SPECIAL STUDY

REPORT ON
APPROACH AND LANDING
ACCIDENT PREVENTION FORUM
OCTOBER 24 - 25, 1972

ADOPTED: SEPTEMBER 19, 1973

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591

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16. Abstract

This is a special accident prevention study which analyzes the papers, recommendations, and views presented by aviation community participants at the National Transportation Safety Board Approach and Landing Accident Prevention Forum held on October 24-25, 1972. This part of the report presents the Safety Board's conclusions and recommendations relative to the prevention of approach and landing accidents, a glossary of terms, and a summary of previous recommendation by the Safety Board as a result of approach and landing accidents.

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FOREWORD

On January 17, 1969, the National Transportation Safety Board issued a series of recommendations to prevent approach and landing accidents. That same month, the Safety Board convened the first of eight conferences that it held with Government officials and aviation industry representatives to study the approach and landing problem.

On December 3, 1970, the Safety Board wrote to 10 airline and private flying organizations and urged that they and the aviation industry develop a sustained educational program for pilots to help prevent approach and landing accidents associated with visibility restrictions and visual illusions in restricted weather conditions.

On December 19, 1972, the Safety Board urged various aviation organizations to impress upon their membership the importance of strict adherence to established operational procedures.

The Safety Board has made numerous recommendations to Government and other agencies as a result of approach and landing aircraft accidents.

Despite the overall efforts of industry, operators, pilots, and government agencies, including the Board, approach and landing accidents have persisted as a major threat to aviation safety.

In organizing the Approach and Landing Accident Prevention Forum, the Board invited more than 50 representatives of Government and civil aviation organizations to present their views, conclusions, and recommendations relative to accidents which occur in the approach and landing phases of flight.

The Forum was organized so that the papers presented would cover the various man, machine, environment, and management system elements needed to prevent approach and landing accidents.

This report is a culmination of the Board's Forum on this subject.

The papers presented or submitted during the Forum are contained in Part II[1] of the report.

To assist the reader, a Glossary of Terms is included as Appendix A of this report.

[1] Copies of Part II are available for sale under the Safety Board's regulations governing the copying of Board records and documents, as provided in 49 CFR 401.13. Further information can be obtained from the Accident Inquiries Section, National Transportation Safety Board, Washington, D.C. 20591.

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Washington, D.C. 20591
SPECIAL STUDY

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INTRODUCTION

The National Transportation Safety Board's Approach and Landing Accident Prevention Forum was held in Washington, D.C., on October 24 and 25, 1972. Thirty-five papers were presented.

Extrapolation of data contained in the National Aviation System Policy Summary for 1971 and the Board's approach and landing accident rates indicates that more than 4,500 U.S. civil aviation approach and landing accidents can be expected to occur in 1981. This projection for 1981 is double the number of such accidents which occurred in the year 1971.

Approach and landing accidents have accounted for about 55 percent of all aircraft accidents during the past 15 years and for as high as 65 percent of all aircraft accidents in a given year. The number of final approach accidents exceeds landing-run, initial-approach, or go-around accidents; and approach and landing accidents are occurring farther from the runway threshold.

The probability of an occurrence of an accident during a night landing approach is 2½ times greater than the probability of an accident during daylight hours. The probability of an approach and landing accident is nearly four times greater in reduced visibility than in good visibility.

Seventy percent of the approach and landing accidents occur while aircraft are being operated under Instrument Flight Rules (IFR). Eighty-three percent of these IFR accidents occur in actual instrument conditions.

From 1966 through 1970:

- Ninety-one U.S. civil air carrier accidents resulted in more than 560 fatalities. About 40 percent of these accidents were clearly identified with the approach and landing maneuver.
- In general aviation approach and landing accidents for the same 5 years, 830 fatalities occurred (12.5 percent of the total), which involved 3,753 aircraft (21.3 percent of the total).

All classes and elements of aircraft operations have been involved in approach and landing accidents: Scheduled air carrier, air cargo, charter, business/corporate, and general aviation. Man, machine, environment, and management have all been implicated in the causes.

In reviewing approach and landing accidents, the Forum attempted to deal with an international problem and, therefore, welcomed participation by foreign companies and governments.

The Board found considerable interest in the forum concept for exploring avenues of accident prevention. Each participant highlighted various aspects of vital safety information and lessons learned. Current research was reviewed, and the needs of the future were defined.

PRESENTATIONS

This section of the report identifies each participant in the NTSB Approach and Landing Accident Prevention Forum and presents a summary of his presentation.

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Mr. Philip H. Bolger . . . . . Department of Transportation
Office of Safety Coordination
Washington, D.C.

The Department of Transportation is quite concerned with the rate and total number of approach and landing accidents. This type of accident is not unique to the air carrier; general aviation is also involved. The Office of Safety Program Coordination feels that the pilot is the key to most approach and landing accidents.

With today's level of technology it seems well within the realm of feasibility to produce systems that will relieve the pilot of stress and strain he experiences in approaches during bad weather conditions.

There is a great need for management and awareness programs that emphasize the requirements for compliance by the pilot with approach procedures.

The potential for Research and Development activities in the area of systems to reduce the pilot's IFR-approach work-load should be examined.

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Mr. A. Scott Crossfield . . Vice President
Transport Systems Development
Eastern Airlines, Inc.
Washington, D.C.

Mr. Bolger is presently Director, Office of Safety Program Coordination, Department of Transportation. Prior to joining the DOT, Mr. Bolger served as Assistant Safety Director of the National Aeronautics and Space Administration and Director of Manned Space Flight Safety. Mr. Bolger is a graduate of the U.S. Naval Academy with extensive flight and test pilot experience.

Since the two-segment approach is for noise abatement purposes only, an objective safety analysis must be made and weighed. It is true that the noise is less during the early part of the descent, but it can be greater during the level-off to 3° glide slope acquisition.

A safety evaluation should be conducted prior to implementation by FAA of the two-segment approach.

Since any approach accident involves altitude error of some kind, the following technique is offered: Three altimeters in the cockpit – No. 1 and No. 2 (pilot and copilot) set on QFE or zero altitude for landing. All outer markers then are at 1,500 feet, and no arithmetic calculations or variations from landing to landing enter the picture. No. 3 altimeter, visible to both pilots, is set to QNH (or MSL) for traffic control purposes.

All airlines should use both QFE and QNH altimeter settings.

Greater use should be made of Area Navigation and Vertical Guidance.

Area navigation assists the pilot in more easily intercepting the localizer, maintaining separation, and station keeping; it also assists the controller in establishing sequence timing. Preparing for Category II has made better Category I pilots; but, other than that, Category II is of little benefit for its cost and should be abolished with the advent of Category III.

Five new series of approach classes or category minimums should be considered:

1. Noninstrumented area navigation approaches.
2. Noninstrumented area navigation and vertical guidance approaches.

As Staff Vice President for Eastern Air Lines, Mr. Crossfield has worked closely with government on shorthaul transportations systems. His responsibilities also include development programs for new aircraft, flight safety, air traffic and flight testing of new aircraft.

Mr. Crossfield holds BS and MS degrees in Aeronautical Engineering from the University of Washington. The first man to successfully fly the X-15 in excess of Mach 3 speeds, Mr. Crossfield is the recipient of both the Harmon and Collier Trophies.

3. Nonprecision area navigation and vertical guidance approaches.
4. Precision area navigation and vertical guidance terminal area and approach techniques.
5. Category III totally defined terminal area maneuvers and approaches supported by area navigation and vertical guidance.

If a "scatter gun" approach is used, the cost may be such as to derrogate safety. Development planning must be dedicated to a non self-obsoleting balance between airborne and ground systems that encompass the need and economics of most users and airports. The degree of sophistication then depends upon the operations, needs, and pocketbooks of the user.

If we are to arrive at proper and acceptable conclusions, in-depth safety analyses must be made before expensive experiments are generated and emotional issues become polarized.

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Mr. Roy Worthing ..... Deputy Director
Flight Safety
Civil Aviation
Authority
United Kingdom

Flightcrew human causal factors are presented in a predominant and consistent proportion of approach accidents, but these factors run significantly higher in the final approach phase than in the initial approach phase.

Weather and airworthiness factors each account for about 10 percent of the causal factors in the two approach phases.

Airport factors account for about two percent to four percent of the causal factors in both phases of the approach. It is doubtful whether a meaningful breakdown of human causal factors can be made from existing accident data. Much more needs to be known of incidents which have a human factors connotation in order to take preventative and remedial actions in this field.

An analysis of worldwide public transport approach and landing accidents was made over the period 1959 to 1970. It included 1780 accidents of aircraft above 12,500 pounds gross weight.

