was presented at the Aviation Contractors' Safety Representatives Conference in Norfolk, Virginia, U.S., March 13, 1968.]

Risk Speculations of the Apollo Project

Jerome Lederer
Director, Manned Space Flight Safety
U.S. National Aeronautics and Space Administration
1968

In less than 70 hours, three astronauts will be launched on the flight of Apollo 8 from the Cape Kennedy Space Center on a research journey to circle the moon. This will involve known risks of great magnitude and probably risks which have not been foreseen. Apollo 8 has 5,600,000 parts and 1.5 million systems, subsystems and assemblies. With 99.9 percent reliability, we could expect 5,600 defects. Hence the striving for perfection and the use of redundancy which characterize the Apollo Program.

Regardless of risks and even of setbacks, man will land on the moon. This exploration is a prelude to the development of vast new scientific and technical resources which will materially affect the social and economic future of all mankind. For example, as a result of revival of interest by NASA in fuel cells, 20 natural gas companies are allocating $27 million to research their development for home use.

The use of unmanned satellites for communication, navigation, weather forecasts, the discovery of earth resources, are hints of what is to come to help man manage his little but important world. In my opinion, the control of waste, the reduction of pollution, the production of new material, the eventual management of earth resources and, perhaps, of society should be significantly influenced by the work now being done for the Apollo Project.

Skeptics properly question why risk men in space and exploration? The answer is at least threefold, aside from any military need:

- The attention and ingenuity of men can conserve an experiment when difficulties and malfunctions occur. They can accommodate and adjust their equipment for unprogrammed events. A $30 million Nimbus had to be destroyed recently because a gyro control was set 90 degrees off its designed axis. Perhaps a pilot on board could have carried on.

  Schirra on Apollo 7 managed to get his stuck camera to operate by applying face cream to its parts. Eisele overcame problems with a malfunctioning fuel cell on Apollo 7. Man will be needed to service and repair satellites as well as manage the stations which will be used for the continued exploration of space and those which will be used to transfer power from the sun for use on earth.

- Man will be needed to conduct scientific and technological experiments as well as to take advantage of the unique environment of zero gravity and zero vacuum to manufacture articles in space, articles which cannot be made on earth.

  Drug manufacturers look with interest at the zero vacuum and absolute cleanliness available in space. Optical glass and lenses of great size with twice the refractive index of glass made on earth could be manufactured in space to improve the efficiency of telescopes, binoculars and cameras. This is because the one gravity of earth causes distortions and imperfections in molten glass.

  A great need exists for better ball bearings for operation of gyros, jet powerplants, high-speed centrifuges, large radar disks and much other precision machinery.

  Premium prices would be gladly paid for better bearings. Because in zero gravity a molten mass can form a perfect sphere, like a soap bubble with no distortion due to gravity, ball bearings can be made so perfect that light waves would be needed to measure the imperfections. They can be made hollow to save weight, to better absorb load deflections and to accommodate the temperature variations. Steel as light as balsa wood can be made in zero gravity by a foaming process. Other intriguing possibilities for using zero gravity and zero vacuum continue to be brought to NASA's attention. Serious consideration is now being given to the growing of crystals of unlimited size and absolute perfection. We have heard that diamonds the size of basketballs are a theoretical possibility.

  Attention is now being given to the development of low-cost transportation into and out of orbit. It is expected that such a space shuttle would be able to deliver payload to orbiting space stations for a tenth of what it now costs. With this development, which could be operable before 1980, we would really begin to realize a return on our investment, and the risks now being taken would pay off to our total economy. One offshoot of a space shuttle is a reusable passenger vehicle which could orbit from point to point on earth. New York to Tokyo in 45 minutes. These are in conceptual stages of design by six manufacturers.

  The commercial potentials of manufacturing in space will be discussed in more detail by Dr. George Mueller, associate administrator for manned space flight, NASA, at a meeting of the New York Society of Security Analysts on January 28 here in New York.

- The third reason for putting man into space was well explained by Schirra on a recent "Meet the Press" program when he said that man is needed to recognize targets of opportunity. He referred, for example, to unusual weather patterns which had focused the attention of his crew. They produced useful photographs for weather research. Man's ability to recognize, analyze, synthesize and react promptly are the characteristics which assure optimum efficiency of a mission.

There is also another consideration for man in space: It may be less expensive to have man manage the spacecraft than to build the complex automatic computers necessary to take his place.

Apollo has often been compared with Columbus's venture. It would be difficult to imagine Columbus's crews replaced by automation and to have had subsequent exploration of America conducted by telemetered robots. While his planning would have been tremendously improved by a photograph or two from an unmanned satellite, I believe we could all agree that the benefits to the world of his discoveries have outweighed the personal risks undertaken by Columbus and his men.

It may be less expensive to have man manage the spacecraft than to build the complex automatic computers necessary to take his place.

Is the Apollo Program worth the risks? The exploration of the universe with the moon as a possible relay or service station should give man new knowledge of solar phenomena and energy, earth origin and development, planetary and cosmic data. These should be of enormous industrial consequence to science and to the industrial developments to which new knowledge ultimately leads. The sun produces 32,000 times as much energy per day as we use on earth. Space developments should help replace dwindling supplies of energy.

In 1927, Lindbergh's flight was compared with Columbus's voyage of 1492. You may recall that it was the far-seeing Lindbergh who in 1930 secured financial support for Dr. Goddard's experiments with modern rocketry. In those days, Dr. Goddard was derided as "that moon man."

Columbus and Lindbergh also endured considerable derision. The world was enriched by their fortitude. Despite the questioning and criticism, there is a future for man in space.

In this short talk, it is impossible to describe, or even list, all the steps which are taken to minimize risks on an Apollo flight. After exhaustive tests, every proposed flight is subjected to numerous critical reviews. There are design certification reviews, flight readiness reviews, countdown reviews and many others.

Every Apollo flight is most carefully covered by telemetry, which monitors temperature, pressure, noise and other effects.

This is so well done that in a few weeks after the unmanned Apollo 6 had two engines shut down, lost a 35-square-foot portion of the Lunar Module enclosure in flight and suffered severe POGO (longitudinal vibration), the causes could be determined, verified by test, and corrective measures taken without anyone ever seeing the parts that failed.

The 3,100 telemetry points on board monitor the 1.5 million systems, subsystems and assemblies on Apollo. During the flight, data is returned and examined on a real-time basis. This data retrieval system is the heart of the so-called "open-end" philosophy which governs the Apollo Program. It is based on constant analysis of all systems so that any malfunction can be instantly known and, wherever possible, compensated for. The continuity of a flight is governed by a series of plateaus. Each plateau provides the time and procedures to ascertain the precise condition of the spacecraft, the crew, ground support and all systems. The next plateau is not attempted until all readings indicate that it is safe to "go."

Another important element in risk management is striving toward the highest degree of care in workmanship monitored by some 3,000 quality-assurance specialists. One contractor confessed to me that working for NASA is an excruciating experience but that he is proud to be part of the team.

An awareness program has been established among all of NASA's contractors and subcontractors — some 15,000 organizations.

Several planned projects to be accomplished on the moon's surface have been deleted from the first landing to provide time for greater assurance of safety.

Thus the 5,600,000 parts have functioned in Apollo 5 with a reliability of 99.9999 percent — a statistical miracle. The various techniques used to attain this will, I predict, have an impact on most of the industry.

Dr. Paine, acting administrator of NASA, has reiterated at staff meetings the importance of getting the astronauts safely to the moon and back. NASA tries to foresee all possibilities of risk in Apollo and minimize those that cannot be eliminated. Several planned projects to be accomplished on the moon's surface have been deleted from the first landing to provide time for greater assurance of safety. But no person or body of persons can foresee every event that may develop. Any exploration into the unknown involves risks. We must be prepared to cope with them within the constraints of time and funds.

In contrast, Columbus took what he could get with available funds, but his ships had to stop for several weeks for repairs in the Canary Isles. They would never have passed NASA's functional tests. His quality assurance was inadequate by Apollo standards. On the other hand, for safety, he ordered two ships because he felt he might lose one.* Friends then came through with a third ship, the Santa Maria. Sure enough, he did lose this flagship on Christmas Eve off Hispaniola.

After reducing provisions to a minimum because of inadequate funds and many delays, the launching of Columbus's fleet took place on August 3, 1492. On T+3 days, the guidance system malfunctioned on the Pinta — it lost steering control as well as springing a leak. This required a mid-course adjustment and a docking maneuver with the Canary Isles for several weeks of repairs. They steered by magnetic compass, time was reckoned by sand glass, speed by a chip of wood dropped off the bow, charts were based more on imagination than researched fact.

Columbus did not know where he was going, how far it was, nor where he had been after his return. With Apollo, there is no such lack of information. We know exactly where we are going and, within a few feet, how far the destination is from the point of departure. We can see our target. Furthermore, there is little doubt that we shall know where our astronauts have been when they return to earth.

How do you prepare a man to cope with conditions when you do not know what all these conditions might be? The NASA answer — call in the experts in all fields to determine these conditions and simulate them within the earth environment. The astronauts are science or engineering graduates. Many of them are test pilots in superb physical condition. A far cry from the tattered and ignorant ragamuffins of Columbus's crews.

The failures to caulk the ships properly, to pre-launch-test the rudders — these are not apt to happen with Apollo. The various systems are tested individually, mated with the spacecraft and booster, and re-tested. Then the whole system is tested, the results examined, and tested again until the launching.

The modicum of mission safety through redundancy provided by Columbus's three ships is duplicated wherever possible in every critical system of the spacecraft and booster. For oxygen supply, there is a capsule supply system, a pressure suit supply system and an emergency system. For re-entry, there is an automatic guidance system, a manual system activated by the astronauts and a third system operated from the ground control stations.

Weather-wise, Columbus had very little to go on. There were no Tiros satellites to provide worldwide photos of the weather and cloud formations, no sophisticated worldwide weather

* In space parlance, this is known as "mission backup through redundancy."

prediction systems. So, as could be expected, he arrived in the New World during the height of the hurricane season. We do not know, of course, exactly how many hurricanes hit the West Indies that year of 1492, but if it is anything like the last 60 years here, somewhere around 85 percent of the year's hurricanes came during his outbound voyage.

Our astronauts will be in a far less hazardous position in their Apollo spacecraft heading for the moon than they would have been in the crew of one of Columbus's ships, heading out for the rim of the unknown world.

Apollo 8, if it is successful, will be an important exploratory step toward the objective of landing on the moon. Just as Columbus had the experience of sailing to Iceland and beyond the Arctic Circle prior to his voyages of discovery, so NASA, with much more precision and organization, is feeling its way to man's exploration of the moon and the universe.

As a comparative newcomer to NASA, I can look at its endeavors more objectively than the old hands. Never in 40 years of concern with the management of risks have I seen such extraordinary attention to success in design, quality assurance, test, procedural reviews and overall planning. The technical and managerial leadership under Dr. Mueller and Gen. Phillips is superb. As an example, every 2.5 seconds of Apollo 8 has been documented.

NASA would not permit the astronauts to do what Lindbergh did: too dangerous! However, his planning too was meticulous and thorough.

The examination of risks in the atomic energy field probably was equally well done. But there the probability of accident had to be eliminated. In manned space, probability cannot be eliminated. The probability of an accident has to be accepted because of weight and space constraints, the hostility of the environment, the greater chance of unforeseeable events, thousands of sensitive pre-launch procedures, new techniques, small factors of safety and the complexity of the lightweight, often miniaturized components.

As an example of possibility of an accident, there is the service propulsion engine which powers the spacecraft of Apollo. You have read in the press of the reliance that must be placed on the performance of this single engine. It has to be operated at intervals to propel the spacecraft to the moon, to get it into lunar orbit and out again for return to earth. A risk is being taken on the possibility of failure of that one engine. But up to the point of the single combustion chamber with its injector and nozzle, every part of that powerplant, the service propulsion engine, is redundant. It is probably less of a risk than Lindbergh took on the failure of his single engine on his flight to Paris in 1927. Incidentally, NASA would not permit the astronauts to do what Lindbergh did: too dangerous! However, his planning too was meticulous and thorough.

This powerplant then is what is called a single-point failure. It is one of several uncertainties and single-point failures of a systems type which could result in a loss. Every test pilot is prepared for the eventuality of a single-point failure, as the record of test pilots shows. Incidentally, every mountain climber knows about a single-point failure: his rope. If it fails, he might wish he were in orbit. But he is trained to use the rope, he buys the correct strength, checks it for quality assurance, and off he goes. Every conceivable test of this engine has been made to assure its reliability. It has been tested 3,200 times. However, if it should fail to operate in the vicinity of the moon, the astronauts will stay in orbit there.

There is a similar single-point failure in the lunar landing expedition when the astronauts take off from the moon. The ascent stage of the lunar landing vehicle has only one engine. If that fails, the two astronauts stay on the moon. If it works, and they take off, they must rendezvous with the command module waiting for them in orbit around the moon. That spacecraft is the one with the same service propulsion engine to be used in this coming week's orbit of Apollo 8 around the moon. The astronauts will again rely on that one engine to return to earth. If it fails to start, they stay in moon orbit. The moon project has these two single-point powerplant failures. Rescue will not be practical.

The rescue of astronauts from a spacecraft in trouble is feasible for certain portions of a mission. Col. Borman, the Apollo 8 commander, emphasized on a recent TV program that he felt satisfied with the current rescue philosophy, considering available resources. Intense studies are underway to determine the optimum methods for rescue in future manned programs such as orbital workshops. There is debate as to whether the total effort should be in inherent reliability and redundancy as against the weight of carrying on-board rescue equipment. But the absence of on-board rescue equipment would assume complete confidence in coping with all contingencies.

If a problem occurs on the pad or shortly after launch, the launch escape system is available to lift the crew away for descent by chute. Gravity is available for return to earth in lunar flight, if problems arise. There is considerable maneuvering allowance for the command and service module to mate with the ascent stage of the LM if it should miss on the first try.

