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TO MAKE ASSURANCE DOUBLE SURE

BY W. T. SEAWELL†

I. INTRODUCTION

SAFETY IS one of those peculiar terms that connotes an absolute, but because of its unattainability, it ends up having to be defined in negative terms, such as, "condition of being safe; freedom from danger or hazard; quality of being devoid of whatever exposes one to danger or harm." By definition, the terms of human existence include risk or a system of relative dangers. One of the aims of existence thus becomes the attempt to reduce risk to its lowest possible level. When aeronautical engineers, for example, discuss a new airplane, they often talk about designing safety into the airplane. They are really discussing an attempt to make the airplane as invulnerable as possible when its machinery or operators fail, as they inevitably will. They attempt, in the words of Shakespeare, to "make assurance double sure."

Making assurance doubly sure has been the cardinal rule of airline operating philosophy from the earliest days of the business. It had to be. The airline founders realized that the public would never use the new form of transportation until it became convinced of its reliability. Unlike other vehicles in public transportation, airplanes operate in a three dimensional environment—an environment that seems alien to some even today. "To fly without feathers is not easy," the Roman dramatist Plautus observed. It was some 1900 years before the Wright Brothers demonstrated that, if flying without feathers was perhaps not exactly easy, it was at any rate possible. It then became the mission to prove that it was not only possible but also practical and safe for mass transportation. Reduction of inherent risk became and remains the primary concern not only of airline top management, but also of any engineer, any pilot, any mechanic, in fact, any person involved in the operation of an airline, acting of course in cooperation with the appropriate government agencies.

The first generation leadership of major airlines has pretty well given way to the second generation management. But as more of the public depend on air to satisfy their transportation needs, airline responsibility for overcoming risk becomes, if possible, more crucial. In the 1930's airline managers thought in terms of hundreds and thousands of customers; today it is millions and billions. In 1936, the year American Airlines introduced the DC-3, the United States airline industry served just over 1 million passengers; last year, passengers numbered more than 133 million. Moreover, revenue passenger miles have soared from 480 million to just under 100 billion. Employment has climbed from under 10,000 to more than 270,000.

Aircraft in 1936 totaled 374, of which the DC-3 was the most advanced; the airline fleet at 1967's end numbered 2,169, of which 80 percent were turbine powered, and the biggest was the 234 passenger, 600 mph long body DC-8.

Despite inflation and despite huge outlays of capital, passengers enjoy a lower fare level today than they did in 1936, when the per mile fare was 5.7 cents compared with 5.5 cents last year. This record was attainable because the massive expenditures the industry has been willing to make have allowed the airlines to operate increasingly productive airplanes which carry more people further, faster.

The airlines in 1934 had a total investment of less than $30 million. The airlines are currently in the midst of the second reequipment cycle of the jet age; during the years 1967 through 1971 the airlines will add more than 1,100 airplanes to their fleets with a price tag of some $8.5 billion. Coming next year will be the 350 plus passenger Boeing 747. Two years later the industry will introduce the jumbo trijet, a 250 passenger, wide-bodied airplane with three advanced technology engines which will allow it to operate from smaller airports, such as New York's LaGuardia. The airlines are making these commitments because all of our projections indicate we will need these new airplanes, and more, to meet the demands for service. By 1975 it is conservatively predicted that United States airlines will serve 200 million passengers; within another decade the total should top 500 million. Airfreight should grow even faster, increasing some 20 times over today's tonnage by 1985.

The industry would not be where it is today, if the airlines had not continuously strived to eliminate risk. The industry will not get where it hopes to go tomorrow, if the airlines do not continue to strive to do so. I would like to describe some of the specific programs we undertook in the past and the key projects of the present. I shall talk primarily about American Airlines which for several decades has directed considerable effort and resources to elimination of risk. Let me hasten to add that other major airlines have distinguished records in this area, as do manufacturers, government agencies, and private groups such as the Flight Safety Foundation.

On a day-to-day basis in the operating area, there are no secrets among airlines. Information is freely shared through regular channels. For example, what may seem to one airline to be an isolated mechanical difficulty, may be detected as a potential problem area when airline experience is pooled. When this happens, the experts correct the difficulty and prevent a minor problem from developing into a major one.