Forty-eight percent of all accidents reviewed were in the approach and landing phase. Taking jet aircraft accidents separately, the figure was 38 percent. There was evidence that occurrence of this type of accident remains fairly constant. Flightcrew error was the predominant causal factor in the approach and landing phases while weather, airworthiness and airport factors were low in comparison.

Flightcrew factors surpassed all other causal factors by a large margin. This suggested that the major accident prevention effort should be made in that area. For every accident involving human factors, there must be many operational incidents which go unreported.

Civil aviation administrators and authorities should appreciate the need to encourage the reporting of incidents involving human failure in order that effective preventive and remedial measures may be taken.

Mr. Worthing has held the Flight Safety post since 1968, and has considerable experience in the technical planning of aerodonetics and the provision of technical services to overseas territories.

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Mr. Usto Schulz .... Acting Executive
Officer
Flight Standards
Service
Federal Aviation
Administration
Washington, D.C.

Mr. Schulz joined the FAA in 1957, and has served in the Alaska Field Office as well as the Kansas City Regional Office as Assistant Flight Standards Division Chief. He was engaged in undergraduate work at Texas A&M from 1938-40 and possessed an Airline Transport Pilot certificate with more than 13,000 flying hours in transport type aircraft.

Flight can be safe with today's equipment and in today's environment, if the flight is well managed. Progress must be made in making safety a conscious part of all management actions. The flight decision makers cannot, however, avoid their responsibilities or abdicate their power to make sound decisions on the pretext that such things as glide slope, runway, or weather information are missing.

Decision making is a key area that must be examined and improved before significant gains can be made in the accident record. The FAA will look for, and adopt, any new advances in technology to assist the pilot's decision making process, but the pilot will still be faced with making the final decision.

Pilots, and supervisory personnel as well, should give more attention to a good management attitude toward safety and strict personal discipline.

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Mr. John H. Enders .... Chief, Aircraft and Airport Operating Problems Branch
National Aeronautics and Space Administration
Washington, D.C.

The goals of safety research are twofold: to prevent accidents and, if they do occur, to maximize the chances of survival for the aircraft occupants.

Safety research seldom enjoys enough funds to do everything which is desirable. This forces a careful discrimination in the choice of problems, and work on those problems having the greater impact on safety is favored. Too little funding, however, causes an inadequate research and technology base from which system safety can be derived. Such a situation is a spawning ground for accidents and frequently results in "after-the-fact" crash efforts at funding solutions. Money spent in this manner is seldom spent efficiently.

The paper covered some of the programs on which NASA has spent about $3 million per year:

Wake Turbulence – Work on modifying aircraft wake turbulence vortex characteristics to controllable magnitudes and methods to predict and measure the intensity and flow direction of vortex systems in the vicinity of airports.

Fog – Research in modification and dispersal of fog.

Low Level Winds – Research in wind flow over nonuniform surfaces, such as in the lee of buildings, and around hills and ravines. A complementary program is the investigation into the use of crosswind landing gear for STOL operations.

Simulation – Use of simulators in the reconstruction of accidents. The simulator's research role in validating systems as well as operational environmental problems.

Ground Environment – Improvement in runway surface traction; improved tire tread design and brake system characteristics.

Altimetry – A program to determine possible effects of local meteorological conditions on the performance of barometric altimeter systems.

Ditching – Small scale dynamic model ditching investigation to determine preferred techniques, safe landing attitudes, and probable aircraft behavior.

Crash Fire – Development of nonflammable and fire-resistant materials. Full scale tests to compare characteristics of materials and define fire propagation and magnitude.

Mr. Enders has been associated with the NACA Lewis Flight Propulsion Laboratory in Cleveland, Ohio, as an Aeronautical Research Scientist performing research on liquid propellent rocket engines; with the USAF as a pilot; and with NASA as a research pilot and engineering manager. A graduate of Case Institute of Technology, with a ME degree, Mr. Enders is currently responsible for NASA Aircraft Safety Research and is associated with government and industry committees on safety research and flight hazard matters.

Terminal Configured Vehicle – Research to adapt the less efficient configuration of the approach and landing phase of the jet transport to the high-volume ATC environment by closer integration of the airplane's structural, aerodynamic, and propulsion systems with the control and guidance systems, including avionics and cockpit layout.

General Aviation – Studies of typical general aviation pilot performance during approach and landing, and of uncontrolled airport traffic flows to determine effects of cockpit geometry, aircraft configuration, and visibility on traffic patterns.

Stall/Spin Research – Research in devices and techniques which will reduce workload and provide simplified controls and displays. The use of spoilers to increase flight path accuracy and reduce touchdown point dispersion is one such device.

Mr. Enders advocated continued and adequate funding for NASA R&D efforts in the area of approach and landing safety.

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Mr. John W. Connolly . . Special Assistant for Aviation Affairs
National Oceanic and Atmospheric Administration
Rockville, Maryland

Despite great technological strides, we are unable to predict details of the weather in terminal areas. Terminal observations are presently a mix of instrumentally and visually sensed values.

There is a lack of automated techniques or procedures for evaluating total sky cover and determining prevailing visibility.

Mr. Connolly has been affiliated with NOAA, or its predecessors, since 1964 and was appointed Special Assistant for Aviation Affairs in June 1972. He concluded a 21-year career in the U.S. Air Force in 1964 with more than 14 years in research and development assignments. He received a BS degree from Boston College in 1951 and a MA degree in 1956.

There is a lack of means to observe and predict wind shear for the 3,000 feet layer nearest the runway.

There is a lack of means to provide slant visual range for the final approach.

There is a lack of technology for automatically determining precipitation types, detecting freezing precipitation and differentiating between liquid and dry obstructions to visibility.

There are a number of ongoing developments within the FAA and NOAA which are expected to help provide solutions to some of these problems.

The following two actions by the FAA and NOAA are required:

- Redefine ceiling and prevailing visibility to allow measurement using current and future state-of-the-art instrumentation.
- Give priority to new approaches in developing techniques and instrumentation for measuring total sky cover, visibility, wind shear, turbulence, slant visual range, and types of precipitation toward the ultimate goal of providing complete automation of the weather observation and prediction system for terminal area operations.

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Mr. Newton A. Lieurance Former Director, Aviation Affairs
National Oceanic and Atmospheric Administration
1903 Great Falls Road, McLean, Virginia

Former Director of Aviation Affairs for NOAA, Mr. Lieurance has been actively engaged in aviation for some 35 years. He was Director of Aviation Weather for the U.S. Weather Bureau. Prior to his government service, Mr. Lieurance was employed by Trans World Airlines for 10 years. He holds a BSCE degree from the University of Kansas and a MD from the U.S. Naval Academy. The recipient of the Flight Safety Foundation Distinguished Service Award and the AIAA Robert M. Losey Award, Mr. Lieurance retired from NOAA in June of 1972.

Appropriations problems were associated with low priorities assigned to the aviation weather service. The need for an in-depth reassessment of the priorities was high-lighted with the objective of placing these priorities in proper perspective. The need to make better use in terminal areas of the weather information already available in the system was reviewed with emphasis on providing better information to the crewmembers during the approach maneuver.

In conclusion:

- Budget and appropriation priorities should be given to the aviation weather service; and
- An extensive review should be made of the funding priority process for terminal area weather service, weather support, and weather R&D requirements.

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Mr. David D. Thomas . . . President
Flight Safety Foundation
1800 North Kent Street
Arlington, Virginia

A review of more than 900 approach and landing accidents revealed that visibility restriction was the major factor in these accidents when vertical guidance was unavailable.

The large number of visual cues which go undetected between the time the pilot transitions from instruments to visual conditions in the last few seconds of the approach results in judgment errors.

Other factors such as VASI, better crew coordination and altitude alerting devices are of assistance, but the primary emphasis should be on providing vertical guidance information.

The review of the 900 approach and landing accidents on a worldwide basis over a 7-year period found that the probability of an accident was more than two and one half times greater during night time than during daylight hours; the probability was nearly four times greater in reduced visibility conditions; less than 15 percent of the accidents occurred when ILS or PAR was available; altimeter error was a small factor in all of these accidents.

The highest susceptibility for a landing approach accident exists in reduced visibility conditions during a nonprecision approach. A gap exists in visual vertical guidance between the time the approach lights become visible and the time the end of the runway is sighted. Because of inadequate visual cues during that period of time pilot judgment is inadequate. Both the avoidance of two-segmented or deliberately unstabilized approaches, and better runway surfaces (grooving or porous asphalt treated) would aid in the reduction of landing accidents.

The following items need action:

- Some form of vertical guidance be made mandatory for air operations (i.e., ILS, airborne computer etc.).
- Increased emphasis be placed on cockpit discipline and crew coordination.
- VASI be installed on all runways used by air carriers.