There will also be times on the Apollo 8 flight when it will be unable to communicate with earth for 45 minutes in each orbit. This means that the careful monitoring by telemetry of astronaut activity by hundreds of technicians on earth will be temporarily interrupted. Throttle and other settings are monitored from the ground. An improper setting or a malfunction could occur that the ground monitors might not catch. The probability, however, is low and I would say less than the chance that Lindbergh took with no monitoring or communication at all for over 33 hours. There are other single-point failures and risks. With three astronauts, the chance of serious illness on board, such as appendicitis, is increased, but this, too, is of very low order of probability.

You may be curious about the ethics of permitting astronauts to risk their lives in such ventures. You all hold shares in this venture through your tax dollars; therefore, you are entitled to a determination of whether your conscience should approve or disapprove the risks of manned space operations.

First, there is the need to find if the risk is tolerable. A high chance of failure or even a 90 percent chance of success would be intolerable in the Apollo Project because, unlike Lindbergh's venture, public funds, not private, are being used.

The next consideration is acceptance of the risk by those who are exposed to it. As individuals, we frequently accept risks in crossing a busy street, driving a car, smoking or overeating. Society permits and even applauds acceptance of risks by the individual so long as he does not unreasonably jeopardize others. Air shows and motor races at Indianapolis are examples. In space, the risks are not to the public but to a small number of astronauts who are willing — even eager — to accept them.

In space, the risks are not to the public but to a small number of astronauts who are willing — even eager — to accept them.

The state of the art is another factor. The art does not permit redundancy to eliminate the risks of single-point failures, nor does it permit more weight for greater strength. These risks need to be accepted if the missions are to go ahead in a pioneering and timely fashion. The development of every vehicle or machine could be improved at the time its design is frozen, but in waiting for total improvement, it would never be put to use. The state of the art improves with time.

Economics is also a problem to consider in accepting single-point failures. Lindbergh did not have funds to obtain a multi-motored, multi-crew airplane as his competitors did (and failed). In the case of Apollo, it is difficult to see where at this stage additional funds could eliminate single-point failures. A high probability of success is assured by tests for compliance with well-established criteria and by the personal responsibility, integrity and monitored performance of the hundreds of thousands of people who comprise the Apollo team.

Another consideration in the acceptance of single-point failures is the importance of the mission from the technological and political standpoint. The safety of astronauts is a matter of national concern. But vis-à-vis the safeguards, this must be balanced against the risk of default in a venture of supreme significance.

It is the nature of exploration to be always accompanied by risk. And the risk must be calculated against the potential gains. Congressman George P. Miller, chairman of the House Committee on Science and Astronautics, recently said, "A progressive society is a risk-taking society."

A fitting conclusion for these speculations on the Apollo risks is a statement made by Lindbergh to Daniel Guggenheim in 1930. Lindbergh was discussing the need for funds to support Goddard's research. He said, "It's taking a chance, but if we're ever going to get beyond the limits of airplanes and propellers, we'll probably have to go to rockets. It's a chance, yes, but I think it's worth taking."♦

[FSF editorial note: This paper was presented at the Wings Club, New York, New York, Dec. 18, 1968.]

Major Contributions to Aviation Safety

Blind flight, radio communication, the 'surrogate' concept, simulators and data recorders.

Jerome Lederer
President Emeritus, Flight Safety Foundation
1979

Aviation safety is the result of an intricate system of care, skill and ingenuity designed to circumvent the unyielding law of gravity. The system includes aircraft design, flight operations, the infrastructure, experienced management and personnel — all performing under an umbrella of regulatory policy. It is monitored by public reaction, communications, costs, ethics and accident investigations as it strives to improve. Each sector of the system can be divided into hundreds of components.

Human factors such as man-machine and man-man relationships are also part of the system, an extremely important part, but this survey will deal mainly with technology, except for blind flying. An airworthy aircraft, operated by trained and prudent personnel, will be taken for granted.

Where the rigorous reliability required for scheduled takeoff and landing is not an essential factor, as in "bush" operations and other types of general aviation, safe flight rests not so much on hardware and on the infrastructure as on prudent airmanship and conscientious maintenance. Air carrier operations demand safety criteria of much greater complexity than general aviation.

Obviously, ground facilities, the infrastructure, are absolutely essential for safe, reliable air transport operations. Airports, ground equipment, approach and landing aids, airway aids, weather services, air traffic control, communications facilities, come to mind. The instrument landing system, approach lighting systems, grooved runways, adequate overrun areas, are sine qua non for aviation safety.

It might be argued that the essential requirement for a safe air carrier operation today is the total system, not any one part of it, such as the aircraft or the infrastructure. And the most important ingredient of the total system is not the physical plant (aircraft and infrastructure) but the manner of its operation. It requires an organization managed by experienced, prudent, disciplined specialists. This would include the selection, training and evaluation of airmen, mechanics, air traffic controllers, dispatchers, weather forecasters, ramp personnel — the whole spectrum of operational personnel. Inherent in the system are operating standards (such as for maintenance and for weather minimums), management-employee relations, awareness programs, exchange of incident data, regulatory requirements, and prompt dissemination of lessons learned from accident investigation.

One might conclude that the development of the total system has been the most important contribution to air carrier safety. Nevertheless, when an emergency occurs, it is the captain who

First instrument simulator at Brooks Field, Texas in 1930. (Carl Crane Collection)

carries the total responsibility. His (her) training, experience, cool judgment, attitude and prudence place him (her) at the apex of the intricate pyramidical structure on which the system is built. But blind flight, radio communication, the surrogate concept, simulators and data recorders have tremendously reduced the probability of accident involvement, if not the responsibility of the captain. This article, therefore, will be limited to a discussion — within the restraints of my knowledge, research and recollection — of those five major contributions to aviation safety.

In my opinion, the ability to fly without visual reference to a natural horizon has been the most important contribution to the reliability and safety and thereby the growth of aviation. But the basic human factor, that pilots cannot depend on their natural senses to fly "blind," was not generally accepted for years. Indeed it was opposed. An extensive study made for the Commandant of the Medical Corps at the U.S. School of Aviation Medicine in April 1928 concluded: "It is strongly recommended that instrument training and training for 'blind flying' be not included in any form of training at the Air Corps Training Center."

Two years earlier, in 1926, Capt. William Ocker of the Army Air Corps had proven the existence of vertigo disorientation in the absence of the pilot's faith in instrument orientation. Ocker's sanity was twice subjected to investigation, though later he won government awards for his discovery. He then boasted that he was the only Air Corps officer who had two official letters to confirm his sanity.

Ocker's original interest in the problem arose from tests given to blindfolded pilots in a revolving chair (a rudimentary form of simulator) by an outstanding Air Corps flight surgeon, Capt. David A. Myers. The pilots could not tell which way they were turning or even when they were stopped. Ocker rigged up a box with a turn indicator to overcome this disorientation. In 1928, he developed a simulator for testing pilots and training them in the use of instruments.

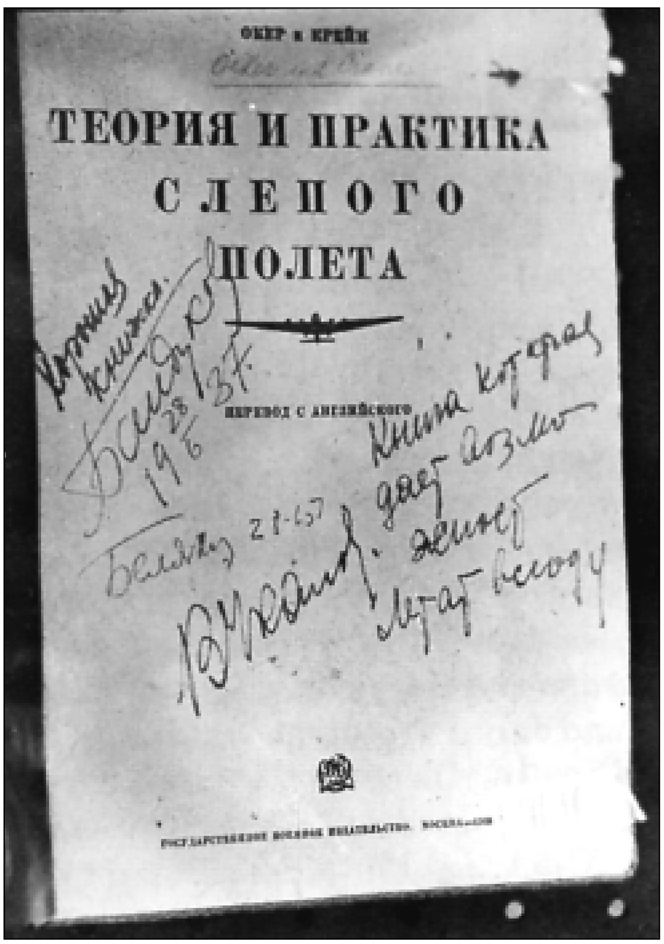
Ocker, with his colleague, Lt. Carl Crane, began to teach Air Corps pilots the art of blind flying in 1930. They developed the needle-ball-airspeed procedure to retain control (rudder-aileron-elevator). Soon after, they co-authored the first definitive book on the subject, *Blind Flight in Theory and Practice*. Published in 1932, it was translated into Russian to become the standard Soviet text many years before the U.S. Air Corps formally adopted its principles.

While preparing this article, the author met a retired Army Signal Corps pilot who instructed at Kelly Field in 1918, flew with the reserves into the mid-1930s and was a private pilot up to World War II. He insisted that he never needed to learn to fly on instruments and that his seat-of-the-pants sense was adequate for blind flight.

I recall an Air Corps general at a pilot training meeting just before World War II declaring that it was not necessary to train bomber pilots to fly instruments because bombing would be done under visual contact conditions. They were not so trained, with few exceptions, until 1943. The Bureau of Air Commerce (now the FAA), as late as 1937, used a Link Trainer on top of the Commerce Building in Washington, D.C., to convince commercial pilots of the impossibility of retaining orientation under the hood. Although airlines began training their pilots for instrument flying in 1929 and a few advanced military pilots were trained for it as early as 1930, it was years before the disorientation theory was widely accepted in both military and civilian flying. An instrument rating was not required for a commercial pilot license in the U.S. until 1974.

Three U.S. Air Mail pilots sought the solution to blind flying in 1926. Dean C. Smith designed a human factor type of instrument panel. In a recent letter, he described the panel of the single-engine open-cockpit de Havilland light bomber converted for airmail operation which he flew:

> The instrumentation was airspeed, tachometer, altimeter, compass, clock. We did not have a turn-and-bank or directional gyro or artificial horizon or rate-of-climb indicator. We got the Sperry turn indicator in 1924. We found it of little use until, in the winter of 1925–26, I put the ball-bank across the face of the turn indicator to make it a turn-and-bank. I then assembled an integrated flight panel with the altimeter along one side (with the needle level at three thousand — safe clearance of the Alleghenies), the tach below (needle vertical at cruising rpm), the airspeed to the left (needle horizontal at cruising speed) and the clock above.
>
> Without the directional gyro, we had to time our turns (about two degrees per second with the turn needle one width over). I shared my ideas with W.L. Smith and J.D. Hill, and we all started practicing blind flying like mad. I do not know which of us was the first to actually fly through weather on instruments, but it was not long until we all three were. Otherwise, it would have been impossible to keep any sort of schedule over the Alleghenies at night.



Russian translation of Ocker and Crane blind flight manual.
(Carl Crane Collection)

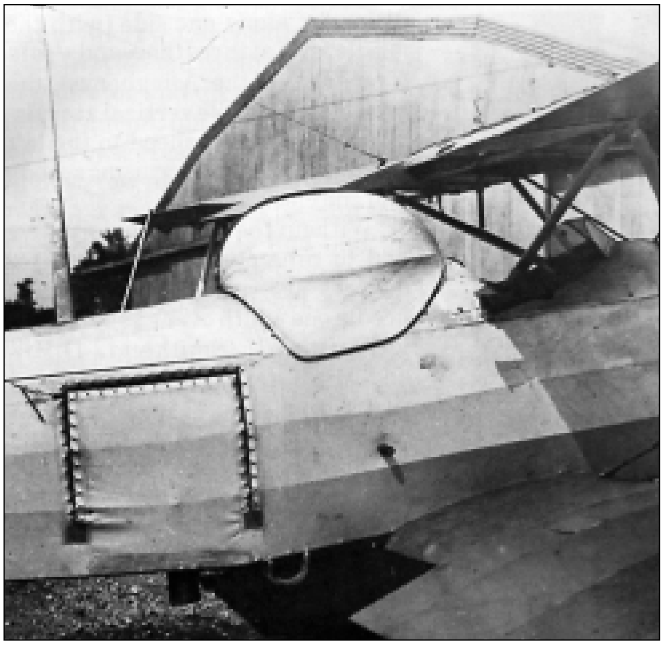
Note that his training for blind flight was done while flying solo, and radio was not available. Radio communication between air and ground was not in use in the nine-year operation of the U.S. Air Mail Service. It came in 1928. Rate-of-climb indicators were installed about that time too.

Doolittle’s Flight

The needle-ball-airspeed system was an important contribution to blind flight. Even today these instruments serve as a backup for the horizon indicator and directional gyro. But improvements were needed. The Sperry turn-and-bank indicator and the altimeters in common use prior to 1930 supplied good qualitative information, but more information was essential for precise navigation and control to meet the rigorous demands of schedule reliability with safety.

The needle-ball-airspeed procedure imposed great strain on the pilot, especially if he had also to attend to ATC and radio communication and fly in turbulence. More accurate devices were needed to display the airplane’s attitude, to replace the magnetic compass (unreliable because of northerly turning error) and to indicate altitude in tens of feet instead of hundreds. Such instruments had to be easy to interpret to reduce pilot strain.