II. AMERICAN AIRLINES AND SAFETY HISTORY

American Airlines (hereinafter American) started out in the mid-1920's as a hodgepodge of airlines which were brought together in 1929 by a holding company, Aviation Corporation. The following year, the airline holdings were separated from other investments and became American Airways. That same year, American hired its first safety officer, William Littlewood, who was to gain fame a few years later as the father of the DC-3.
There had recently been a bad hanger fire at Chicago and lesser ones around the country. Littlewood's first assignment was to make a survey of the system and to recommend ways to prevent and combat fires. Word of Littlewood's mission spread across the country. One day he arrived at El Paso, Texas, and was waiting in the manager's office when a wire came which said, "Littlewood is coming; clean the place up." The mere fact someone was checking provided motivation to improve standards. At any rate, after Littlewood equipped each station with rules and regulations for preventing and fighting fires, the number of fires decreased noticeably. An organized safety program was born.

Littlewood shortly thereafter was responsible for establishing another tradition that is still followed, and probably has had more to do with guaranteeing United States airline technical superiority than any other single factor. The airlines then had fleets of little airplanes such as Wacos and huge airplanes such as Ford Tri-Motors. Neither could make money. Littlewood set down the first specifications for an airline airplane which, it was hoped, would be economical. Aviation Corporation laid out the then startling sum of $35,000 for this work. A single-engine, nine passenger airplane called the Pilgrim emerged from this effort. It did not make money either, but the first step had been taken. From then on the major airlines worked closely with manufacturers on development of new airplanes designed specifically to airline needs, which included the need to minimize risk.

The second major step brilliantly succeeded. American bought a dozen DC-2's which, though a decided improvement over previous planes, were still money losers. American convinced Douglas it should build something bigger and better. Though the airline thought originally the new plane could be 85 percent DC-2 and 15 percent new, in the end the percentages turned out to be reversed. The airplane had a 50 percent increase in payload, from 14 to 21 seats, but operated at the same per mile cost. American also specified a number of technical improvements, such as, stronger landing gear, stronger engine mounts, and a larger fin with a dorsal fin added to solve a fishtailing problem. The new airplane, the DC-3, went into service in June, 1936. It was a money-maker, and its place in aviation history is well-known.

Research and development aimed at risk control extends to systems. The early development work on airborne radar is a case in point. At the end of World War II, C. R. Smith, who had just returned to American as chairman following wartime service in the Air Transport Command, wrote a characteristically terse note to the engineering department: "Find out ways of using wartime devices to avoid collisions with mountains." An engineering team acquired a Navy radar system and installed it on a DC-3. Then they set forth in search of mountains and bad weather. Within a few months, the improvements the men made in the system allowed them to fly a collision course on Pikes Peak during heavy rain, photographing the scope until time came to take evasive action. Carrying the work one step farther, the team refined the system so that radar could be used to navi-
gate around thunderstorms over land as well as over water. When the experiments ended in 1949, work remained to be done before production systems could be available, but these experiments had proved airborne radar's practicality and its usefulness in risk reduction.

Also during the early postwar years, another American engineer conceived the idea of installing evacuation slides in aircraft. He visualized a slide as a sort of coal chute. Prototypes were installed in a DC-4, and employees revived a grammar school pastime and slid down them until their trousers shone to demonstrate their practicality. Though way beyond the coal chute in sophistication, slides are now standard on all transport aircraft.

American also was responsible for relocation of the fuel tanks of the early postwar twin-engine Convairs and Martins from between the fuselage and powerplants to outside the engine nacelles. The redesign set new industry standards for accident survivability.

When American introduced the 707 into transcontinental service in January, 1959, the company was already planning to reengine the airplane as soon as the turbofan engine could replace the turbojet. The original jet engine was a military powerplant, well proven and reliable, but more suited to fighter planes than to transports. American’s support of the fan jet development speeded its introduction into service by several years. Today, the turbofan is the standard engine for all the Free World’s airplanes. The new engine combined the proven reliability of the turbojet with substantially greater power and substantial fuel savings through the installation of a big fan, which acts quite like a propeller, either fore or aft of the basic powerplant. American introduced the first fan-powered airplanes, which we call Astrojets, in March, 1961. Because of the engines, Astrojets can carry greater payloads, takeoff in less distance, climb more swiftly to altitude and deliver more thrust per gallon of fuel. Its faster climb-out provides noise relief on the ground. Its fuel economy increases range, providing a greater schedule dependability on longer routes. Its increased thrust provides a greater margin of safety for engine-out performance, particularly on takeoff, and additional reserve power for emergencies.