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Mr. H. Grady Gatlin, Jr. . . Director of Operations
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Captain J.

Former Deputy Administrator of the FAA, Mr. Thomas has held various posts with FAA and American Airlines. Highly specialized in the field of air traffic control, Mr. Thomas is the recipient of numerous awards, including the Laura Taber Barbour Award for air safety. A pilot for more than 35 years, he has a degree in Mechanical Engineering from the University of Tennessee.

Prior to joining ATA in 1955, Mr. Gatlin was a Marine Aviator and served as a trial attorney with CAA on matters of safety enforcement, including air space and aircraft accident litigation. He is responsible, within the Operations Department, for coordination of all

regulatory
Mr. Gatlin
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With increased implementation of ILS, increased availability of VASI, sensible operating rules, sound ground training, and crew discipline, the problem of approach and landing accidents can be greatly reduced.

Action should be taken in the following areas:

- Vertical guidance is needed at all runway ends normally used by scheduled airline jets.
- All runways normally used by scheduled airlines which do not have ILS glide slope information should be provided with visual approach slope indicators (VASI).
- Category II and III (III-A) facilities should be implemented.
- In pursuit of the recommendations of RTCA SC-117 and the National Plan for Development, the Microwave Landing System should be implemented.
- A study should be conducted into the need for, and value of, curved approach and departure paths.
- There should be but a single transition from ILS to whatever new system is decided upon.
- The minimums for nonprecision instrument approaches should not be increased.
- There is a need for greater pilot discipline (human factors) in adhering to procedures and operating techniques.

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Captain J. L. DeCelles . . Trans World Airlines
ALPA All-Weather Committee
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regulatory matters on behalf of ATA member airlines. Mr. Gatlin holds both a BA and LLB degree from Vanderbilt University and is a member of the Tennessee Bar Association.

A pilot for more than 30 years, Captain DeCelles served with the Troop Carrier Command during World War II and since 1945, has been employed as a pilot with an international airline. Captain DeCelles has served as Chairman of the ALPA All-Weather Flying Committee since 1969. He was the recipient of the ALPA Air Safety Award in 1960.

In certain conditions of darkness and/or reduced visibility, electronic glide slope guidance is required. If the landing approach is based upon the see-to-land principle, there is a requirement for vertical guidance in the external visual field. These requirements are particularly acute in the presence of very low visibility, darkness, illusory ground lighting patterns and/or windshear.

The concept of MDA/DH is not sufficiently delineated by the FAA for decision-making use by the air carrier pilot; nor has the FAA published a formula for rational calculation of DH. The visibility minima currently specified by the FAA are not compatible with the requirement for vertical guidance during descent below DH and, when actually encountered, require excessive rates of descent from MDA. Although the FAA concedes that approach lights do not provide vertical guidance, its regulations permit descent below MDA/DH with nothing in view except approach lights. Crew coordination procedures in general practice make no provision for continuous monitoring of electronic guidance and other pertinent instrumentation after visual contact with the approach lighting system has been established.

The Air Line Pilots Association supports NTSB recommendations that the pilot flying the aircraft be required to monitor the instruments continuously until the runway has been called in view.

Accident and incident experience – particularly with high performance aircraft – indicates a requirement for terrain warning equipment. The FAA contention that strict adherence to prescribed procedures is an adequate safeguard against inadverent descent through minimum safe instrument altitude is not consistent with either the realities of human nature and other factors, or with the FAA's own regulation requiring altitude alerting equipment as a safeguard against deviations from cruising altitude.

FAA criteria for nonvisual landing are predicated upon a single, highly reliable electronic guidance system. ALPA believes that unless it is proved possible to provide virtually infallible approach, flare, decrab and roll-out guidance with a single system, pilot verification by reference to an independent, generically different, redundant guidance system will be required.

It is the opinion of the ALPA All Weather Flying Committee that U.S. airline pilots will not accept a nonvisual approach philosophy relegating them to the task of monitoring the automatic landing by reference to instrumentation which is inadequate for manual landing. Only a situation display of "raw" guidance data projected in the windshield area (HUD) and used routinely on visual landings, can build and maintain pilot confidence and competence in the use of a similar display to monitor or manually perform landings in nonvisual conditions.

The following areas were identified as needing action:

- Accelerate the installation of ILS localizer and glide slope systems on all runways used by air carrier aircraft.
- Install ground-based VASI on an accelerated basis on *all* runways used by air carrier jets or, in the preferable alternative, require installation of "airborne VASI" (i.e., VFR heads up displays (HUD) in air carrier jets).
- Develop and publish a rational formula for establishing decision height.
- Determine the minimum visual reference capable of providing adequate vertical guidance in reduced visibility and/or darkness, with special consideration of the illusory effects and flightpath control problems which can be caused by windshear and/or certain ground lighting patterns.
- Pending development of a rational decision height formula and determination of the minimum adequate visual reference, prohibit descent below DH unless the runway is in view, and establish DH at least 50 feet above the minimum level to which descent can safely be continued on instruments without a decision to land – making proper allowance for the height of obstacles, for altimeter system error and for the height loss which may be expected after a decision to abort the approach.
- Increase visibility minima sufficiently to assure that the runway will be in view at the DH specified.
- Require that the pilot flying the aircraft continuously monitor the electronic glide slope and other pertinent flight instruments until the runway has been called in view.
- Where electronic glide slope guidance is not available, provide an electronic "descent fix" at that point where the MDA intercepts the equivalent of a 3° descent path leading to the aiming point on the runway.
- Prohibit descent below MDA until the descent fix has been reached and the runway is in view.
- Increase visibility minima to assure that the runway will be in view at the descent fix.
- Require installation of suitable terrain warning equipment on all air carrier jets.
- Require redundant, generically different electronic guidance signal systems for nonvisual landings.
- Require heads-up display of electronic guidance for nonvisual landing.
- Require ASDE at all air carrier airports as a condition for authorizing visibility minima lower than ¾ mile (RVR 4,000) for either landing or takeoff.

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Mr. Ralph F. Nelson . . . . Executive Vice President
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4650 East West Highway
Bethesda, Maryland

As Executive Vice President of the AOPA, Mr. Nelson directs all safety and training programs for the organiza-

Windsocks at uncontrolled airports are often not properly positioned or visible; this has resulted in downwind landings, landings on the wrong runway, and unnecessary crosswind landings.

A substantial number of stall spin accidents are also attributed to this lack of wind information.

Standardization of traffic patterns at uncontrolled airports will alleviate the threat of midair collision during approach and landing operations.

VASI systems would eliminate the incidence of descents below safe approach slopes at airports. Meetings with the FAA may bring changes in the TERPS criteria for nonprecision approaches to cover the gap between MDA and touchdown. VASI would supplement the sometimes marginal cues available during low visibility approaches, as would omnidirectional strobe light runway alignment indicator lighting systems.

A number of incompatible microwave landing systems are being installed at airports by private companies and State Aeronautics Commissions without the benefit of FAA standards.

Unicom (122.8 MHz) is crowded and often unusable; therefore, 122.0 MHz should be used to report aircraft position in the traffic pattern of uncontrolled airports. Additional unicom frequency acquisition is recommended.

Another causal factor in approach and landing accidents is the pilot's unfamiliarity with operational characteristics and performance data of different aircraft. Standardization of aircraft manuals would aid in providing better information. Scan training should be expanded and made available to all pilots. Stall/spin demonstration or practice training would make safer pilots.

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tion. Such programs include flight training clinics and special refresher courses for airmen throughout the country. Mr. Nelson is also Executive Vice President of the AOPA Air Safety Foundation and responsible for AOPA liaison in Washington. He is the recipient of numerous awards and a member of various professional societies.

The following areas require action:

- Standardize location and size of windsocks at all uncontrolled airports.
- Evaluate methods of collision avoidance in traffic patterns of uncontrolled airports with special emphasis on standardization of traffic patterns.
- Install VASI systems on primary runways.
- Develop standards for a microwave landing system.
- Develop standards for obstacle hazards within approach zones.
- Standardize aircraft manuals.
- Require stall/spin training for private pilot license requirements.

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Dr. Richard L. Masters . . Department of Aerospace and Environmental Medicine
Lovelace Foundation
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Albuquerque, New Mexico

Preliminary details from an analysis of accidents in U.S. air carrier turbojet and turbofan operations from 1958 through 1970 are presented with assigned causes involving pilot/human error. Ten critical elements that occurred prior to the accidents are defined as causal elements, attributes, events, or conditions which significantly contributed to, or were related to,

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Dr. Masters heads the Department of Aerospace and Environmental Medicine for the Lovelace Foundation. He also serves as a consultant to various governmental, industrial and educational organizations. Previously with the U.S. Air Force Medical Corps, he served in various assignments including Chief of Aerospace Medicine, Director of Life Support and Chief Flight Surgeon at Edwards AFB, California. Dr. Masters is a member of various professional societies, the recipient of numerous awards and the author of many professional publications.

the occurrence of the accident. These elements are listed for each accident under *man, machine,* or *environment* headings, and are empirically subdivided.