In 1929, as head of the Full Flight Laboratory of the Guggenheim Fund for the Promotion of Aeronautics, Lt. James H. Doolittle (now Lt. Gen., USAF, Ret.) sketched a design for the face of a horizon indicator and directional gyro. His



Hooded cockpit of Consolidated NY-2 used by Doolittle in 1929. (Sperry Flight Systems)

Lt. Doolittle and NY-2, in which he made the first blind flight. (Sperry Flight Systems)

sketches were translated into reality by Elmer Sperry Jr. of the Sperry Corporation. Doolittle's first sketch combined the horizon indicator and directional gyro in one instrument, but Sperry separated them for ease of construction. Doolittle told me a few months ago that he had flown in a modern cockpit and was pleasantly surprised to find that the horizon and directional gyro were combined in one instrument, as in his original concept.

Another important instrument in current use, requested then by Doolittle and designed for him by Paul Kollsman, was the sensitive altimeter, which can be read accurately in tens of feet instead of hundreds. In his first flight completely "under the hood," on September 24, 1929, Doolittle also used a rate-of-climb indicator and radio beams for guidance. But the directional gyros, horizon indicators and sensitive altimeters now considered so intrinsic to blind flight are essentially those that Doolittle designed or requested in 1929.

Doolittle's success in a completely blind takeoff, 20-mile flight and blind landing opened the door to dependable all-weather flying. Completely routine blind landings, a recent development, are still limited to a few properly equipped airports, but the practicability of more relaxed blind flight was established. Horizon indicators, directional gyros and sensitive altimeters began to be installed in transport aircraft in 1930.

Many advances have been made in the art of blind flight since 1929. The automatic pilot is one example. But the basic components developed 50 years ago remain essential to modern blind flight today. The blind flight instruments combined with radio communications and reinforced by the simulator are, in my opinion, the most important technical contributions to the extraordinary safety record in aviation.

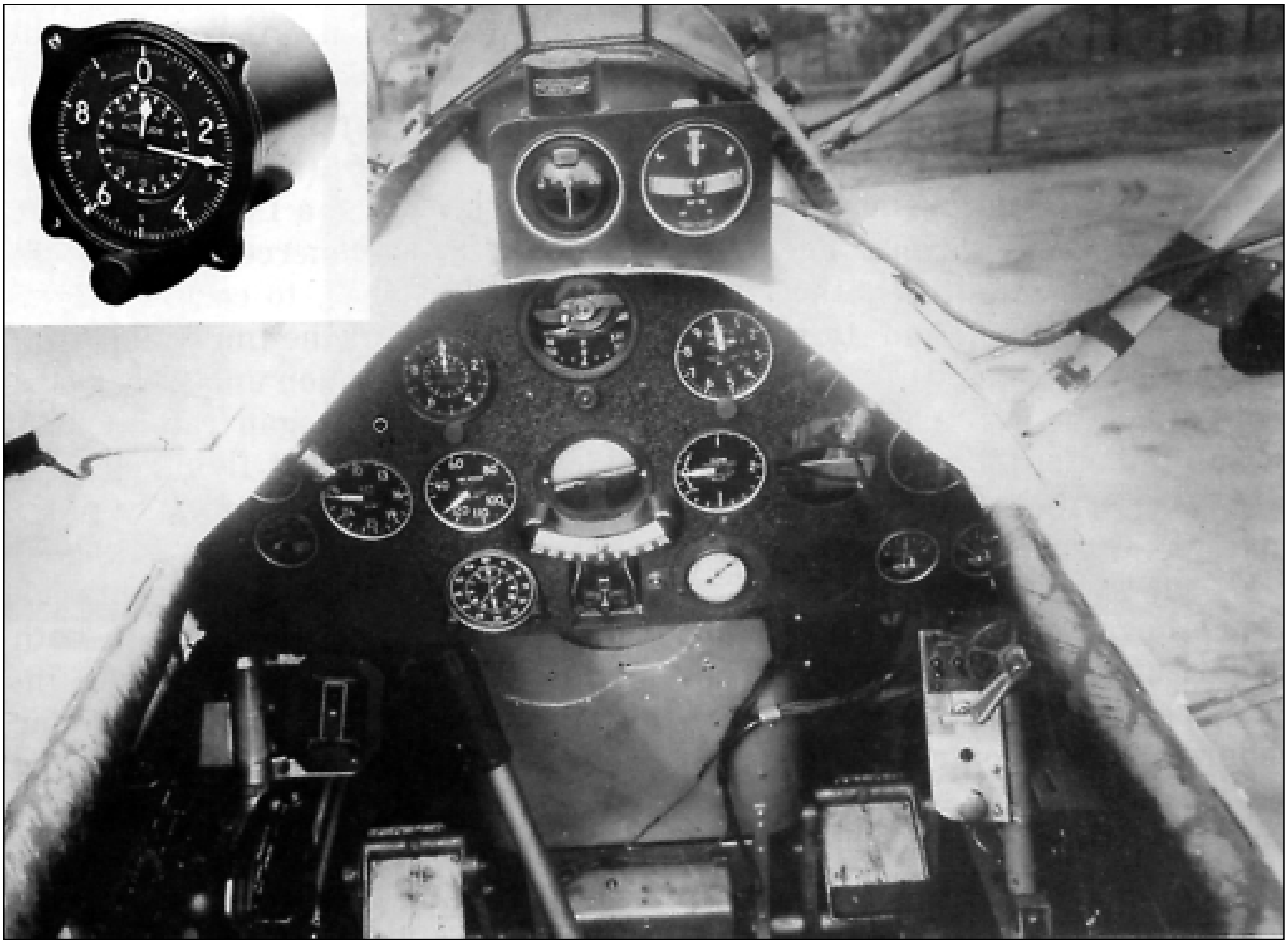
Radio Communication

It would be difficult to imagine fully successful blind flight without radio communication. However, radio communication for in-flight operation was introduced before blind flight. It contributed to a marked improvement in safety and efficiency at the threshold of modern air transportation 50 years ago.

Wireless was used in World War I, but it was so uncertain that homing pigeons were used as backup. Pilots on cross-country flights often carried two pigeons, one to be released at the halfway point and one upon arrival at the destination to advise the home base that the flight had reached those points safely.

The introduction of radio in airline operation was spurred by the inability to advise pilots en route of deteriorating weather conditions, which often resulted in crashes. In the U.S., airline radio communication was developed collaboratively by Thorpe Hiscock of United Air Lines and Herbert Hoover Jr., an engineer employed by Western Air Lines. By 1928, Western operated 11 radio-equipped aircraft.

Some European airlines are reliably reported to have used airborne radio years before it was used in the United States. (See, for example, "Looking Down on Europe," by Parker Van Zandt, *National Geographic,* March 1925.) This may have been one of the reasons European airlines carried hundreds of thousands of passengers safely in the 1919–1927 era. They obtained weather data en route by radio whereas the airmail pilots in the United States had to depend on an occasional red



Sensitive Altimeter (insert) was final addition to NY-2 panel. (Smithsonian Institution [76-17205], insert courtesy Kollsman Instrument Corporation.)

flare on the ground to warn them of deteriorating weather ahead.

The U.S. Air Mail Service suffered the loss of 40 lives in 200 crashes from May 15, 1918, to August 31, 1927. One in six pilots was killed. Surprisingly, in 1922 the Air Mail Service won the Collier Trophy for operating a year without a fatality — but there were 760 forced landings that year in about 1,800,000 miles of flight. Airborne radio would unquestionably have prevented many of the losses and forced landings, most of them related to weather.

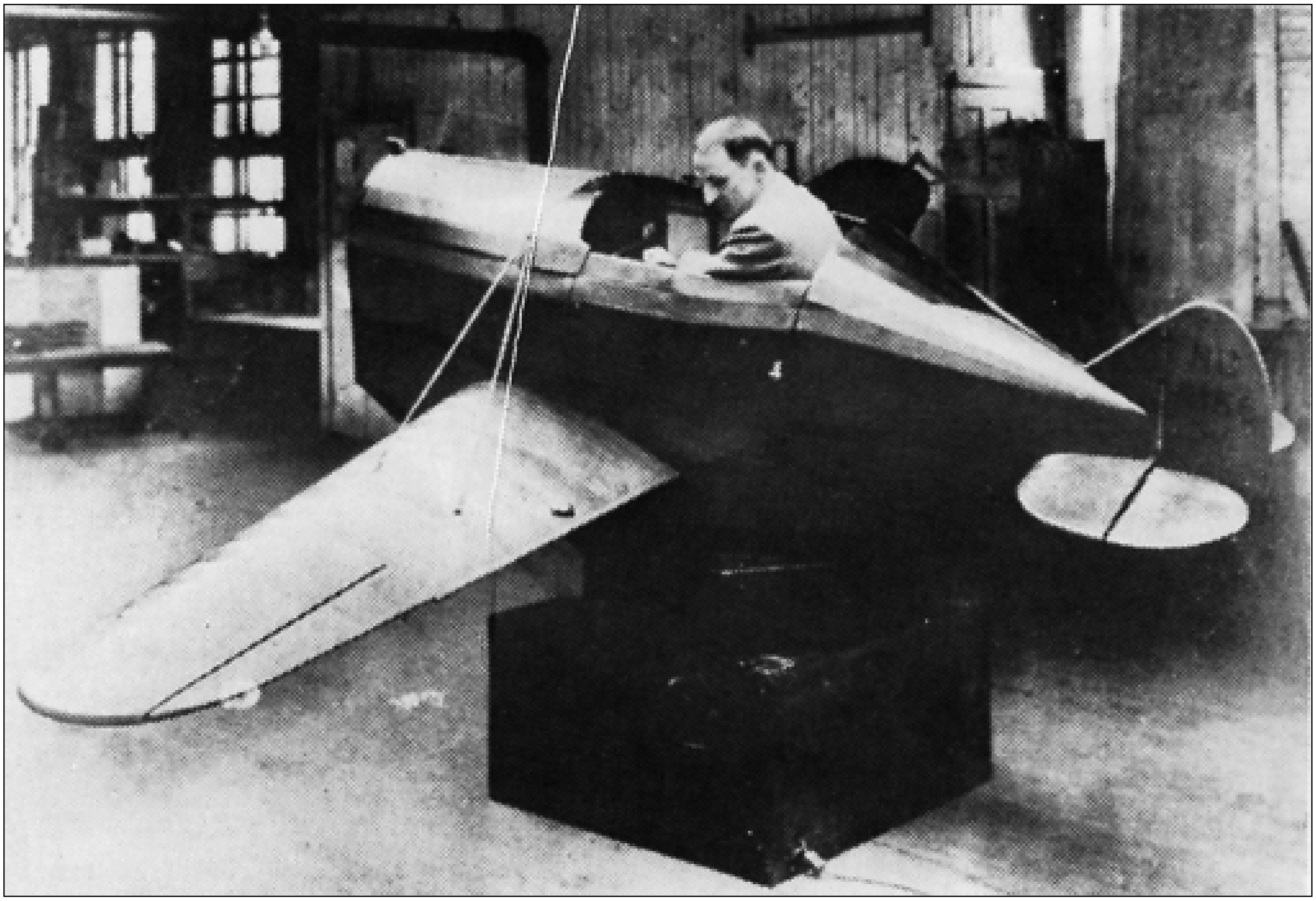
The 'Surrogate' Concept

If structural integrity, power plant reliability, acceptable aerodynamic characteristics, crashworthiness and all the other elements that constitute airworthiness are taken for granted, the most important contribution from the standpoint of design, in my judgment, is to protect the flight against grave and unexpected malfunctions. This demands redundancy, backup systems, fail-safe design or what I prefer to call the surrogate (substitute) concept of design for safety.

Leonardo da Vinci, some centuries ago, suggested fail-safe design. "In constructing wings," he said, "one should make one cord to bear the strain and a looser one in the same position so that if it breaks under strain, the other is in a position to serve the same function." Multi-spar wing construction is an example of this design practice. The double flying wires on biplanes is another.

Years ago, in single-engine airplanes, fail-safe practice called for a spring installed in the throttle system that would prevent the engine from shutting down if the throttle rod broke. Not long ago, a jet transport, struck by lightning on a night instrument approach, lost all electrical power to instruments, lights and radio. A backup horizon indicator independently connected to the battery was the sole means of maintaining safe flight for several minutes until one of the three (for redundancy) bus bars returned to operation.

These examples of fail-safe and backup features — in addition to multiple power plants, duplicated control systems, duplicated radio and duplicated navigation systems — represent the tremendous respect for the surrogate



E.A. Link flying the first Link Trainer around 1928. (Singer Simulator Products Division)

concept in safe design. Not least is the duplicate pilot: the copilot.

An essential adjunct to the surrogate system is the support provided by numerous warning measures to alert the crew of equipment malfunctions. The bells, flags, lights, stick shakers, gauges and voice call-outs display the urgent need for the redundant systems, the backup devices, fail-safe provisions to operate either automatically or by manual control.

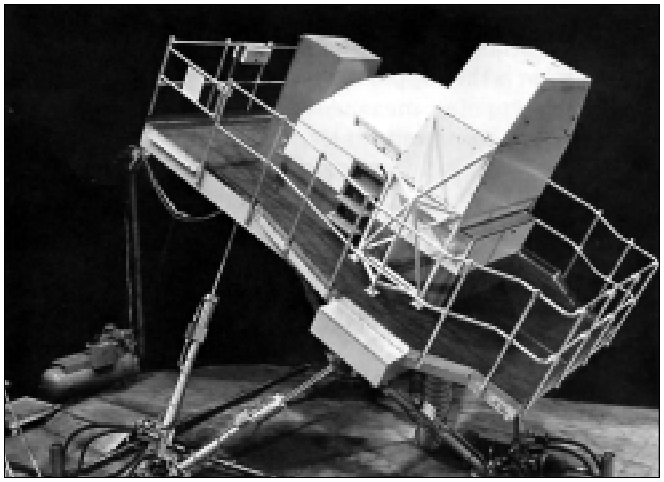
Many other safety devices or design concepts might be considered as very important — anti-icing, for example — but the possibility of their failure is ever present. Hence the overriding importance of the surrogate concept.