Other improvements provided greater controllability on takeoff, on approach and in the air. Substitution of full span leading-edge wing flaps for the original single flap improved the wing’s high-lift characteristics, providing greater stability at low speeds. This decreased the runway length requirement and cut the approach speed ten knots. Addition of several feet to the vertical tail and installation of a ventral fin beneath the tail, plus a considerable improvement in the rudder power control system, eliminated the Dutch roll characteristic of the original airplane.

III. CURRENT SAFETY EFFORTS OF AMERICAN AIRLINES

Elimination of risk from our environment is a continuing process. Daily we attempt to assess the pattern of relative danger and direct our time and resources toward elimination of the risks that are the most worrisome.
American's current prime safety efforts are focused on two main objectives: (1) development of a reliable, fully automatic landing system, and (2) management of the flying end product to make certain that crews receive realistic training and retraining as necessary. Neither of these is a new objective. For the first time, both seem possible to achieve. A look at the jet accident record shows why expenditure in these two areas should be the most useful. Of 23 jet accidents involving fatalities United States airlines have experienced, 13 have occurred during approach or landing. Of worldwide jet accidents, 50 percent have been in this phase of the operation. Of 75 airplane accidents in the United States in 1966, of which 8 involved fatalities, crews were cited as the major cause or as a factor in 72 percent of the Civil Aeronautics Board's investigation findings.

Everybody in the aviation business has been experimenting with automatic or "blind" landings for 40 years. There have not been any spectacular breakthroughs, just steady, sound progress. When the jets first went into service, landing minimums were set at 300 feet ceiling and three quarters of a mile visibility. In working toward the first improvement target, 200 feet and one half mile (generally expressed as 2,600 feet runway visual range), American chose to upgrade its autopilots since this would be necessary for the next step forward. American had the modifications completed and crews trained to fly the new minimums in November, 1962, becoming the first airline to fly revenue passengers in what are called Category I landings. The next step, to 100 feet and 1200 feet runway visual range, requires further refinement of cockpit instrumentation, notably further upgrading of the autopilot and installation of radio altimeters for more reliable readings. Although American received Federal Aviation Administration approval for Category II approaches some time ago, the airline has not fully implemented the program. Its use requires improved airport facilities, such as more accurate instrument landing systems and touchdown zone and centerline lighting. Only one airport has a fully approved Category II runway at this time. Ahead lies one more milestone, Category III, and then American will be prepared to aim for an operational all-weather landing system. A version is already in service in Europe, and developmental models of United States systems are flying. Again, it is an upgrading, building-block process, with the key new instrumentation an automatic throttle device which will make a true "hands off" landing a reality. Incidentally, the pilot's hands may be above his head, but he will not be idle. He will be busy monitoring the black boxes, and will be able to override the system immediately with the press of a button.

Obviously these systems will have to be extremely reliable; American could not afford to have the cure worse than the disease. However, the technology now exists to build reliable systems. American is so convinced that the technology does, in fact, exist that plans have been made to install them on Boeing 747's and jumbo trijets. In preparation, American will shortly install one on a Boeing 707, from its present fleet, for further development and evaluation. In addition to reducing the risk, all-weather landing will greatly improve schedule dependability both through a sig-
sificant decrease in diversions and through an increase in the efficiency of airports.

The second major safety objective, providing realistic training, is now within American's grasp. Pilots are frequently blamed for an accident. However, in almost every case, there are contributing causes. The weather changes suddenly, or weather conditions are inadequately or incorrectly reported. Sometimes partial failure of equipment occurs, although this is usually difficult to pinpoint after the fact. To eliminate the impact of these contributing causes is the responsibility of flight management. This is currently the area of the flight department's greatest concentration of effort. To help pilots keep ahead of the game, American has a group of supervisory pilots constantly analyzing and revising procedures to keep them current with changing situations. Another group of chief pilots, operating on a systemwide basis, conducts line checks to make sure the procedures are understood and followed. To assist these two groups, American is currently pioneering the installation of an airborne monitoring and recording system, not surprisingly dubbed "Astrolog." This system monitors all aspects of every flight, some 1200 a day, from the time the flight leaves the gate until it docks at destination. It measures three dozen flight characteristics, such as takeoff speed and deck angle; flap settings; climb, cruise, descent and landing speeds; bank angles and descent rates. Tapes are removed from the airplane at the end of the flying day and fed into a computer which reads all the data and prints out exceptions to the programmed limits. When the system is in full operation, management pilots will have a complete picture of how every flight was flown the next morning. Using check pilots to perform this monitoring function, only 1.0 percent of the flying end product could be sampled; with Astrolog, sampling will be 100 percent.