Critical decisions made prior to the accident are similarly treated and analyzed.

A matrix for cluster analysis is developed and data are entered for cluster analysis and pattern recognition. The hypothesis is that the data being collected can be classified and sorted into clusters or sets of hierarchical categories. These techniques attempt to show interrelationships of accidents as well as variables studied.

A sample of 25 approach and landing accidents provide trends in the critical element analysis of this study. Of 197 critical elements cataloged, 117 are grouped under the general category "man," 12 under "machine," and 68 under "environment." Within the "man" category, the element occurring most frequently is crew coordination (38.5%), e.g., contingencies arising out of role ambiguity developing between pilot and copilot whose experience levels are, for all practical purposes, equal.

Research requirements must be defined and organized to provide a holistic approach to the prevention and elimination of human error aircraft accidents. The model developed is expected to have applicability to all aircraft accidents, thus identifying further research needs.

An attempt is made to arrive at a generalized model which defines the relationship of critical events on a time scale prior to the occurrence of the accident, and which may provide the basis for further requirements arising from human error related accidents.

This research is directed towards the identification of commonalities occurring in human error related accidents using three analytical techniques:

- Critical Element-Analysis
- Critical Decisions Analysis
- Cluster Analysis/Pattern Recognition

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Mr. Lawrence L. Burian

Assistant Executive Director
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About 70 percent of all accidents occur during some part of takeoff and landing operations. Most occur in the approach and landing regime of flight. Management is a contributing factor in the causes of these accidents. A reemphasis on the conduct and management of the flight syllabus is urged. The safety record may be improved by recognizing and overcoming deficiencies in the area of flight operations management. The need for improvements in flight operations management is evident in the following:

- Excessive workload of CFI's due to inadequate economic or management resources.
- Inadequately prepared students endorsed for solo flights.
- Aircraft inadequately equipped for the type of flight given to students.
- Inadequate checkout of pilots on more sophisticated equipment.
- Aircraft rented to pilots who are not qualified for the intended flight environment.

Management, which controls the design and ultimate use of the machine, can influence man's knowledge and respect for the machine.

Lack of knowledge of FAR's and aerodynamics is a controllable factor contributing to accidents, as is the proficiency level of the nonprofessional pilot. Stall-spin accidents are the primary cause of general aviation fatalities.

Prior to joining NPA, Mr. Burian was engaged in various commercial flying operations and served as a certificated flight and ground instructor in a number of college projects. In addition to his activities with the NPA, Mr. Burian also serves as an FAA designated Accident Prevention Counselor.

Action needs to be taken in the following areas:

- Recurrent flight training should be made mandatory.
- Ground school instruction should be improved.
- Training should be expanded.
- The Flight Test Guide should be reviewed with an eye towards improvement and expansion.
- More staffing and funding should be given to the general aviation accident prevention program.

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Mr. Heber J. Badger . . . . Chief, Safety and Airworthiness
The Boeing Company
Box 3707
Seattle, Washington

Much can be done with the present technology, and at relatively low expenditure of money, to give the pilot better tools for safer approaches and landings. Priority should be given to installing ILS's on all runways in use and approach lighting at a maximum number of airports; secondly, aircraft should be equipped with Ground Proximity Warning Systems.

There is a need for the following ground equipment: ILS-type aids at both ends of all normally used runways; top of descent fixes; more thorough radar coverage; more VASI's; and standard approach and threshold lighting.

There is a need for the following airborne equipment: ground proximity warning equipment; filtered ILS; control wheel steering autopilot; and area navigation.

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Mr. Roy Christiansen . . . Senior Product Manager
Sundstrand Data Control
Overlake Industrial Park
Redmond, Washington

In the past 20 years, over 150 commercial aircraft approach and landing accidents and an untold number of incidents have occurred in VFR conditions where the pilot, or crew, had the runway in sight during approach. These aircraft touched down disastrously short or long with respect to the touchdown zone, or hard enough to cause major structural damage or injury. Approximately 1,000 lives were lost, and financial losses to airplane hulls totalling more than $75 million were incurred in these accidents. Examination of the initial and final approach flight profiles and conditions of these accidents reveals certain key characteristics. Although aircraft and crews were airworthy, pilot error was often noted as a probable cause. Eighty-three percent of the accidents occurred in night VFR conditions; the other 17 percent occurred during the daytime, often in dusk or conditions of darkness. Generally, there were one or two minor distractions in the cockpit. Some occurred with a VASI and/or ILS system installed and operating.

Since joining the Boeing Company in 1961, Mr. Badger has held many engineering management posts including both the TFX and SST programs. A graduate of the U.S. Naval Academy, Mr. Badger served as a carrier aviator and test pilot with the Navy Test Pilot School. He is a former Director of the Naval Test Center at Patuxent River, Maryland.

A graduate of Lehigh University, Mr. Christiansen holds a BSME degree. Since joining Sundstrand, he has specialized in stall warning and auto throttle systems as well as flight data and cockpit voice recorders. Prior to joining Sundstrand, Mr. Christiansen was employed by Talley Industries and Hamilton Standard as a field engineer on fuel control, jet engine starters and powerplants.

It is apparent that an instrument displaying the actual visual approach slope to the runway aiming point would have been helpful. This information would answer the question for the pilot "where am I?" with respect to the runway touchdown zone. It is apparent that a display of the ground velocity vector of the airplane would have been helpful in approximately one-third of the situations where an unnoticed increase in sink rate or windshear occurred. This information would answer the question for the pilot "where am I going?" with respect to the runway.

The Visual Approach Monitor was designed to display, in a heads-up format, approach angle and flightpath bar on the runway touchdown zone. The pilot will bring the aircraft to the proper point on the touchdown zone at the proper flight path angle regardless of whether the approach is initiated high, on the proper glide slope, or low. The Visual Approach Monitor thereby helps the pilot prevent the short, long, or excessively hard landing. All air carrier aircraft that have occasion to make VFR approaches and landings should be equipped with a Visual Approach Monitor.

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Mr. David Graham . . . . . Assistant Director General,
Civil Aviation Department
Melbourne, Australia

In matters of safety, communication of accurate and pertinent data is essential. The incident reporting system in Australia is essentially voluntary on the part of pilots and operators and involves a high degree immunity from punitive or enforcement action. Information so obtained is used solely for safety improvement.

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Mr. John S. Leak . . . . . . Technical Advisor to USAF
Director of Aerospace Safety, USAF
Norton, AFB, California

Mr. Leak stated that the United States Air Force has the same problem all other aviation community segments have: the approach and landing hazard.

An analysis of approach and landing accidents from 1965 through July 1972 showed pilot error to be the primary causal factor, as expected, but other causal elements, such as fire warning lights, and failure of systems, prevented clear insight into the factors underlying pilot error.

Seventy-two percent of the approach accidents had clearly defined extrinsic contributing factors in one or more of the following categories:

- Lighting and markings of runway environment
- Other airfield hazards
- Terrain hazards
- General information
- Weather information
- Factor of control
- Mission essentially

Control, an extrinsic factor present in 32 percent of the accidents, was the highest of the seven categories. Weather information and general information factors together equalled 32 percent. This, surprisingly, exceeded the actual physical hazards (25 percent).

These extrinsic factors, tabulated under "Conclusions," showed the principal extrinsic

Previously, Mr. Leak was Chief, Technical Service Branch, Bureau of Safety, CAB. He has held positions in aerodynamics engineering in both the missile and aircraft industries. His present duties include all functional safety areas in the USAF. Mr. Leak is the author of numerous technical articles related to aviation safety.

element underlying pilot error to be a lack of communication. Better communication (information) is needed during instrument oriented approaches in which the pilot relies on others and their available information more than during any other flight regime.

More emphasis should be given to the communications problem as an aspect of the decision-making process.

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Mr. Raymond S. Baran . . Technical Procedures Specialist, Air Traffic Control Association
Suite 409, Araba Building
525 School Street
Washington, D.C.

All of the terminal airspace actions procedures, and rules which have been implemented within the past 10 years were devised for the specific purpose of decreasing the midair collision factor in terminal airspace. All of the terminal airspace actions taken prior to the establishment of Terminal Control Areas (TCA) achieved their individual goals; however, they fell short of total safety because they did not prohibit the unknown aircraft from operating within the same airspace used by controlled aircraft. The only positive method of minimizing the midair collision problem in terminal areas is to control both VFR and IFR flights at all airports during their transition from an enroute envelope to the landing phase of flight. The "see-and-avoid" concept of VFR flight during the approach and departures phase of flight is questionable because of sheer traffic volume and increased cockpit duties.