Simulators

In the current aviation environment, the simulator is the principal tool for attaining proficiency in blind flight. In many other ways, it is contributing mightily to aviation safety. Maneuvers can be practiced which would be extremely hazardous in flight. Mistakes and dangerous situations can be programmed to assure proper crew coordination. It has become very useful for accident investigation. Its relatively low cost of operation and fuel conservation in comparison with an airplane act as a powerful incentive to use it for practice.

The collision potential of air traffic is markedly reduced by the use of simulators for training. New navigational and control devices can be service-tested in a simulator safely and

Interior of modern visual simulator for Boeing 747. (Singapore Airlines)



Exterior of modern simulator. (Singer Simulator Products Division.)

inexpensively. Air crews can familiarize themselves, prior to flight, with the approach and landing requirements at strange airports, an important safety factor.

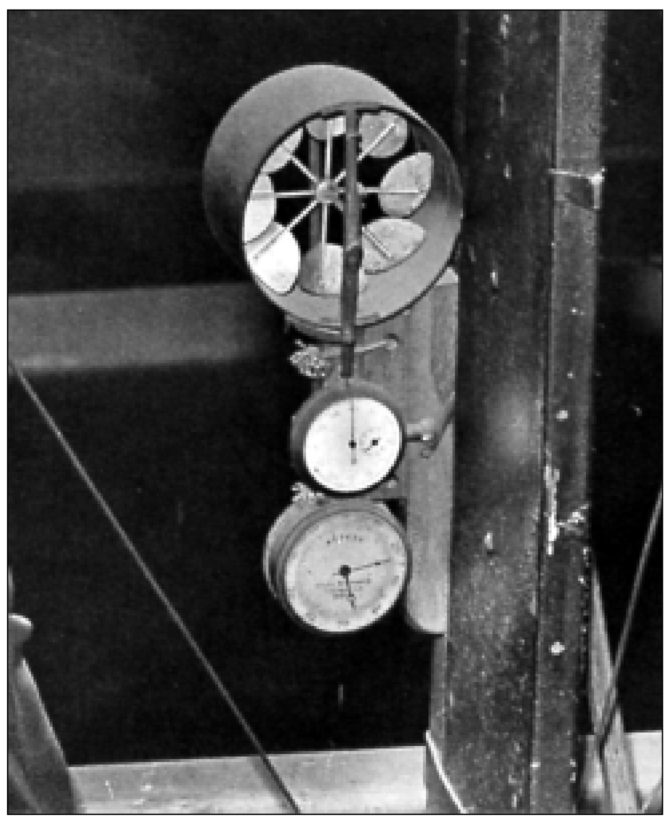
It would be irreverent to discuss simulators without mentioning the contribution made by the Link Trainer. Applying the concepts of Ocker and Crane, Ed Link's ingenious, inexpensive design of the early Link Trainer helped thousands of pilots learn to navigate and control aircraft safely in instrument weather. The more sophisticated simulators in current use for crew training were pioneered for the U.S. Navy by Adm. Luis de Florez during World War II. Dehmel of Curtiss-Wright followed soon after. Widespread use of simulators for modern air transports, costing millions of dollars each, confirms the creative contributions of Ocker, Crane, Link and de Florez.

Orville Wright had some pertinent observations about blind flying and simulators. In a letter to Dr. Charles Kettering dated March 21, 1941, he said:

> Colonel Ocker … is the man that after years of persistent endeavor succeeded in getting the Army and Navy to adopt training in blind flying.
>
> He is now experiencing the same difficulties getting the Army to adopt pre-flight training of pilots. I have been advocating this for years but never got anywhere with it … .
>
> I have always considered the present method of doing all the training on planes as entirely too slow and too expensive. There are certain things which the pilot must do by reflex action without conscious effort. From my experience in teaching years ago, I found these things could be done better and more quickly on the ground. In the present-day plane, one of these things is the control of the rudder. You and I learned to steer a bobsled by pushing with the right foot when it was desired to turn to the left. All the younger generations have learned to steer their go-cycles, etc., in exactly the same way. But when they are learning to fly, they have to learn to do exactly the opposite of what they have been trained to do since childhood. More training in overcoming these acquired reflex actions can be had in one minute on a ground trainer than can be had in an hour in an inherently stable aeroplane such as is used today in training.

Data Recorders

Aviation safety has been immeasurably advanced by lessons learned from accidents. Examples are available by the score from the National Transportation Safety Board. The analysis of accidents has been tremendously celebrated by the installation of flight data recorders (FDRs) and cockpit voice recorders (CVRs). As a supplement to the meticulous procedure and tests used during accident investigation, they remove much of the speculation inherent in determining flight path, maneuvers, "g" loads, asymmetric control, speed variations, the problems confronting the crew, and response and behavior of crews prior to the crash or incident. Readouts from flight data recorders are particularly important in determining accident causes on sophisticated, high-performance aircraft.



Wind gauge and stop watch were Wrights' "flight recorders." (Federal Aviation Agency)

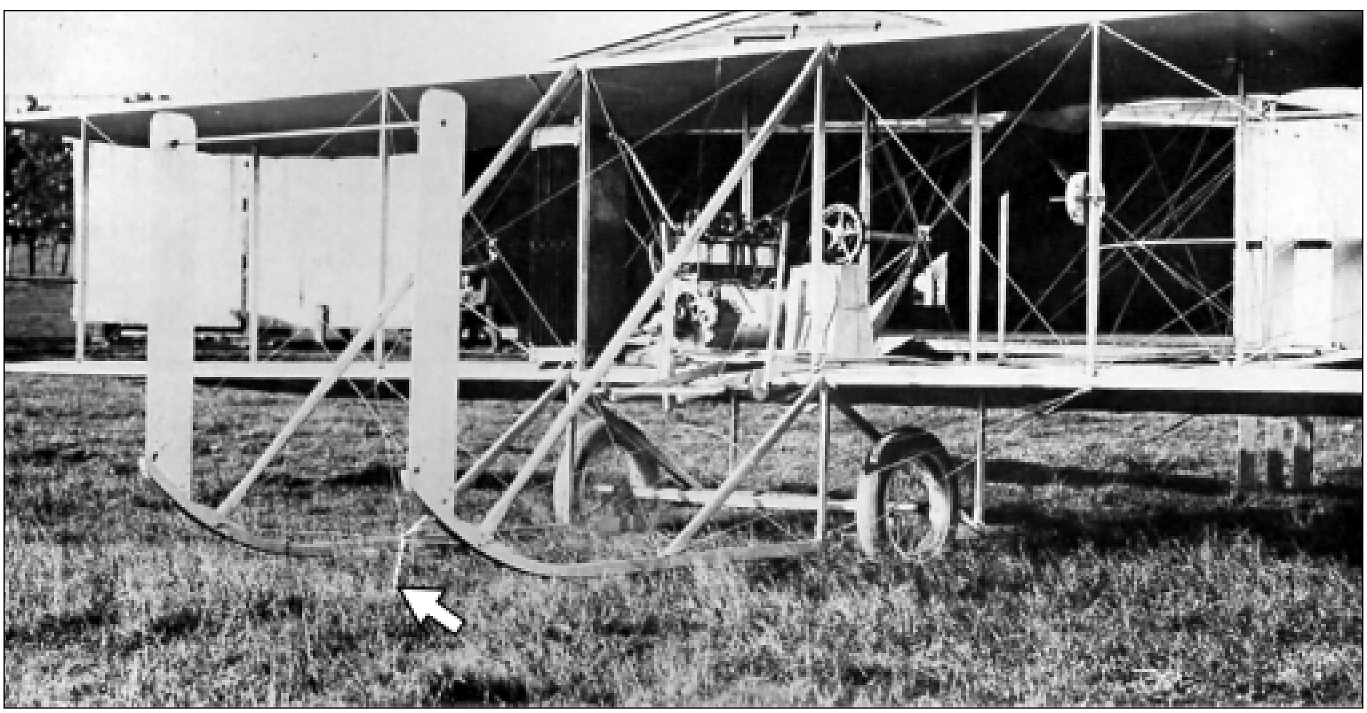
Pilot pushed lever at end of flight to stop engine and "flight recorders." (Federal Aviation Agency)

Flight data recorders are also becoming valuable in preventing accidents per se. For example, a routine check of FDR readouts recently showed that air crews on at least one large airline were inadvertently descending at speeds considerably beyond acceptable practice. Voice recordings have proven equally useful in determining crew reaction in emergency situations by recording cockpit comments and discussion. The sounds of malfunctioning equipment heard in the cockpit by the voice recorder, especially power plant noises, provide significant information that would otherwise be lost.

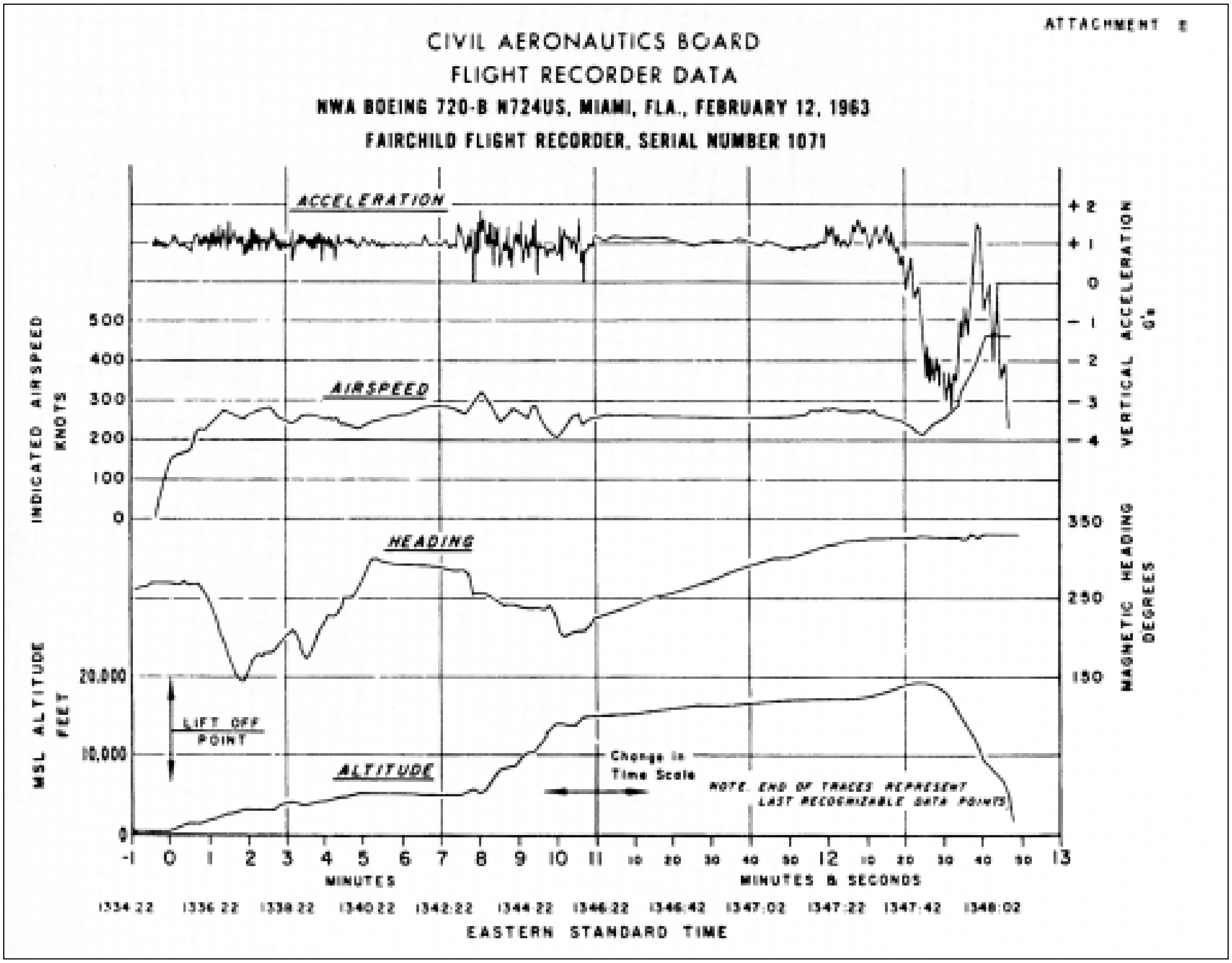
The Wright brothers were the first to recognize the importance of recording flight data. They installed a recording stop-clock, engine revolution counter and wind log on the very first flight of December 17, 1903. In some of their later models, they measured sideslip with a length of thick, light cord fastened to a wire in front of the pilot. They also fitted a vane-type angle-of-attack indicator on a wing strut. The first instrument ever installed for aircraft guidance was the string used by the Wrights to indicate sideslip or skid.

United Air Lines installed primitive recorders on its DC-3s in the late 1930s. They were used successfully to monitor flight, as well as in accident investigations. It wasn't until 1958 that they were installed by regulatory requirement on aircraft weighing over 12,500 pounds flying in air carrier service above 25,000 feet.

The National Transportation Safety Board, faced by inability to determine the causes of almost 20 percent of the fatal accidents involving air taxi and corporate/executive operations without recorders, has recommended that voice recorders be installed in turbine-powered airplanes carrying six passengers or more and requiring two pilots.



String (arrow) served Wrights as sideslip indicator in 1913. (Loening Collection)



Typical readout from modern flight data recorder after crash.

Accident investigations contribute immensely to aviation safety. The most important developments in that area have been voice and data flight recorders.