Astrolog will lead us to identification of strengths and weaknesses. It will give management the opportunity to evaluate scientifically the effectiveness of training programs, flying procedures and policies it has developed and to correct any deficiencies that become evident. For example, if Astrolog reveals that a significant number of pilots are exceeding the limits of one phase of flying, it will be known that something is wrong with pilot training and American will be able to correct this deficiency. Astrolog is not designed in any way as a disciplinary tool. In developing it, American worked closely with the pilots' union and the system has the union's endorsement. Monitoring engine health through recording of key engine performance data is another task assigned to Astrolog. Again, instant answers will be obtained. Every night a computer will analyze each engine's performance for that day and determine whether any faults are developing. In case there are problems, the computer will identify the most likely faults and estimate the urgency for corrective action in terms of the likelihood of inflight engine shutdowns, flight delays and cancellations. Reports will be immediately sent to maintenance and engineering specialists so that corrective action can be taken.

Training is a big operation these days. Since 1964 American has doubled
the number of flight deck crewmen on its roster, and the ranks will continue to expand. Although American hires only highly experienced crewmen, before they take the controls of the airplanes, they go through a 12 week ground and flight school course. In fact, neither they nor the most experienced men on the seniority list ever stop going to school. They go back to class before they are promoted from first officer to captain, or when they make the transition from one type of airplane to another. There are also frequent refresher and homestudy courses. To handle this expanding operation and to standardize training, American is in the process of centralizing all crew training at Fort Worth on a campus adjacent to its Stewardess College. Together the campuses will be the largest crew training facility in the world. When completed in 1969, the flight school will house all the latest training aids, including ten digital computer-operated flight simulators. These advanced simulators, of which two are now in operation at a temporary Fort Worth facility, feature visual and motion simulation. They are allowing a decrease in the amount of time a student spends in an actual airplane, thus turning out better pilots for less money. By 1970, when the simulator fleet on order is complete, cost savings over 1966 will be $7.6 million. And, again, this reduces risk exposure since it is advantageous for a student to practice engine-out landings, for instance, in the classroom before an instructor simulates the same problem on a real airplane. Impressive though these new simulators are, they are crude compared with what the industry's training experts envision. Wrap-around visual systems will allow simulation of circling approaches, air work, taxiing and parking at the terminal. These and other advances should within the foreseeable future allow the airlines to do all flight training in simulators.

To close the loop in aviation safety requires added attention be given to the airport and airway traffic control system. The industry recently recommended a number of improvements in the system to Congress. Some of the more important ones are as follows:

1. The scheduled airlines serve 526 United States airports of which only 234 have control towers. All of them should.
2. Only 105 of the airline airports have terminal radar. Again, all should be so equipped.
3. All radar systems should be updated, as they have been at a few airports. Installation of name-tag systems, which automatically identify an airplane by airline and flight number and show whether it is climbing or descending, should be expedited.
4. Improved weather radar should be installed at all towers. So, too, should be bright-tube scopes, which provide a clear display when the ambient light in the tower is bright.
5. Every airline airport should have an instrument landing system on at least one runway; only 189 are now so equipped.
6. More stringent regulations should be written to separate instrument flight rule and visual flight rule traffic. All airplanes operating at major airports should be required to have basic navigation/communi-
cation equipment.

Turning again to present work that promises future rewards, within the past few months, the airlines, several avionics manufacturers and the FAA have concluded, after more than a decade of experimentation, that a practical airborne Collision Avoidance System (CAS) is feasible and can be in operation by the early to mid-1970's. CAS will not in any way replace the Air Traffic Control system, but will offer an important margin of safety when the ground-based ATC system fails. Cooperative systems which the airlines anticipate buying will analyze threats to determine potential collision hazards. The system will alert the pilot to a threat, tell him what evasive action to take, and when, to avoid the hazard. In addition to the highly sophisticated and expensive airline CAS devices, it appears probable that an inexpensive pilot warning indicator, which will warn a pilot of a hazard, but not tell him what to do about it, will be available for general aviation aircraft.

All these advanced systems will greatly improve the environment in which our pilots work, through reducing unexpected situations which they sometimes encounter through no fault of their own and which occasionally lead to trouble.

IV. Conclusion

To predict that in the future there will be no more airline accidents of any type is, by the nature of existence, impossible. But risks inherent in a changing environment can be identified. We can—and we have, and we will—work to eliminate these risks. Their percentage can be infinitesimal. Airline safety is NOT a myth. It does require hard work and continued progress. American never takes it for granted.