The following actions need to be taken:

- Revise the Federal Aviation Regulations to incorporate Airport Traffic Areas with Control Zones.
- Revise the Federal Aviation Regulations to relinquish pilot visibility observations to the official reporting station for a control zone.
- Revise the Federal Aviation Regulations to increase the present visibility requirements for VFR from 3 to 5 miles in control and transition areas.
- Revise the Federal Aviation Regulations to prohibit the use of instrument approach aids within a control zone unless an ATC clearance is obtained.

Prior to his assignment at the Great Lakes Region, Mr. Baran was with the Operations and Procedures Division, FAA, Washington, D.C. Responsibilities included Air Traffic representation on the Wake Turbulence Committee which devised the present criteria for separation behind heavy jets. Mr. Baran has also served as an Air Traffic Control Specialist at O'Hare and Midway Towers in Chicago, Illinois.

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Mr. Robert Poli . . . . Executive Vice President
Professional Air Traffic Controllers Organization,
Suite 214 2100 "M" Street, N.W.
Washington, D.C.

Although improvements have been made over the years in the ATC system, many more should be made to obtain a viable system.

Collision avoidance systems may well result in more midair collisions than they are designed to prevent.

FAA has initiated programs to enhance safety of aircraft operating in terminal control areas such, as: TCA; expanded radar service; "Keep 'em high" policy; and Automatic Radar Tracking Systems.

Prior to his election as a National Officer of PATCO, Mr. Poli served as a radar air traffic controller in the Cleveland Air Route Traffic Control Center. Mr. Poli's record as an air traffic controller is marked by numerous citations and meritorious service awards from the FAA.

There will never be a completely safe air traffic control system unless general aviation is brought under the same controls as the air carriers. Only 20 percent of the approaches and 40 percent of the takeoffs are under positive control.

The greatest hazard today is a recurrence of manpower shortages, excessive workloads, and, the author believes, a complete disdain for the system by the air traffic controllers. Terminal facilities are drastically understaffed whereas the aviation industry is growing at an alarming rate. Additional funds should be made available to insure a sufficient flow of new controllers into the system.

The following things need to be accomplished:

- Bring general aviation under the same ATC controls as the air carriers.
- More manpower at terminal ATC facilities.
- Additional funds be made available for this purpose.

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Mr. Richard H. Jones . . . Farrell & Jones Attorneys
General Aviation Building
Washington National Airport
Washington, D.C.

Summaries of a number of recent civil court findings were presented concerning the legal responsibilities of both operators and air traffic controllers to provide precautionary and avoidance action with regard to wake vortex turbulence generated in terminal areas.

Whereas some shift away from the pilot's ultimate responsibility theory had been evident, recent civil cases have reaffirmed pilot responsibility for avoidance and caution. Courts have tended, for a brief recent period, to hold the controllers responsible, but this trend is now reversing.

- Pilots must be further educated regarding the dangers of wake turbulence.
- Controllers must act aggressively and affirmatively in their exercise of good judgment when giving pilots warnings concerning wake turbulence.

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Captain A. V. Appelget . . Director
Flight Standards
Eastern Air Lines, Inc.
Miami, Florida

There is a common problem of discipline, technology, hardware and economics. More attention must be paid to planning the flight in its entirety in order to expect a satisfactory approach and landing. This includes many things, such as, establishment of the center of gravity (c.g.) as well as the condition of the tires and anti-skid system. The compatibility of airplane and airport is also important in that a buffer should be provided between certification requirements and the pilot/airplane capability. Compatible alternatives should be chosen.

Coordination with the ground-based facilities in case of emergencies is of utmost importance. Pilot training, coordination and discipline are as important as the satisfactory condition of the

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Captain Jones is currently employed by one of the major air carriers as a pilot. He is a graduate of Virginia Polytechnic Institute and American University with a BS and LLB degree. Captain Jones has served as a member of the Virginia Advisory Committee and President of the Bar Association of Airline Pilots. Legal specialization includes aircraft accident neglience litigation and NTSB enforcement proceedings.

Captain Appelget's flying experience extends back 38 years, the last 33 years with Eastern Air Lines, 16 years in management. He has participated in the introduction of each of the last several generation of aircraft in the EAL fleet. He provided operational input and guidance for the development of computerized flight plans. In recent years, Captain Appelget has participated in ATA and FAA liaison with respect to air safety, training, and noise abatement.

airport facilities. A margin of safety should be maintained between the FAR minimum runway requirements and the aircraft/pilot capabilities.

Choice of a weather alternate should be made with certain conditions such as traffic density and saturation of facilities uppermost in mind.

Crews should be thoroughly drilled in their ability to handle system failures enroute, and should be encouraged to make use of ground-based facilities by radio or phone patch in obtaining assistance. In like manner, the experience of other pilots, specialists in system maintenance, and the manufacturer may be used.

All instrument or contact approaches should be an nearly alike as possible. This could develop a habit pattern and behavior to which the pilot would revert automatically in unusual circumstances.

Good performance, good teamwork, and good results can best be assured by capable and authoritative line management and check pilots. The safety record of an airline rests on the quality of their work.

It was advocated that:

- More attention be devoted to training of personnel, including line personnel and dispatchers as well as pilots.
- Crew coordination and discipline be stressed.
- VASI's be installed at airports.
- Standardization of operations be stressed.

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Captain Walter P. Moran . Director Flight Training
American Airlines
Greater Southwest International Airport
Fort Worth, Texas

Visual simulation can expose the trainee to all combinations to real world conditions and continue repetitive exercises until the attainment of the needed proficiency. Training can be accomplished at any time of day and in any type of weather.

A slide presentation was given on the use of visual simulation in the training of pilots for the approach and landing phase of flight.

Increased use of modern simulators with visual systems was recommended since the many precise disciplines of the approach and landing flight regime may be duplicated, stopped, backed up, and reinitiated.

The aircraft cockpit can be duplicated, and motion cues, control forces, etc., can be introduced, as well as all types of weather conditions and visual outside cues.

Drills may be facilitated by problem freezing, spatial repositioning, play back, and malfunction simulation.

Hazardous condition trend recognition and crew coordination are also facilitated.

There should be increased use of visual simulators in training pilots to the proficiency levels demanded for the approach and landing phase of flight.

A Captain with American Airlines for 29 years, Captain Moran has also served as a Flight Test Pilot, a Flight Instructor and Flight Superintendent. Actively engaged in new techniques of flight instruction using simulators, Captain Moran received the De Florez Training Award in 1971 for his pioneering efforts in the utilization of flight simulation to increase safety in airlines flight training.

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Captain W. L. Thomas . . Director, Flight Training
United Air Lines
Stapleton Int'l Airport
Denver, Colorado

Accidents and incidents have occurred during low visibility approaches because of excursions from the desired approach path resulting when both pilots were simultaneously looking outside

Captain Thomas has been a UAL pilot since 1945 and assumed the position of Flight Manager at Chicago in 1965. The following year, he was named fleet manager for the DC-8 at UAL's executive headquarters. Captain Thomas attended Northern Michigan College of Education before serving in the Army Air Corps during World War II as a B-24 pilot in the Southwest Pacific.

the aircraft. The obvious answer is that one pilot monitor the flight instruments for out-of-parameter excursions while the other looks outside for visual cues. A high degree of self-discipline, training, checking, and supervision is necessary to assure compliance and standardization.

A major contribution to accidents and incidents associated with the approach and landing phase of flight has been the fact that both pilots were simultaneously looking outside the cockpit.

The adequacy of cockpit procedures was investigated. Discussions with the Pilot Factors Program (PIFAX) participants from the U.S. Air Force, and analysis of actual trial runs of Category II and III approaches, convinced United Air Lines to change their cockpit procedures and require the copilot to monitor the flight instruments throughout the approach, including that portion below decision height to touchdown and roll-out or go-around.

The new procedure was evaluated in over 50 approaches in a visual simulator flown by six line crewmembers and four managers. All managers and five of the six crewmembers judged the new procedure to be a superior for approach and landing.

The new procedure calls for the captain to fly the approach when weather is below 4,000 feet RVR, or ceiling 300 feet and ¾ mile visibility. They also call for indicating: Target speed setting variations; 1,000 feet above airport elevation and flight instruments check; 500 feet above field elevation; course displacement errors and airspeed deviations starting 500 feet above field elevation at 100-feet increments; and excessive rates of descent (over 1,000 feet per minute).

Action is needed in the following areas:

- Visual simulators should be used for training and for providing greater crew concepts.
- More VASI's should be installed.
- Emphasis should be placed on cockpit procedures and discipline during the approach phase.