Future Developments

If an article on the major contributions to aviation safety were to be written at the end of a century of powered flight, 25 years from now, it would probably include the following:

- The reduction of human error by a system of self-surveillance (recognizing the unsafe act before it results in an accident);
- Human factors fully applied to design;
- Rapid collection and worldwide exchange of critical safety information;
- All landings made automatically;
- The elimination of fire following a crash;
- Structural fatigue discovered long before failure;
- The ground-proximity warning system in worldwide use (the potential is already proven);
- Automatic collision avoidance systems;
- The use of satellites for monitoring flight and for flight assistance (continuous pictures in flight of weather ahead are already in use); and,
- Ground transportation to and from the airport as safe as the flight.

It is even possible that such an article might be written in the quiet serenity of a colony in space.♦

[FSF editorial note: This article originally appeared in Exxon *Air World*, Volume 31 No. 1, 1979.]

Pros and Cons of Punishment for Achieving Discipline in Aviation

Jerome F. Lederer
Electric Power Research Institute and University of Southern California
1979

These observations on the pros and cons of punishment concern only the acts of professional airmen, well-trained and conscientious, with a history of disciplined performance. Unfortunately, judgment and actions are subject to the frailties of human nature and the force of circumstances. Air traffic controllers, mechanics, flight crews, in common with all mankind, occasionally experience a lapse in self-discipline. If an incident or an accident occurs, does punishment make them better airmen? Airmen are distinctive from most other professionals in that their occupational misfortunes are more likely to become visible to the public. Punitive measures then become mandatory. Besides this, the ego of management, whose prestige has suffered because of an accident, must also be satisfied by punishment. Both demand their pound of flesh, regardless of its effect on the discipline of the offender. Unlike physicians — the other professionals who deal with life and death — airmen cannot bury their mistakes.

Most of us were raised with the opinion that the most effective way to obtain discipline is by the threat of punishment itself. However, in the existing social, cultural and operative environment of aviation, in a democratic community, management is compelled to rethink the traditional concepts of punishment. (The military is not excluded.) John F. Kennedy suggested that, "Too often we enjoy the comfort of opinion without the discomfort of thought."

The problem is: How can public safety be meshed most effectively with the accountability of a normally well-disciplined airman who has unexpectedly veered from some pundit's concept of perfection and has suffered an accident?

General Considerations

Discipline is essential in the conduct of high-risk ventures. By one definition, curiously, discipline is a synonym for punishment as a way to spur self-control. In the context of this dialogue, it means a systematic, willing and purposeful attitude toward the performance of an assigned task. It is often achieved by a random system of communication involving subtle as well as direct pressures and at times by negotiation rather than by command. Discipline is subject to distortion by life events (see "Candidates for Accidents," page 84), by understandable lapses in self-control, by miscalculation, by unforeseen circumstances which induce deviations from expected performance. Punishment for the consequences of undisciplined operation or for a failure in judgment is usually based on the expected conduct of a model airman who does not exist in real life.

Punishment and awards are important segments in the system of communication that leads to better discipline. Punishment, however, could be an uncertain variable. It may be argued that neither punishment nor awards is as effective in securing discipline, especially self-discipline, as the judgment of one's peers, or the latent mortification that follows misfortune or the ordeal created by one's inner conscience. If this is so, what is to be gained by suspension, by fines or by other penalties? The professional has learned from his unfortunate experience. Nevertheless, punitive measures are applied through the regulatory agencies to appease an apprehensive public or to satisfy the ego of a macho manager. Most important, however, is the adverse effect on the discipline of the offender's organization if he is not punished. How can punishment be achieved without creating in the offending professional a feeling of resentment or impelling him to seek revenge among his peers, if they agree that under the same circumstances they would have acted in the same way? There is also the element of danger if the threat of punishment induces the concealment of mistakes that might otherwise be voluntarily admitted. This dilemma will be explored later. Constructive catharsis may better serve the public and the offender than the usual intent of punishment.

The threat of punishment must also be considered for its adverse effect on accident investigation. It is a dormant evil which inhibits full and free confession which a professional might make for the good of safety. Accident investigations by governments are assumed to be, and usually try to be, objective, nonaccusative, nonadversarial proceedings. They are expected to provide information to prevent the reoccurrence of an accident. However, the threat of punitive action, in addition to legal liability, cannot be disregarded, consciously or subconsciously, by participants to the investigation. How much does this threat of punishment color the evidence submitted by the dedicated professional airman during the investigation? What is a dedicated professional?

The dedicated professional is represented to the highest degree by the following anecdotes:

Many years ago, two accidents came to my attention which involved pilots with previously unblemished civilian records. Impelled by conscientious duty to themselves and to aviation, they freely confessed errors which led to their accidents. In one case, the instructor pilot, who was also chief pilot of the airline as well as the pilot for the king of his country, widely recognized for his contributions to safety, allowed a trainee to land a DC-4 with the undercarriage up. No one was harmed. In the other case, a highly experienced scheduled-airline captain, flying a DC-3, undershot an airport. A baby was killed. In both cases, their moral sensibility drove them to suicide.

If these two pilots had decided to live, would punishment for their accidents have made them any better pilots? Among professionals, which is most effective in stimulating discipline: their inherent desire to perform correctly; their reputation among their peers, families and friends; or their fear of punitive measures? Would they not have been better pilots for having been through the experience of an accident? Aren't we all better operators of dangerous equipment — such as automobiles, airplanes, motorcycles — for having nudged danger?

Punishment is commonly defined as the imposition of a penalty such as a fine, suspension, pain, loss or suffering for an offense. However, to the professional, it also implies a degraded reputation, humiliation, peer-group censure, a feeling of incompetence or blameworthiness. This inner penance may be much more meaningful to the involved, conscientious airman than a fine or suspension, but it may be very vague to the public, to management or to the regulatory agencies which demand specific retaliation (their pound of flesh). Of course, a willful or malicious act or lack of self-control, such as the use of drugs, demands prompt and tough punishment.

In addition, management is obliged to communicate promptly at least its apprehension and anxiety or strong disapproval of any complacency, lack of awareness or skill, disobedience or poor judgment displayed by the offender if organizational and individual discipline is to be maintained. Steps taken by management will, of course, vary with circumstances.

Communication and Discipline

Punishment and rewards are forms of communication between management and employees. It is important to relate punishment to communication because communication in its broadest sense influences morale, motivation and, therefore, discipline. Morale, defined as the mental and emotional attitude toward tasks and functions — the esprit de corps — can be powerfully affected by punishment and reward. Motivation, a close ally to morale, is defined here as need or desire that impels a person to act in the way that is best for his organization. It is very sensitive to punishment and rewards.

Morale and motivation which result from clearly expressed communications combine to induce discipline, previously defined as a systematic, willing and purposeful attitude toward the performance of an assigned task. Discipline is essential for organizational control. A respected, exacting taskmaster is important, but discipline can be seriously influenced by inappropriate punishment which, among other consequences, may induce resentment and perversity.

Punishment as a form of communication in a high-risk environment must be used adroitly in dealing with the well-trained, conscientious employee, whether he be in the highest or lowest echelon of the organization. Even the lowly cleaner who inadvertently leaves debris on the ramp or hangar floor can be the cause of damage, injury or even death. The word "inadvertent" should be stressed, because willful departures from good practice, such as drinking on the job, are not considered in this discussion.

The inadvertent action may be caused by distraction, cockpit environment, design-induced error, inadequate training or supervision, fatigue, anxiety, illness, psychological pressures — even by the time of day.

Communication as a path to discipline need not be vocal, written or specific or itemized. It may be conducted by gestures, mannerisms, attitudes, facial expressions, symbolism and by the poise of a supervisor to influence the employee's reaction. Silence is often an excellent form of communication. These types of communication may be more effective in strengthening discipline than a fine or suspension. A good manager knows how to use them as advantageously as he uses a smile or a pat on the back to reward good performance.

Management equates discipline as a respect for authority. In aviation, with its unique comradery and social environment, coupled with a complex technology, this respect must be earned by management, not imposed by penalty except for unpardonable disobedience or deliberate departure from accepted practice. And it must be admitted that at times authority and therefore discipline result not from command, but from negotiation with peer groups (unions or trade associations).

Col. Richard Wood — in his treatise "Can You Punish an Accident?" prepared in December 1978 for the Institute of Safety and System Management of the University of Southern California — declares that "a particular unit or group perform in the way they do, not because they fear punishment, but because they have been trained that way and they are individually convinced of the wisdom of conformance as a means of achieving objectives." He considers adverse action taken against a pilot, for any reason, to be punishment, not discipline.

A corollary to this concept is the reinforcement of disciplined behavior by recognition for good performance. This may be more effective organizationally than the demeaning of professionals by public punishment for inadvertent departures from good practice. This, however, in no way should affect the great importance of calling attention to improper practices to the individuals concerned in person and to the organization in a generic sense. Monitoring of performance on a nonpunitive basis to ensure compliance with accepted practice has already proven of enormous importance to safe aircraft operations.

The Military View

Punishment for deviations from discipline has been a strong military tradition. In today's operational and social climate, old military traditions, operable in the days of simple technology, are difficult to justify. Respect for authority, which is the basis of operational discipline, must be attained by means other than 60 lashes.

Respect for authority ideally stems from the decisiveness and good judgment of a firm management, rather than from fear. In an emergency, a clear touch of tyranny is also important for control.

Social Pressures

Respect for authority may be unevenly divided at times between management and peer groups. Authority or leadership is based largely on the competence of the person in command. He may be able to hoodwink his seniors, even his peers, but rarely his subordinates. A subordinate's faith in the competence of management is necessary for it to exert the authority of leadership.

However, in several organizations widely recognized for their operational efficiency and dedicated personnel, discipline results from the special characteristics of management-employee rapport supported by the mores of the people. Japanese industry is a good example. Several organizations in the United States also achieve outstanding results by encouraging self-discipline and group-discipline, some by participative management. Perhaps the principal reason for their success is a function of expectation: the employee becomes stimulated by what is expected from him by his peers and by his management, both operating in harmony. The pervasive threat of displeasure by fellow workers can be very effective.

Punish Management?

Management or regulatory bodies are rarely, if ever, punished for mistakes or errors in judgment which lead to accidents. But airmen are. For example, the pressure by management for on-time performance may persuade a mechanic to take shortcuts. The *Los Angeles Times*, Aug. 15, 1979, reports that two airline mechanics reported a bolt installed upside down in the reverse-thrust system. The plane was signed out nevertheless. The two mechanics were suspended but later exonerated by union intervention. If true, a gray area exists since management is rarely criticized, let alone penalized, for the pressure it exerts on employees. And who faults the aircraft manufacturer for approving a design that allows a critical bolt to be installed upside down?

Manufacturers are seldom subjected to punitive measures for design judgments that create operational problems, such as those which induce pilot error. This audience does not need examples to prove the point! But should judgment be subjected to penalty? Let him who is without sin cast the first stone.

These viewpoints attempt to crystallize a break with traditional punishment to secure operational discipline. Nevertheless, where public safety is concerned, complacency, carelessness or neglect should never be condoned. Morale and motivation, on which discipline depends in our current societal environment, rest on a system of understandable communication, on objectives accepted by management and employees. Several cases to support these observations follow.

Specifics

Some 25 years ago, while visiting Europe, the president of an international airline faced a practical problem in discipline in its punitive sense. This airline's most experienced and respected captain had landed a DC-6 at night in Cairo with the undercarriage up. Damage was minimal. Cairo landings presented awkward problems to flight crews at that time. Management pondered what punitive measures to apply. Suspension of the captain from duty or his reduction to copilot status would have a very small corrective effect, if any, in comparison to the mortification and distress he had suffered from the mishap. Again quoting Col. Richard Wood, can you punish an accident? On the other hand, organizational discipline called for management action. Other airmen might misunderstand management's tolerance of the captain's misfortune, despite his stature.

The president happened to be a lawyer who had made a thorough study for a college thesis on man's compulsion to punish. He presented five reasons for the imposition of punishment and requested the Flight Safety Foundation (FSF) to consider their application to his current predicament.

His five reasons for punishment were: revenge; protection of the transgressor; protection of society; instruction; a mark of authority.

Since this was an administrative problem, Professor Kenneth Andrews of the Harvard Graduate School of Business Administration was requested to prepare a study on the effectiveness of punitive measures in aviation for the FSF International Seminar of 1952. Under the title "Crime and Punishment," its logic appealed to large organizations as well as other schools of business administration who requested copies. He concluded that none of the reasons for punishment applied in this case. Dr. Andrews provided the following observations on punishment from management's point of view (i.e., purposes for discipline):

- Discipline for revenge: "Most of us are familiar with the more common approaches to punishment taken by those who mete it out. One of the oldest and most primitive uses of punishment may have been simple revenge. An eye for an eye and a tooth for a tooth was an equitable retribution, evening a score, canceling an offense. The offender paid in the currency in which he offended. Thus, if a small boy breaks his sister's bow and arrow, and we as parents break his bow and arrow as punishment, we follow this obsolete approach to discipline. In certain very simple situations, this generally obsolete basis for punishment is still useful. But it is not practical to punish a pilot who has crashed an airplane through carelessness by asking him to ride in a plane which is crashed on purpose."

- Discipline for protection of the transgressor: "A more subtle purpose of punishment is usually cited by management to be, rather than revenge, the protection of a man against himself. His transgression is punished to enable a man to keep his baser impulses under control in the future. This theory is false to present-day psychology which postulates that persons (at least those not suffering from schizophrenia) do not have personalities divided into bad and good halves. Our pilot, for instance, would probably not be punished to protect him from his desire to be careless."

- Discipline for protection of society: "A closely related purpose is to protect society against offenders. We remove hardened criminals from society not to protect them from themselves, but to protect us from them. This purpose hardly applies to organization discipline, and it is not relevant to organizations except where the law is violated. And in safety matters, there cannot be laws against bad judgment."

- Discipline as instruction: "A more constructive purpose is said to be to teach offenders to comply. But our pilot, again, has learned his lesson from his accident. Most persons in aviation have more pressing reasons to abide by safety regulations. In violations where accidents do not occur, this purpose might apply, but certain problems of communication keep most breaches of discipline which have no bad result from coming to the attention of management at all.

  "The point of view most commonly taken toward the usefulness of punishment is that a penalty teaches others a lesson. Disciplining an offender thus deters others from the same offense. This purpose has much plausibility, but who wants to offend? Are the persons whose carelessness, bad judgment and error cause accidents doing something which the fear of punishment would prevent them from doing? Without knowing more about the very complicated situations out of which each offense comes, it is not possible to say that proper punishment actually reduces the number of violations of good practice."

- Discipline as a mark of authority: "Many persons in management who question the effectiveness of

> punishment as a method of administration cling to it for reasons of authority. Does not the administration of punishment underscore the power of management to manage? Does not the application of discipline go with authority? While the more common reasons for punishment prove more and more inapplicable to present-day situations, it is generally felt that punitive discipline cannot be abandoned without weakening the position of management and removing from it its prerogative of 'managing.' So whether punishment serves the purposes of better results or not, it is, at least from the point of view of management, a means of pointing out who's boss."

Dr. Andrews provided the following observations on punishment from the offender's point of view:

> While it is true that managements in business organizations, and perhaps even parents in families, are a little unclear about what punishment is all about, its reason for being becomes even more confused when we examine it from the point of view of the persons being disciplined. What will our "perfect" pilot make of being made an example for the trainee pilots of his organization? What is the reaction to his suspension of a flight engineer who fails to fasten a door properly and loses a passenger? When several people are killed because a mechanic does not change a fuel-feed-valve diaphragm as required at engine overhaul, what is his reaction to being suspended? According to the logic of punishment fairly administered, these offenders should see the justice and importance of their being punished, learn a good deal from the experience and go on to performance which is the better in the future because of the punishment suffered now.
>
> We know by now, however, that persons under the pressure of punishment do not look so logically at their predicament. They may resent being made an example. They may resent being punished for a violation of a rule which in their experience has never before been enforced. Since a whole range of information is available to them which is not easily available to management, they look upon their own offense quite differently. They may reason that because an accident occurred following their violation, bad luck is involved rather than a punishable misdemeanor. A stewing about a fancied injustice, the emotional disturbance of adjusting to important punishment like suspension or dismissal, not only creates negative rather than constructive effects in the offender but may, through his expression of his feelings, have a bad effect upon the morale of others as well.

There often appears to be a considerable irrelevance between the theoretical purposes of punishment and the actual effects upon the offender and his associates. One of the commonest consequences of discipline rigorously adhered to is increased insecurity and fear, which is already an important factor in the performance of persons in crews and on the ground. Without doing more than ask you to think of instances from your own experience, I should like to raise the questions: Does not discipline serve the punisher better than anybody else? Does not the purpose of punishment as conceived by management often fail to be communicated to the organization and individuals supposed to be instructed?

Constructive Use of Punishment

Dr. Andrews advocated the use of "punishment" as a constructive force. This airline's action was in that spirit. It was constructive, while concurrently providing relief for the pilot's humiliation and need for penitence. Management ordered him to schedule a series of conferences with groups of pilots to explain what happened, why it happened and lessons learned.

An Adverse Effect

The threat of punishment may predispose an airman to conceal known errors. Charles E. Cornell of the McDonnell Douglas Astronautics Company summarized a formal investigation of this tendency in *Space/Aeronautics* for March 1968.

A study was made of human errors for the purpose of minimizing them. One interesting "discovery" was that the tough boss's approach resulted in concealing errors:

> The "crackdown" method of error reduction (historically, the military's favorite response to the failings of human nature) has an adverse effect, as shown by the typical distributions of human errors over the phases of an aerospace program. The total number of errors decreases only very slightly, but the operators threatened with the boss's displeasure or worse become adept at hiding their errors, so that more errors remain undisclosed until later program stages, when they cost more to correct.

Nevertheless, the working atmosphere should not be relaxed to the point where complacency sets in. Constant vigilance is necessary. Respect for management's intentions and know-how is important. The careful worker usually is well-disciplined. Motivation programs are important. Recognition for good effort is vital.

The military services have formalized procedures to learn from accidents by encouraging free disclosures of personal error. Under USAF Regulation 127-4, accident reports will not be used as evidence for disciplinary action, as evidence in determining the misconduct or line-of-duty status of any personnel, as evidence before flying evaluation boards, or as evidence to determine pecuniary liability. These confidential findings cannot be used for punitive purposes. But the military also conducts an independent collateral investigation, AFR 174-4, to obtain and preserve evidence for use in litigation or disciplinary action. The airmen's statements in the adversary investigation may differ from the confidential enquiry.

These examples indicate that punishment for accidents or inadvertent departures from accepted procedures may often be an unwise method to induce discipline among dedicated professionals operating in a high-risk environment. Nevertheless, it would be difficult to disprove that discipline is not strengthened by apprehension in the mind of the airman that he will be called to account when he makes a mistake. The solution rests on the manner by which the offender is held accountable.

Strong punishment has been generally discarded as a way to correct relaxed discipline. A typical case: "B-747 inertial navigation system indication incorrect. Crew had not followed the correct procedures for loading the INS. This was not picked up during the subsequent preflight checks. Chief pilot has discussed the incident with the crew concerned." On the other hand, gross departures from accepted good practice, as distinct from errors in judgment or inadvertent mistakes, are subject to severe punitive action — for example, the firing of a crew for inadequate cockpit awareness and coordination resulting in a crash.

Peer-group acceptance or criticism may be as effective, and in many instances more effective, than organizational authority. An old War Department manual on leadership says, "Strong men, inculcated with a proper sense of duty, a conscious pride in their unit and a feeling of mutual obligation to their comrades in the group, can dominate the demoralizing influence of battle far better than those inculcated only with fear of punishment or disgrace."

This paper has dealt mainly with the transgressions of the individual. The problems of dealing with management lapses are more complex. A few years ago, the president of an airline was under criminal indictment for a fatal accident over which he had little if any control. An item in *Aviation Week & Space Technology*, Sept. 3, 1979, says that legislation is being introduced in the United States to add criminal penalties to FAA violations. The pros and cons of this, if applied to management, should be of interest to all of us in the future. Such legislation would certainly exact a devastating effect on accident investigations.

Discipline is essential for operational safety. If these thoughts have stirred your interest in how discipline can be improved by methods other than the threat of common concepts of punishment, except for willful and deliberate misconduct, it will have served a useful purpose.♦

[FSF editorial note: This article originally appeared in the International Association of Air Safety Investigators' *ISASI Forum* winter 1979 issue.]

Appendix
Candidates for Accidents

Studies indicate a pilot's emotional stability is related to flight safety.

A U.S. Air Force general once told me how strongly he wishes for a device that would quickly indicate the emotional stability of a pilot just before takeoff. He kept careful tabs on the family life of his pilots, for example. Those who were soon to expect an addition to the family, for instance, were not permitted to fly very far from the base. He felt that a pilot was likely to take unusual risks to get back to his family if the baby arrived while he was some distance away.

Efforts have been made to develop a "human performance measuring device." One is described in U.S. National Aeronautics and Space Administration (NASA) Tech Brief 70-10619. Called the "complex coordinator," it tests perceptual and motor skills by posing a series of problems through means of a pattern of lights. The problems are solved by correct manipulation of the hands and feet. When the subject is in a good "psychomotor state," a baseline is established for his response to problems. When he is distracted or under the influence of drugs or alcohol, his performance will vary from the baseline.

This can be applied to the early detection of psychophysiological body changes due to toxicity or stress. Other methods are under investigation, such as voice patterns electronically recorded or brain-wave monitoring. The pressure with which a pen is squeezed and the pressure exerted on the paper while writing have also been validated as clues to varied emotional states (gripping the wheel).

Perhaps of more immediate usefulness, however, is a weighted list of life events that increase the probability of human error because of emotional instability. This concept was appraised in the September–October 1973 issue of *Lifeline*, the excellent safety publication of the Naval Safety Center at Norfolk, Virginia.

In the article, Dr. Robert A. Alkov of the center briefly described studies underlying the relationship between personal stress, disease or accident-precipitating behavior. Some people, he suggests, are more susceptible to emotional factors than

Table 1

Rank	Life Event	Mean Value	Rank	Life Event	Mean Value
1	Death of spouse	100	22	Change in work responsibilities	29
2	Divorce	73	23	Son or daughter leaving home	29
3	Marital separation	65	24	Trouble with in-laws	29
4	Jail term	63	25	Outstanding personal achievement	28
5	Death of close family member	63	26	Wife begins or stops work	26
6	Personal injury or illness	53	27	Begin or end school	26
7	Marriage	50	28	Change in living conditions	25
8	Fired at work	47	29	Revision of personal habits	24
9	Marital reconciliation	45	30	Trouble with boss	23
10	Retirement	45	31	Change in work hours, conditions	20
11	Changes in family member's health	44	32	Change in residence	20
12	Pregnancy	40	33	Change in schools	20
13	Sex difficulties	39	34	Change in recreation	19
14	Gain of new family member	39	35	Change in church activities	19
15	Business readjustment	39	36	Change in social activities	18
16	Change in financial state	33	37	Mortgage or loan under $10,000	17
17	Death of close friend	37	38	Change in sleeping habits	16
18	Change to different line of work	36	39	Change in number of family get-togethers	15
19	Change in number of arguments with spouse	35	40	Change in eating habits	15
20	Mortgage over $10,000	31	41	Vacation	13
21	Foreclosure of mortgage or loan	30	42	Christmas	12

others. He also suggests that "it is incumbent upon those in supervisory positions to monitor and observe how turmoil in the personal lives of these personnel affect their performance."

Dr. Alkov then presents a list of events with their scale of importance (see Table 1); the list was developed by questioning hundreds of people.

Life style, as distinct from the life events in Table 1, also plays a part in a person's predisposition to error. An intolerable burden may develop when life events are coincident with changes in life style, as shown in Table 2.

— Jerome F. Lederer

Table 2

Rank	Life Style	Mean Value
1	Marital separation	65
2	Change in responsibilities at work	29
3	Change in living conditions	25
4	Revision of personal habits	24
5	Change in working hours or conditions	20
6	Change in residence	20
7	Change in recreation	19
8	Change in social activities	18
9	Change in sleeping habits	16
10	Change in eating habits	15

Human Factors in Communication (at the Working Level)

Jerry Lederer
President Emeritus, Flight Safety Foundation
1981

Abstract

The exchange of thought, information, opinions, feelings, moods, by printed matter, voice signals, feedback and even silence has profound implications for aerospace safety at the working level. Communication, the transfer of information, is essential for control, command, morale, motivation, interpersonal relations, discipline, leadership, management-employee rapport and safety. Rewards and punishment are features of communication. Representative topics are scrutinized.

> "It has been my experience that, if you explained 'why' to an Air Force man, you don't have to give an order. You just get out of the way and let him get on with the job." — Gen. Curtis E. LeMay, chief of staff, U.S. Air Force. Quoted from "U.S. Air Force: Power for Peace," *National Geographic,* 1965.

Communication Is More Than Words

The customary meaning of the word "communication" is "to make known." The phrase "human factors," when associated with communication, has a twofold significance: Ease of understanding or comprehension is, of course, one; the effect of the communication on individuals is another.

Aside from its purpose of transferring intelligence or interpreting information, communication is essential to secure control, command and discipline; to improve morale and motivation; to stimulate thought; to sharpen awareness; to improve interpersonal or industrial relations (management-employee); and to attain leadership.

Communication need not be limited to the written or spoken word or to graphics. Color-coding is a form of communication, as are cockpit displays, whistles and bells, facial expressions, mannerisms, attitudes, clothing. It may be formal or informal. "Hangar flying" represents the earliest and most effective mode of informal aviation communication, a derivative of old-fashioned tabletalk or over-the-fence gossip. The U.S. Civil Air Regulations exemplify the utmost in formal communication on air safety.

Punishment and praise are important methods of supervisory communication, and both may hinder safety if unwisely applied.

Silence can be a powerful form of communication. The presence of a very high official silently but watchfully strolling through the shop or office usually exerts an intense concentration on one's work.

Reluctance to ask a question or to comment or to respond to a question in the presence of others because of apprehension about exposing one's ignorance is a silent form of negative communication. Remedies for this will be discussed.

Specifics: Written Communication in Aviation Operations

Aviation is a sophisticated technology developed by masterful engineers who habitually find it difficult to communicate except with their peers. Maintenance manuals, technical orders, procedural instructions, are often written by engineers for engineers rather than for the mechanic or technician with less formal education who is supposed to understand them.

The difficulty in comprehending much of this complex terminology stems, in my opinion, from the understandable chauvinism of the educated professional, the engineer, the lawyer (who usually checks all publications before issuance) who tend to write to be understood by their colleagues rather than by the person who is expected to follow their thoughts or instructions. Here are examples in aviation taken from the Flight Safety Foundation *Human Factors Bulletin* on "Intelligibility," September–October 1975:

> A quick look around the cockpit is sufficient to see the impact of the engineers. Many of the names of equipment and procedures come from engineering. Engineers frequently use words such as integrated, proximity and intersecting, when they mean mixed, near or crossing. They do not put anything next to anything else, they laterally pre-position it. A name becomes a nomenclature; upside down becomes inverted; next to becomes adjacent; rub becomes burnish; middle is medial; notch becomes detent; and brackets become bracketry.

Ordinary words with double meanings may also confuse the technician. The word "redundant" in this country means "duplication" or "alternative backup." In England, its first meaning is "superfluous, not needed." The redundant control systems, essential in air carrier type of operations, certainly are not superfluous.