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Captain Paul A. Roitsch . Director, Flight Operations
Technical Services
Pan American World Airways
JFK Int'l Airport
Jamaica, New York

The Pan American World Airways B-747 evaluation program culminated in Visual Approach Monitor (VAM) system certification in the United States by the FAA on April 27, 1972.

The system permits a smooth transition from any aircraft approach angle to a -3° programmed flight path, simply by aligning a single display symbol with the touchdown zone.

The system uses pitch information, barometric sink rate, and ground speed from time (airspeed). From these inputs, a computer determines the correct flight path to achieve the desired descent angle.

The heads-up instrument display projects guidance intelligence on a transparent lens through which the pilot views the intended aiming point on the runway.

The following was suggested:

- The aviation industry should take advantage of the VAM, a landing approach guidance system which has been fully developed and qualified, has achieved FAA certification, and is now in production.
- The aviation industry needs a system to aid the pilot in judging his angle of elevation on approach. There is a greater need for this system when visual cues are degraded or deceptive, such as at night, over water, or approaching sloping terrain. More than 2,500 VAM approaches have been made in

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Captain Roitsch began his aviation career 28 years ago as a Naval Aviator and has been with Pan American for the past 20 years. As Director, Flight Operations Technical Services, his responsibilities include company test flying, the provision of flight techniques and crew procedures, and the evaluation of proposed new aircraft and systems. He was the first airline pilot to be graduated from the U.S. Navy Test Pilot School and the first American to fly the Concorde S.S.T.

a variety of aircraft including B-747, B-727, DC-8 and DC-9. The system is independent of ground based aids.

- At minimum altitude, the captain will adjust his scan pattern to include outside visual cues while the copilot remains on instruments.

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Captain Bert A. Smith . . American Airlines, Inc.
Washington National Airport
Washington, D.C.

The views expressed were entirely his own.

To help prevent accidents resulting from vertical position errors during approach and landing, standard operating practices, including strict adherence to altitude callouts, should be stressed.

Should errors occur anyway, vertical guidance and ground proximity devices can prevent them from becoming catastrophic.

A review of air carrier accidents revealed a diversity of causal factors; however, error of vertical position is nearly always a common denominator.

Elimination of this error of vertical position was thought to be possible through increased flight training and crew standardization. The best safety devices are not procedural but electronic.

Some form of vertical guidance should be made mandatory for air carrier operations, and radio altimeters should be made mandatory and used for ground proximity warning devices.

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Captain Smith began his pilot career in the USAF as a SAC fighter pilot and instrument instructor pilot. He joined American Airlines in 1956 and was promoted to Captain in 1966. With more than 13,000 flight hours, Captain Smith has accomplished considerable research into the flight characteristics of modern aircraft. He is the author of numerous technical articles.

Mr. E. King Stodola . . . . Syracuse University
Syracuse, New York

The following observations were made:

- A more precise system is required for the pilot to follow after he reaches MDA.
- There is no particular manner of making a descent to MDA from the final approach fix (FAF). A fairly rapid descent is often used which tends to give the pilot a maximum opportunity for visual observation.
- Rapid descents from initial fix to MDA put the pilot in position for a much longer, shallower approach (as low as ½°) before final descent to runway.
- Pilot ability to establish a proper angle by strictly visual means is limited.
- At night, the pilot sees the runway light outline, but its appearance is a complicated function of the field dimensions and pilot position.
- The pilot needs one or more definite points along the approach at which altitude minimums are to be observed.
- The key-point fix could be a 75 MHz radio marker.
- Program for installing radio markers is developing, however, they are not required for use in the visual phase of landing.
- Navigation systems and procedures are complex and require personnel specialization. This leads to the involvement of many people in writing published instructions, with neglect, sometimes, of a comprehensive overall review.
- There is a danger of incorrect or misleading written material reaching pilots.

A consultant on operational and technical problems in aviation, Mr. Stodola is now on the research staff of Syracuse University Research Corporation, and was formerly Chief Scientist for the Electronic Division of Dynamics Corporation. Mr. Stodola has had 35 years experience in design development, and the application of radio, radar and control systems. He holds an EE degree from Cooper Union, a commercial pilot certificate, and is a fellow of the Institute of Electronic and Electrical Engineer.

- Systematic means should be developed to detect and correct offending material.

Normal approaches are made by crossing initial fixes and intercepting altitudes. The aircraft is then aligned with a radial by radio aid and descent is conducted to MDA. The pilot then is required to obtain visual contact with the runway environment, complete the descent, and land by visual means.

Something is needed to indicate to the pilot how far along the flight path he has progressed; he should not start his final descent – even though he has broken out in the clear – until he has reached a fix that will assure him terrain clearance.

A system is needed to review written or published procedural information continuously so that the pilot always has proper and up to date material at hand.

Another excellent safety device is the radio altimeter. Its use should be made mandatory, and it should be redesigned so that noncancellable tone or a distinctive pitch will sound in the cockpit whenever the aircraft passes through 300 feet above the terrain.

The following conclusions were made:

- Procedures for nonprecision approaches should be modified to include position fixes, visual or radio, for use after visual contact with the runway is achieved.
- Provide for systematic overall review of operational procedures and related matter to detect and correct published material which may result in hazardous operations.

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Mr. Herbert J. Frank . . . President
Aerosonic Corporation
1212 No. Hercules Road
Clearwarer, Florida

Many laboratory tests have proven that during descent, water can be ingested into the static system. The amount of error depends on when and where the test is started. Static system design requirements of FAR Part 25 take into consideration water ingestion by requiring drain traps, drain fittings, and tube routing to alleviate this situation.

Today's jet aircraft has approximately a dozen warning devices to attract the attention of the pilot. The small, single-engine general aviation aircraft has only one or two aural warning devices. Pilots with a minimum experience level in instrument approaches would be especially assisted by a warning device, either visual or aural, to alert them when they have reached the MDA altitude. A device of this type could be the reminder they need to assure a safe approach.

Altimeter readability is also an important problem. Many varied types of presentations are found in today's aircraft. This is especially true in small, twin-engine aircraft which have a dual panel instrument installation. In the majority of these aircraft, the newest and best altimeter is installed in the left side pilot's panel and a minimum requirement type of altimeter in the right side co-pilot's panel. This is strictly a result of economics. The problem with this arrangement shows up when the pilot is on the final leg of a nonprecision approach and attempts to cross-check two completely different altitude presentations.

Another helpful program would be a requirement for all IFR pilots to possess a current experience rating. The purpose of this rating would be to give the airport controller some idea of the pilot's ability to make a precision or nonprecision approach. This appears to have merit since the controller could then assist the pilot with additional information, helpful suggestions, etc.

Mr. Frank has been engaged in the design, development and manufacture of aircraft instruments since 1941. Formerly with the Bendix Corporation, Sperry, and Lackmer Corporations, Mr. Frank has been President of Aerosonic Corporation since 1956. A graduate of California Institute of Technology, he holds a MS degree from the University of Cincinnati. He is currently a multi-engine, instrument rated pilot.

It was concluded that:

- All IFR aircraft should have two altimeters and separate static systems.
- All IFR aircraft should be provided with an aural and visual warning when reaching MDA.
- FAA controllers monitor all instrument approaches and warn pilots when lower limits are exceeded.
- General aviation pilots be given an experience or competence rating of IFR capability.
- Air carrier and general aviation type aircraft approaches should be separated into two categories: high and low-speed.

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Mr. Roderick A. Dennis . Nuclear Ranging and Guidance Landing System (NRGLS)
555 South Trenton
Englewood, Colorado

With regard to dependence on barometric altimetry for approach operations, flight through local "wet" air masses, with a relatively dry air mass altimeter setting, will cause altimeter readings that are higher than actual altitudes. The theory of microlows and their effect on altimetry was discussed.

The system (NRGLS) utilizes a series of calibrated, geographically placed, radioactive sources and gamma-photon detectors to drive solid state circuitry to "localizer" and vertical displays in the cockpit. Precision approach guidance to final flare, zero-zero touchdown and taxi guidance is afforded by a signal which is unaffected by weather and cannot be turned off.

Mr. Dennis has served as a consultant with various companies and is the holder of numerous patents. His familiarity with navigational problems, weather, and his scientific background have lead to several studies related to accident phenomena, causal factors and possible solutions. He is a graduate of Otterbein College with a BS degree in Chemistry, Cornell University, and USNR Midshipman School.

The Nuclear Ranging and Guidance Landing system should be evaluated by the FAA for possible use as an approach system.

Too much emphasis may have been placed on radio type devices for ILS systems. Since World War II, we have learned to handle nuclear devices safely. Nuclear devices are now acceptable energy sources for electrical power generating stations, and it makes good sense to apply the idea to other fields.