The word "normal," such as in "exert normal force," may be understood to mean "usual," "typical," "average," whereas its actual meaning, technically, is "perpendicular" or "at right angle." Many examples of double meaning occur in acronyms used in air traffic control. NTSB [U.S. National Transportation Safety Board] Safety Recommendation A-77-48 lists "OTS," which could mean either "out of service" or "organized track system," according to FAA [U.S. Federal Aviation Administration] manuals or handbooks. "OT" may mean "other times" in flight information publications or "on time" in Handbook 7340. The substitution of popular phrases for approved terminology can be hazardous. The use of "OK" was a factor in the KLM–Pan Am collision at Tenerife in 1977 — the worst disaster in aviation history. People often hear what they want to hear.

Synonyms may also induce ambiguities. The word "caution" is defined in an air transport operations manual as "an operational procedure which, if not followed, may result in damage to equipment." It is distinct from "warning," which defines a procedure which, if not followed, may lead to loss of life. It is believed that the misuse of the word "caution" in an operations manual is considered to have led to the loss of 43 lives. Earl Wiener cites other cases in Reference 1.

Workers and mechanics who do not readily comprehend what they read should not be considered as lacking intelligence. They may just be less skilled in high-class rhetoric than the engineer. Their lack of reading or writing ability may often be traced to an unfortunate or insular home environment, or by a distortion of our educational system, or by a preference to learn by watching or by on-the-job training — even by pictures rather than by reading. Respect their potential.

Schooling problems in many of our educational facilities add to the problem of communication, especially for the military services. A recent study disclosed that of 23,000 young recruits at the Navy Recruit Training Center in San Diego, 37 percent of those tested read below the 10th grade level (LAT 7/24/77). The problem is not unique to San Diego, and it cuts across all races. A U.S. Office of Education study of 1979 reports that "fifteen million Americans are unable to address an envelope well enough to assure that the Postal Service could deliver it. Nearly 17 million are unable to make out a personal check correctly enough for a bank to process. More than one out of every four adults, if given a store receipt listing the purchases and total spent, are unable to figure out the correct change after paying with a twenty-dollar bill. And 11 percent of those holding professional and managerial jobs are among the 'functionally incompetent.'"

At the University of California, freshmen often have such poor reading ability that they are given courses in "Bonehead English."

Airline and corporate operators may not be so concerned by problems in written communication as are the military services. The corporate operator has superior selection and training procedures, and FAA certification for basic competency. But operators in lands where English is not the basic language have told the Flight Safety Foundation of their serious problems in interpreting manuals. At times, they may not even know that their understanding may be faulty. And, as indicated before, even the educated in English-speaking countries may be trapped by a misunderstanding of terms.

For example, the word "finish" has eight meanings, five of them have manufacturing connotations.

The lesson from this in regard to high-risk situations is that supervisors should question their subordinates for their understanding of every critical communication. The alternative for self-supervised pilots in flight is uninhibited inter- and intra-crew coordination (see Figure 1, page 88 and Figure 2, page 88).

Factors in Runway Incursions

Factor	Pilot	Controller
Coordination problem in cockpit	11	0
Coordination problem between aircraft and ATC	17	19
Coordination problem within tower	3	29
Coordination problem within tower and approach control	1	8
Phraseology	3	2
Language problem	3	1
Frequency congestion	3	3
Similar flight numbers	1	0
Controller technique	9	61
Pilot technique	43	11
Intersection takeoff	2	4
Landing to hold short of intersection	0	2
Airport lighting and markings	4	3
Airport, other factors including staff	3	7
ATC and controller procedures	3	8
Pilot/flight procedures	7	1
Training in progress	0	5
Environment (weather)	4	6
Workload	3	2
Fatigue	0	1
Other factors	0	2
Total Factors	**120**	**175**

Source: British Airways *Air Safety Review*, February 1981

Figure 1

Mumbles

There have been several ATC incidents attributed to improper communications procedures. The following is a prime example of what we mean.

"It was Friday night at JFK, and at about 1930 both air and ground traffic was very heavy. The weather was reported as RVR 1600, and Interim Cat II Landings were in progress. We were cleared to taxi to the runway. After cautiously picking our way out to the parallel taxiway, we were switched to tower.

"The first communication we heard, upon switching, was a garbled reply from an aircraft just cleared for takeoff. For some unknown reason, I put a tick-mark on my scratch pad and said, "That's one." By the time we were cleared into position for takeoff, I had nine ticks on my pad.

"Nine of the previous 12 departing aircraft had failed to acknowledge their takeoff clearance using standard phraseology."

Were You One?

Source: U.S. National Aeronautics and Space Administration Aviation Safety Reporting System Technical Memo 78550, October 1978

Figure 2

Understanding Instructions

The finest engineering designs can be ruined or caused to malfunction by misinterpretation of instructions on the workbench or in operating procedures.

In a dynamic industry such as aviation, it is often necessary to issue new technical instructions. What is the most effective way to get the message to the workbench, to the technician, to the operator? North American Rockwell, now Rockwell International, explored this subject during the Apollo 1 (landing on the moon)* program. The reputation of the nation and billions of dollars were at stake. Apollo had 5,600,000 parts and 2.5 million systems. If Apollo operated with a reliability of 99.9 percent, NASA [U.S. National Aeronautics and Space Administration] could expect 5,600 failures! Every precaution had to be taken to avoid misunderstanding in that program.

A controlled experiment by Rockwell involved some 200 mechanics on the problem of understanding instructions. The experiment included combined written and oral instructions, written only, oral only, the bulletin board and the grapevine.

First let me explain that without *two-way* dialogue, we acquire 83 percent of our information by sight, 11 percent by hearing. We generally retain 30 percent of what we see and 20 percent of what we hear, and 50 percent of both combined.

The result of the Rockwell tests were:

- Combined written and oral instruction achieved a grade of 7.70, with 10 as tops;
- Oral only, 6.17;
- Written only, 4.91;
- Bulletin board, 3.72; and,
- Grapevine, 3.65.

The combined written and oral instruction is best because the worker learns via two senses and has an opportunity to ask questions. Remember this in light of the previous discussion

* "Human Factors in Quality Assurance," Harris and Chaney; Wiley Pub. Co.

of terms that can easily be misinterpreted. In any case, it is necessary to put instructions in writing for administrative reasons, but written instructions should be wedded to oral instructions and *response* to assure optimum compliance.

Understandable Writing

Writing is not always the most effective form of communication.

Vendors of aircraft and associated hardware employ specialists in technical expression, graphics, films, information transfer, with excellent results. Computer-assisted training programs are the way of the future, but writing will continue to be the prevailing method of communication, especially in critical situations where time is short. What can be done to improve clarity of writing?

The U.S. Department of Defense has adopted the Flesch–Kincaid Readability Formula for communicating complex technical content effectively to a population of individuals with a wide range of intelligence and reading levels. The formula is based on studies by Rudolph Flesch, published in 1949 as "The Art of Readable Writing." I paid $1.25 for a paperback copy in 1962. It came to my attention when C.R. Smith, president of American Airlines, gave a copy to each of his executives. It provides logical, orderly, readily applied recommendations coupled to a system by which publications can be measured for readability. Typical of its recommendations are:

- A sentence should contain not more than about 17 words, especially if the audience consists largely of readers with a 10th-grade education. Cartoon writing provides good examples;
- Conjunctions such as "and" or "but" should be used sparingly, if at all;
- Heavy prepositions such as "in the neighborhood of" should be replaced by "about"; and,
- Where feasible, use short, familiar words instead of longer Latin-derived words. Examples are "check" instead of "verification"; "value" for "parameter"; "urge" for "encourage"; "put" for "incorporate"; and "add to" for "supplement."

Flesch recommends make-up by columns rather than across the page to ease eye scan. Examples are newspapers, *Time*, *Science 80*, *Reader's Digest*, advertisements, etc.

Flesch's book also has suggestions on type, color and related factors which compose his formulae for measuring readability.

Other books have enhanced Flesch's original text but are not as readable!

Acceptance of his ideas in recent years by the Department of Defense, as well as the world of popular literature, has vindicated his research. Most educated people feel that they know how to write understandable English. Probably so for their peers, but perhaps not for rapid comprehension by others. Learn how from the skilled professional.

Participative Communication

When instructions are given to a group and the supervisor asks for questions, some individuals may be reluctant to expose their uncertainty or their slow comprehension in the presence of fellow workers. The supervisor should later ask each worker privately if he understands the instructions, time-permitting.

Prior to issuing formal instructions, it is often gainful, sensible and discreet to consult with the individuals who are to be involved. They should be given the reason for the instruction before discussing it. This offers at least three potential benefits to management:

- Management may receive suggestions to improve the instructions;
- The individuals are likely to accept the instructions more readily when issued; and,
- Their pride will be warmed by this recognition. Morale and motivation will be enhanced.

Individuals may deliberately deviate from instructions to bolster their ego, satisfy their sense of independence, or in the belief that they know better. Consultation prior to implementation of instructions tends to alleviate these impulsive or potentially hazardous types of noncompliance. Or as Dr. Flesch might argue, "Take time to check with your coworker." This is especially important where continual supervision of the individual is awkward or impractical.

Safety Motivation

Safety platitudes or slogans are rarely effective unless they act as reminders of specific actions. A generalized slogan such as "Fly Safely" is not meaningful except to show that the organization which displays it is interested in safety. On the other hand, a sign such as "Have You Checked Your Notams?" carries a specific message which is likely to induce response. It is an appeal to logic. Emotional appeals are effective but usually only for a short time, so these should be varied frequently. They are in the class of the serious injury, let us say, of a worker who loses a hand in a punch press. Those punch-press operators, who are normally a bit indifferent in following safe practices, will be careful for a week or two, when disregard again sets in. Hence the need for constant attention by the supervisor. The supervisor is the most important safety motivator.

Indirect appeals may be more effective than direct appeals to follow safety procedures. In a machine shop with many grindstones, it was remarkable to find that all the operators wore their protective eye goggles day in and day out. The reason was a rueful reminder which they could not fail to see as they entered the shop. It read, “There are eleven factories making artificial eyes.”

An effective sign displayed in several places on an oil rig showed a gruesome picture of a hand minus its fingers. It said, “Fingers Don’t Grow Back.”

A very innovative approach concerns a large number of women who worked on the third floor of a building in a shipyard during World War I. When the five o’clock whistle blew, they rushed pell-mell down the stairs, trampling and injuring anyone who had the misfortune to stumble. The cure for this was simple. A large mirror was placed at each landing. The women could not resist the temptation to pause in the rush downstairs to look at themselves in the mirror!

On the aircraft carrier *Ranger*, the chart table had been damaged by sailors sitting on top. This was corrected by displaying a large picture on it of a female beauty. Under the picture was the caption: “Now that we have attracted your attention, do not sit on this table.”

Audiovisual presentations often cause drowsiness. But when associated with programmed learning, computer-assisted training and questions, they are very effective. Nevertheless, attention span is limited.

Much research has shown that “scare” messages may be counterproductive, more difficult to use and less effective than emphasis on positive gains from safe practice. This is counterintuitive but probably true.

Management-Employee Rapport: Interpersonal Communication

A good leader creates a climate of discipline and expectation among his subordinates. Discipline in this sense means not rigid attention, but the systematic willing and purposeful attention to an assigned task. It is the antonym of that often-used ambiguity “complacency,” a very important but inadequately defined concept.

A way to encourage fault-free operation is for the top executive or manager to visit the workplace without an entourage. This demonstrates personal concern with employees and their environment. It should be done habitually without advance notice. His attitude should be one of warm interest, not of suspicion. He should nod to his supervisors and employees, pause for brief chats when feasible. The Japanese managers go much further. They occasionally work alongside the employee. Employee-management rapport is an important element in the magnificent productivity of Japanese industry (see Figure 3, page 91).

When indifference sets in, the top executive or manager may combat it by striding through the workplace in searching silence. The presence of the boss has powerful disciplinary effects if he is respected.

Communication From the Bottom Up

High morale and the helpful loyalty of employees are objectives of modern managements in high-risk situations. They enhance safety.

At the Flight Safety Seminar of 1954 in Bermuda, Professor Kenneth Andrews of the Harvard Graduate School of Business Administration spoke on “Morale and Safety.”

The substance of his paper, which, with his previous paper on “Crime and Punishment,” became widely demanded by industry and universities, was that in current industrial society, it is important for good employee-management relations to provide ways by which the employee can communicate upward to management and participate in management decisions regarding his work. This policy is in strong contrast to past practices where communication has usually been solely from management downward to the worker. Upward communication has been a very important element in Japanese industrial success.

This policy is also evident in several successful American companies. At IBM, for example, the employees have direct access to the chairman of the board. I was with Tom Watson, at the time he was chairman, when his secretary made an appointment for the janitor to come to see him. I had a similar experience while visiting with Roy Grumman, president of the Grumman Corporation at the time. This general policy also prevails at Delta, considered by many to be the world’s most efficient airline. At Delta, the employees elect their own supervisors.

The Japanese manager seeks consensus from his employees in making decisions. Ford, General Motors, Chrysler and other companies are adopting guidance in this area from Japanese policy. Several large American companies already have adopted the policy of participative management. Its very special benefit is to increase interest in the success of the organization and quality of work by employees.

It is worth noting that Gen. George Washington, despite his austere character, invited noncommissioned officers and troops to consult with him. Napoleon read his battle orders to nearby corporals to determine their clarity before issuing the orders.