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Mr. Lawrence A. Gross . . Engineer, Norden Division
United Aircraft Corporation
Helen St., Norwalk, Conn.

A large number of accidents that occur during approach and landing can be attributed to an altitude error that ultimately results in inadvertent collision with the ground.

Radar altimeter measurements are limited to indicating the height above the terrain directly below the aircraft, which often is not indicative of closure with terrain ahead.

The forward-looking radar altimeter concept is based upon the vertical terrain profile measuring technology that has been accrued during the development of terrain following (TF) radar systems for military applications.

In addition to the basic forward looking sensor, an independent altitude monitor (IAM) concept can provide altitude warning and time-to-touch-down during approach and landing, and an altitude warning during climbout.

Mr. Gross has been associated with Norden since 1966 and is responsible for the formulation of concepts, preliminary system design, and proposal preparation for various radar and display programs. He has had extensive experience with military systems for low level flight and formulation of a forward-looking altimeter concept for civil transport aircraft. Mr. Gross holds a BSEE from Ohio State University.

No estimate of cost and availability was presented. At present, no further development is planned until more interest is generated by the airlines, the FAA, and the NTSB.

Altitude alerting devices which would monitor altitude above the ground along the flightpath and would provide adequate warning of impending ground contact were recommended.

This concept incorporates a new altitude measuring sensor, which can anticipate a hazardous situation regardless of barometric pressure or other external influences.

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Mr. D. Travis Engen . . . . Product Engineer
Bell Aerospace Company
Box 1, Buffalo, N.Y.

The redundancy present in enroute traffic control is not carried into the terminal area. An additional redundant system should be deployed with all ILS/MLS systems permitting ground personnel to monitor and assist all landings made and advise pilots of unsafe conditions caused by equipment misalignments, outage, pilot disorientation, local features, etc., that are not discernible in the cockpit.

An Automatic Aircraft Carrier Landing System was developed for the U.S. Navy in an attempt to reduce their landing accident rate. As operational experience was gained with this system, it became apparent that a means had to be devised to monitor its accuracy. Such an independent monitor was developed and resulted in a significant increase in the safety of landing operations.

Mr. Engen holds a BS degree in Aeronautics and Astronautics from M.I.T. His background includes several years experience with the U.S. Navy Automatic Carrier Landing System as a field engineer for Bell Aerospace. He is currently responsible for marketing activities in the landing systems area, which encompasses the Navy Carrier Landing System as well as FAA Microwave Landing System development.

Because of the absence of functional redundance in the civil terminal area, all evaluation of the progress of an approach is made in the cockpit. This is a highly accident-prone situation which could be alleviated by an independent ground based monitor providing data on the progress of an approach.

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Lt. Col. D. Carmack . . . . United States Air Force
Instrument Flight Center (IFC)
Randolph AFB, Texas

The United States Air Force Instrument Flight Center has made over 300 approaches during the Landing Weather Minimums Investigation of the low visibility flying program. The film shown at the symposium demonstrated some of the approaches. The flights were conducted both at night and during daylight hours. The three modes of operation, capable of use with their T-39 Sabreliner aircraft were: completely automatic ILS coupled to touchdown; and two manual modes, one with altitude stabilization. It was their belief that the pilot should be in the control loop through force wheel steering so his inputs, his inate judgment, and his ability could be used to compensate for certain happenings on final approach such as wind shears, feasible beam bending or scalloping, and other anomalies of the glide slope or localizer.

Lt. Col. Carmack participated in numerous Air Force studies including the Landing Weather Minimums Investigation. This study represents the experiences acquired from more than 300 approaches and landings in visibilities as low as zero-zero. Lt. Col. Carmack also participated in such Air Force studies as Lateral Axis Central Display Requirements, Runway Markings Improvement, and Crew Duties Mode and Function Study. All such studies have been associated with the USAF Instrument Flight Center at Randolph Air Force Base, Texas.

Their test procedure was for the right seat pilot to come "heads-up" at 200 feet above ground level, assess the visual environment, and then, later record his comments on tape. The left seat pilot flew the aircraft and remained "heads-down" all the way through the landing. The right seat pilot made verbal calls to inform the "heads-down" pilot of the information available from the visual environment. If he could ascertain part of the runway environment, he would call "cue." If there was enough information to determine lateral alignment with the runway, he would call "lateral." If there was enough visual information to maintain lateral alignment and flare the aircraft, he would call "visual." On one of the approaches, when the right seat pilot felt that there was enough visual information for him to complete the landing visually, he had the left seat pilot come heads-up. It took the left seat pilot 3 to 4 seconds to accommodate to the outside visual environment.

The following actions are advocated by the USAF Instrument Flight Center: 1,600 feet is the lowest practical visual range that can be assigned to a decision height of 100 feet; the pilot should be provided access to the control loop through force (control) wheel steering; the present system of runway markings is inadequate for any landings below Category I; and a new guidance system will be required for Category II and III operations. The Center supports the microwave system.

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Mr. David J. Wilson, Jr. . . Lockheed Missiles and Space Company
Huntsville Engineering & Research Center
Huntsville, Alabama

The encounter by light aircraft with wake vortices generated by heavy aircraft can be disastrous. This hazard has been emphasized by 128 general aviation accidents and one air carrier accident which were attributed to wake turbulence.

The FAA has implemented increased separation criteria for aircraft. This increased separation has decreased the rush hour capacity of major air terminals and with traffic predicted to double in the next 10 years, a wake vortex avoidance system is a must. For several wake vortex avoidance options, the "Predictive-Detective Concept" is listed as the best. This system uses forecast meteorological data together with information from vortex sensors to locate and track vortex cores. Aircraft can then be spaced in arriving and departing lanes more efficiently and safely.

Mr. Wilson advocated that a wake vortex avoidance system should be installed at existing air terminals.

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Mr. Anthony J. Mule' . . . Safe Flight Instrument Corporation
White Plains, New York

Mr. Wilson received his BS degree in Engineering Physics from Auburn University and his MS in Electrical Engineering from Stanford University. His first assignment with the Lockheed Missiles and Space Company was in the development of Atmospheric Sensing Systems. He later became involved in the development of laser Doppler instrumentation for remotely monitoring wing velocities. Since 1970, Mr. Wilson has been project engineer for development of detective and predictive systems for wake vortex avoidance in the air terminal area.

Mr. Mule' joined Safe Flight Instrument Corporation in 1971 as Director of Marketing. He has placed heavy emphasis on the critical need in General Aviation for Speed Control indicators based on angle-of-attack. He was employed by Kollsman Instrument Corporation for 13 years in various supervisory positions, including Product Manager for Air Data Computers and General Sales Manager for the Avionics Division. Mr. Mule' obtained his BSEE from the Polytechnic Institute of Brooklyn.

At least eighty percent of general aviation aircraft flying today have wing-mounted angle-of-attack sensors for stall warning.

Fourteen percent of all general aviation accidents are the result of stalls.

Twenty four percent of general aviation fatalities are attributable to those accidents resulting from a stall.

Statistics indicate that in certain very common flight situations (i.e., while banking rapidly during the approach to the stall,) the stall warning horn blows; but before the pilot reacts, the airplane has stalled. If the aircraft had a visual stall trend indicator, based on angle-of-attack, the pilot would see his approach to the stall before the warning horn blows.

Angle-of-attack indicators, driven by wing mounted sensors, give indications of stall regardless of gross weight, air density, flap/gear configuration, wing loading, or turbulence variations.

Mr. Mule made the following conclusions:

- All aircraft owners should have their pre-stall warning system checked to assure proper calibration and operation.
- Assure that all pilot training facilities make students aware of angle-of-attack and its critical relationship to stall.
- All Certificated Flight Instructor's (CFI) constantly alert students to understand and react to the term "Angle-of-Attack."
- Have every general aviation aircraft equipped with a visual type angle-of-attack stall warning indicator which provides a continuous indication of where stall is and instantaneous trend toward or away from it.

ANALYSIS

The National Transportation Safety Board reviewed the papers and summaries of each participant in the Approach and Landing Accident Prevention Forum, as well as other papers submitted by nonparticipants. Analyses of this information and other data, reports, and accident statistics related to approach and landing accidents, indicate four main areas of concern:

Approach and Landing Guidance,
Human Performance,
Management, and
Environmental Aspects.

Approach and Landing Guidance

The history of approach and landing accidents indicates a need for vertical guidance assistance to crewmembers to facilitate and improve the safety of IFR and VFR operations. Nine significantly hazardous areas were discussed by participants during the Forum.

Three-Dimensional Area Navigation

Three-dimensional area navigation, which can contribute to more orderly and efficient operation of air traffic, offers a potential in approach and landing guidance. However, as the area navigation route structure evolves, problems associated with VOR, airborne equipment accuracy, and their integration with air traffic control facilities will have to be soh u.