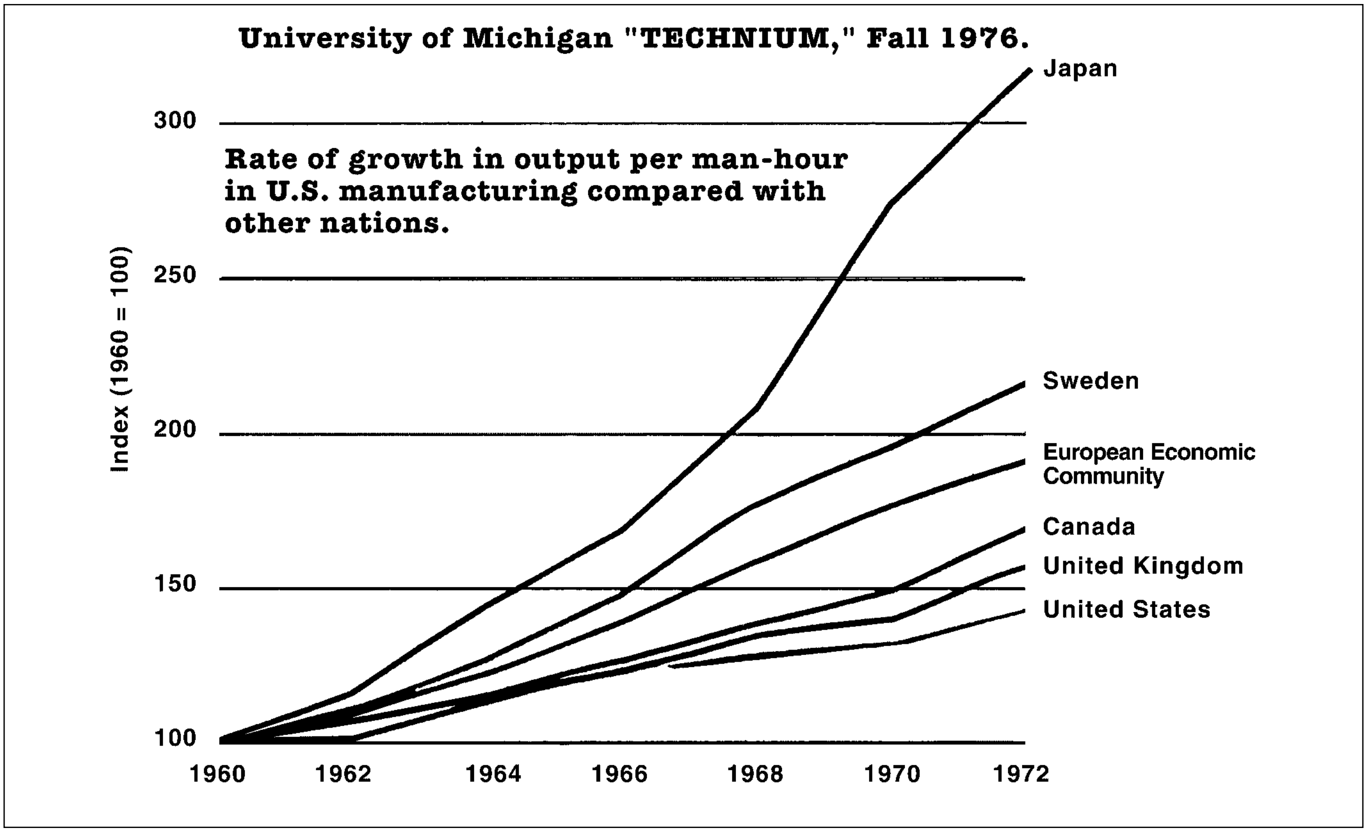


Figure 3

What can be done in Japan and other nations is not always possible in the United States. Other nations have a more homogeneous population with consistent ideology and mores. A good reference on Japanese industrial supremacy and reasons therefore is "Japan as No. 1," by Professor Ezra Vocel of Harvard University.

Incidentally, in Japan, management's first loyalty is to its employees, not to its stockholders. Its second loyalty is to its customers, not its stockholders. Its third loyalty is to its stockholders. This is the reverse of customary American policy. However, the Japanese believe that if management is successful with its employees and customers, the stockholders' interests are assured. Group loyalty is the key. Group interactions with management encourage discipline. They watch or help each other. Recognizing group achievements induces individual members to monitor each other.

Handling Friction

Inevitably, frictions and complaints arise between employees and management. In this country and others, the unions often take a hand in settling these on an undesired basis of confrontation. Other ways exist. One large international airline has appointed an ombudsman. Any employee can vent his frustrations and complaints in assured confidence to management via the ombudsman. Another system, known as the "Michigan System," offers direct confrontation of employees with management but provides confidentiality for the employees. Management calls for a meeting with employees. The employees sit around tables of ten. Each table has a chairman. He presents to management on the dais the various questions or frustrations submitted to him by the others at his table. Both sides should be cautioned to be good listeners.

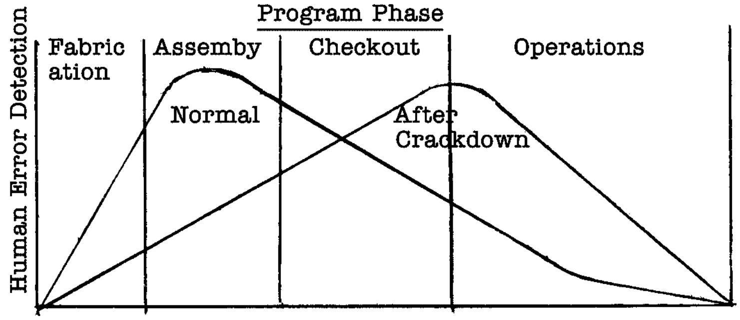
In Singapore, the government has provided "frustration" rooms where civil servants can take some satisfaction in striking punching bags or kicking soccer balls marked with the names of the bosses!

Punishment

At the beginning, I mentioned that punishment is a form of communication. Punishment usually results from a breach of discipline defined as the systematic, willing and purposeful attention to an assigned task. This breach may be deliberate, such as failure to use a checklist, or it may be inadvertent, such as overlooking an item on a checklist due to haste or fatigue or familiarity. Punishment is not a desirable way to discipline except for deliberate, unreasonable departures from good practice. Punishment inhibits free communication. Figure 4 (page 92) illustrates what happens when management cracks down on all oversights, in contrast with praise to the person who admits an inadvertent blunder, indiscretion or error.

Voluntary Admission of Errors and No Punishment

A study was made of human errors for the purpose of minimizing them. The chart shows that the "tough guy" approach results in concealing error.



During the four phases of an aerospace program the "crackdown" method for error reduction induces the threatened operators to refrain from admitting errors. When these appear in later stages, they become hazardous and more costly to correct. Total number of errors decreases only slightly.

****

"Experience is the name we give to our mistakes."

Oscar Wilde

Fig. 4 – C.E. Connell, McDonnell Douglas, Space/Aeronautics, 1968

Figure 4

The figure shows that under a crackdown philosophy of punishment, employees tend to conceal their errors. The errors then appear later in the operational stages where they create hazardous situations or cause expensive repairs. In contrast, the enlightened approach is likely to bring out the errors which can be remedied (see Reference 2, the inspectors' confession).

An example of an enlightened approach to organizational discipline concerns the lunar excursion module (LEM) of the Apollo project.

The thousands of organizations involved in the Apollo program were encouraged by NASA Awareness Programs to adopt a policy which tempered punishment for employees who confessed their inadvertent mistakes, oversights or laxity; in fact, management appreciation for free confession of error was suggested. This paid off. In the case of the LEM, an inspector, examining the interior for workmanship, cracks, corrosion, inadvertently dropped the mirror he was using. It fell below, fracturing into many parts. No one saw this. The inspector could have avoided blame. Instead, he promptly confessed his clumsiness, although realizing that the cleanup job would take several weeks at a cost of hundreds of thousand of dollars, causing his company very considerable embarrassment. Management was grateful for his confession and took steps to praise it, thus encouraging others to follow his example. Had he not reported this incident, the company's excellent reputation might have been seriously jeopardized by pieces of mirror floating in the cockpit under zero gravity to bother the astronauts. Recognition and appreciation of personal actions are facets of communication.

Incidentally, this incident is in strong contrast to an earlier event when technicians in the act of replacing a module of the Apollo guidance system were horrified to discover that the nuts on the bolts holding it had been overtorqued, that the bolts had failed and then were cemented together!

Gen. David C. Jones, chief of staff, U.S. Air Force, presented his views on punishment in *Air Force Magazine*, May 1978:

> When you stop to think about it, fear is probably the *least* effective tool for fostering the sort of discipline needed among a modern force of educated, technically oriented and trained people from a democratic society. It's one thing if a commander's only concern is narrow, uncomplicated instructions. But modern warfare has grown too complex for sole reliance on this essentially medieval foundation for military discipline.

The shift I see is an evolution from a norm of arbitrarily imposed authoritarianism to greater reliance on *self*-discipline. We have worked hard to substitute mutual respect and understanding of the mission for the old-style "do-it-because-I-say-so" philosophy.

Overall, we've made good progress both in the transition and in raising the standards of discipline in the Air Force, but we still have a way to go on both counts.

The sanctions are still there if needed, but our low rates of disciplinary action persuade me that they are being effectively employed by leadership as a backstop rather than as a club.

In view of the increasing complexity and technical sophistication of the modern battlefield, I'm convinced we've chosen the right path in engaging people's minds, not just their bodies, in our concept of discipline. Our peacetime management and our combat capability will be strong, more flexible and more imaginative because of it.

Summary

Communication is vital in cooperative ventures to secure discipline, coordination, awareness, mutual motivation, development and safety. Communication is a multi-faceted art. The definition "to make known" should not be limited to written and/or oral expressions. This overlooks a variety of other effective methods for communication, such as silence. The supervisor who communicates or transmits messages or commands should consider the educational or other limitations of the subordinate if he desires optimum acceptance and compliance. The effect of the communication on the subordinate is an important consideration. Supervisors should not confuse ignorance with intelligence; ignorance may veil talent.

Even the educated and well-trained can be misled by words or phrases that have a variety of meanings. The combination of written and oral communication is superior to either. An effort should be made to use short, simple, commonly understood words and phrases in short sentences. Subordinates should be invited to critique instructions which they are to follow, where feasible, especially in complex or high-technology situations. Management will profit by providing subordinates with opportunities to communicate upward. Platitudes should be supplanted by innovative, specific concepts for safety motivation. Inadvertent departures from good practice or mistakes should receive constructive correction or discipline rather than harsh treatment. It is important for management to support the dignity and good intentions of the normally dutiful, conscientious subordinate in high-risk environments. For them, discipline should be tactfully administered but never overlooked: a communication challenge to effective management.♦

[FSF editorial note: This paper was presented at the Flight Safety Foundation Corporate Safety Seminar in Denver, Colorado, in 1981.]

References

1. "Controlled Flight Into Terrain Accidents: System Induced Errors," Earl L. Wiener. *Human Factors Journal*, April 1977. Also: "Human Error in ATC, Operation," James W. Danaher. *Human Factors Journal*, October 1980.

2. U.S. National Transportation Safety Board Release 79-59 2709 about a train accident said, "Inspectors said they did not report the problem (a cracked wheel) to their supervisors for fear of a reprimand if they delayed the train for repairs."

Bibliography

1. "Communication Problem Cited in Failure of Seasat Spacecraft," *Aviation Week & Space Technology*, Feb. 5, 1979.

2. "For Many Workers Participation and Productivity Go Hand in Hand," Bruce Stokes, Worldwatch Institute, *Los Angeles Times*, April 22, 1979.

3. "Safety via Discipline," Elwyn Edwards, Flight Safety Foundation (FSF) International Air Safety Seminar (IASS), 1979.

4. "Pros and Cons of Punishment," J. Lederer, International Society of Air Safety Investigators (ISASI) International Seminar, 1979.

5. "Crime and Punishment," Kenneth Andrews, FSF IASS, 1952. Explains reasons for punishment: for revenge; as a discipline to protect the transgressor; to protect society; to instruct; as a mark of authority.

6. "Morale and Safety," Kenneth Andrews, FSF IASS, 1953.

7. "Human Relations in Modern Business," sponsored by American Business Leaders. A booklet published by Prentice-Hall Inc.

Notes

What can you do to improve aviation safety?

Join Flight Safety Foundation.

AVIATION SAFETY RESOURCES TO THE WORLD FOR MORE THAN 50 YEARS

Flight Safety Foundation

An independent, industry-supported, nonprofit organization for the exchange of safety information

- Read internationally recognized publications including *Accident Prevention, Cabin Crew Safety* and *Flight Safety Digest.*
- Use resources of the Jerry Lederer Aviation Safety Library.
- Attend renowned safety seminars for airline and corporate aviation managers.
- Access convenient links to member-company home pages.
- Benefit from safety services including safety audits and internal evaluation programs.

Want more information about Flight Safety Foundation?

Contact Ann Hill, director, membership and development
by e-mail: hill@flightsafety.org or by telephone: +1 (703) 739-6700, ext. 105.

Visit our Internet site at <www.flightsafety.org>.

We Encourage Reprints

What's Your Input?

In keeping with FSF's independent and nonpartisan mission to disseminate objective safety information, Foundation publications solicit credible contributions that foster thought-provoking discussion of aviation safety issues. If you have an article proposal, a completed manuscript or a technical paper that may be appropriate for *Flight Safety Digest*, please contact the director of publications. Reasonable care will be taken in handling a manuscript, but Flight Safety Foundation assumes no responsibility for material submitted. The publications staff reserves the right to edit all published submissions. The Foundation buys all rights to manuscripts and payment is made to authors upon publication. Contact the Publications Department for more information.

Flight Safety Digest
 ISSN 1057-5588

Staff: Roger Rozelle, director of publications; Mark Lacagnina, senior editor; Wayne Rosenkrans, senior editor; Linda Werfelman, senior editor; Karen K. Ehrlich, web and print production coordinator; Ann L. Mullikin, production designer; Susan D. Reed, production specialist; and Patricia Setze, librarian, Jerry Lederer Aviation Safety Library

Subscriptions: One year subscription for twelve issues includes postage and handling: US$480. Include old and new addresses when requesting address change. • Attention: Ahlam Wahdan, membership services coordinator, Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: +1 (703) 739-6700 • Fax: +1 (703) 739-6708