A critical-event, system-hazard lysis has not been undertaken. Proliferation of such a system without clear definition and identification of inherent potential hazards and the means to prevent them could result in the creation of serious environmental airspace hazards.

Cockpit Vertical Guidance Displays

Cockpit vertical guidance displays provide vertical guidance control information that can be used during the visual segment of a see-to-land approach. It aids visual approaches, particularly, because it enhances precision height control during overwater approaches. The system which consists of airborne equipment, is an operational scheme that provides visual cues for vertical guidance under visual conditions. Several systems of this type are operational.

Altitude-Warning/Alerting Devices

The Board believes that air carrier training departments, aviation simulator training organizations, and certificated flight instructors should stress understanding and use of altitude-alerting devices and radio altimeter systems and their limitations. Only then can crewmembers use these systems to their fullest capability.

The Board supported the requirement for altitude alerting devices as a means of preventing an unintentional descent below minimum safe altitudes, especially in the descent and approach phases of flight. Such a requirement has not been implemented.

As a result of several recent accidents and incidents which involved nonprecision approaches, Board investigators observed the use of altitude alerting devices by various air carriers. The following observations were made: (1) Altitude-alerting devices for terrain avoidance or MDA warning were not used by the carriers observed. (2) Flightcrews were not well trained in the use and operation of altitude alerting equipment. (3) Flightcrews were unaware of the operational limitations of altitude warning equipment. (4) Crewmembers complained that audio- and-visual alerting systems associated with altitude alerting devices were distracting, and, thereby, nullified these warnings.

Terrain-Proximity Warning Devices

Altitude awareness is an old aviation problem. With the advent of high-performance airplanes and the continued use of low-level, nonprecision IFR-approach operations, a need exists for an integrated-system approach which is aimed at a terrain-proximity warning device. The device should warn crewmembers of potentially dangerous flight profiles that result from combinations of altitude, sink rate, and terrain shape. Appropriate operational procedures and training standards should be devised for this device.

During the investigation of many nonprecision approach accidents in which crewmembers survived, the Board found that the crew's lack of altitude awareness caused, or contributed to, the accident. Many of these crewmembers indicated that they were unaware of their altitude until late in the approach sequence. As a result, the Board has recommended to the FAA that a terrain-proximity warning device be developed along with appropriate operational procedures for its use. Such a device is being manufactured and installed on many new wide-bodied jets, particularly, those being delivered to foreign air carriers.

Such a device--when integrated with equipment already installed on commercial aircraft—gives crewmembers advance notice of unsafe flightpaths relative to the ground, which could help reduce the losses which result from accidents that occur during nonprecision approaches.

Terminal Instrument Procedures (TERPS)

There has been controversy over certain parts of TERPS. The controversy involved visibility minima, the establishment of descent fixes, the definition of DH and MDA, and other procedures.

The FAA has been holding Government and industry meetings to formulate proposed revisions of portions of TERPS. Notices of Proposed Rulemaking are anticipated on this subject in the near future.

Two-Segment Approach

The two-segment approach has been introduced essentially as a noise-abatement procedure. This approach entails keeping aircraft at high altitudes until they are vectored nearer to the terminal area, and then, bringing the aircraft down from steeper glide slope angles to the normal glide slope for the final approach to the airport.

The two-segment approach is a marked departure from approach and landing techniques used previously.

ILS Performance and Improvement Plan

Landing systems were first developed because of World War II. The unfavorable weather conditions in Western Europe hindered fighter and bomber operations. As a result, ground-controlled approach (GCA) radar was developed, which did not require "onboard" equipment or pilot display. Concurrently, a very high frequency (VHF) instrument-landing system (ILS) was being developed. This system required airborne receivers, pilot displays, and elaborate ground facilities.

During the past 20 years, the ILS system has been improved and is now intended to meet the needs for Category I and II requirements. In addition, manufacturers of ILS equipment are designing Category III-ILS applications and are evaluating performance at experimental facilities.

Several participants at the Forum thought that ILS equipment should be provided at all airports which have scheduled airline service. These participants stated that all runways which do not have ILS glide slope information should be provided with visual approach slope indicators (VASI).

The spokesman for the Air Transport Association of America (ATA) stated that airlines oppose the inclusion of additional, nonstandard landing systems into FAR Part 171, and added:

> "Where specialized, nonstandard landing systems must be used to meet special requirements, such as the inability to site ILS at a reasonable cost, prolonged delay in ILS installation, or special STOL/VTOL needs, FAA should make clear that authorization to use such systems is temporary until ILS can be installed or appropriate versions of the universal microwave landing system can be made available."

A recent report, prepared by MITRE Corporation for the FAA's Office of Systems Engineering Management, describes an overall plan of action, including Research and Development and coordination activities, for improving ILS performance at existing and future Category I, II, and III sites throughout the United States. The report and other information indicate that the FAA is committed to support Category II service with conventional ILS equipment at approximately 74 U.S. sites by 1976. Fifty-three of these sites have been designated. In October, 1972, there were only 19 full or partial Category II runways on only 18 airports.

The magnitude and extent of current and anticipated ILS problems associated with the proposed Category II sites are considerable. Obviously, if there are problems confronting Category II applications, more serious constraints are applicable to the Category III situation, particularly if present and future ILS-equipped sites are intended to be used for Category III operations.

The problems with ILS improvement which confront the FAA are associated with siting and developing. Siting problems involve design for terrain irregularities, snow cover conditions, reflections from hangars and other structures, taxiing and overflying aircraft, and localizer coverage along the runway. In addition to these problems, other problems include development of improved localizer and glide slope antenna and monitoring equipment.

There are now 35 Category II problem sites which affect 37 runways. There are problems associated with terrain features, building profiles, and antenna arrays—all of which need to be evaluated in order to make decisions as to the feasibility of various ILS antenna configurations. These problems must be eliminated to achieve desired Category II performance at the sites already scheduled for the system.

Several participants at the Forum thought that the development of automated landing systems, the fallacies of the see-to-land concept, the infrequency of Category II minimum weather conditions, and the lack of confidence in the present ILS system for meeting Category III standards support the need for a new guidance system for Category III-type operations.

Microwave Landing System (MLS), Nuclear Guidance, and Automatic PAR

To increase airport and airway system capacity and to provide a landing system which would not be adversely affected by weather, terrain, structures, and other aircraft; the FAA has begun a national program to develop a new, common, civil/military aircraft approach and landing system known as Microwave Landing System (MLS). This is an air-derived data system which operates at microwave frequencies much higher than the VHF/ILS. The performance qualities of MLS as an approach and landing aid exceed those of the VHF/ILS system in both accuracy and flexibility. The MLS system is not subject to environmental interference from sources such as hangars, airborne or taxiing aircraft, or irregular topography.

According to FAA reports on all-weather landing capabilities of U.S. civil aviation and according to the views of several participants in the Forum, all-weather landings will require substantial improvements in the integrity and reliability of guidance systems and aircraft flight-control systems.

The MLS system scheduled for initial operation in 1977, will be designed to provide service until at least 2000.

The FAA all-weather landing development plan indicates that the transition from ILS to MLS will be a slow process, which will extend at least 10 years beyond the date on which the first MLS is operational. Therefore, it will probably be 1988 or 1990 before VHF/ILS systems start to phase out. Under these circumstances, considerable improvements and modifications to VHF/ILS systems will be needed to enhance reliability and maintainability, as well as to provide the necessary improvements to meet Category II/ILS approach standards. The cost of installing an MLS appears to be equal to or less than the cost of installing the VHF/ILS.

At least six differently designed MLS's are available to provide vertical and lateral guidance onto the runway. Since each design is apparently adequate, it is difficult to standardize a universally acceptable system.

Other landing systems under development appear to offer the potential of extended centerline guidance, extended automatic guidance control, and fully automatic approach and landing capability.

The nuclear guidance landing system, which is said to be virtually interference- and maintenance-free, appears to have considerable potential and should be given research and development consideration in conjunction with the fully automated approach. The cost of the equipment, reportedly, is about equal to that of the current VHF/ILS installation.

Altimeter Settings (QNH and QFE)

Two altimeter settings are used by air carriers today during approach and landing. The QNH altimeter setting indicates height above mean sea level (MSL), whereas the QFE altimeter setting indicates height above the airport elevation. All European carriers use QFE settings, but most U.S. carriers use QNH settings.

Two U.S. air carriers use three altimeters in the cockpit. The two main altimeters are installed in the pilot's and copilot's instrument panels. The third altimeter, a standby, is usually mounted between the pilot's panel and the copilot's panel. The two main altimeters are set to QFE, and the third is set to QNH. This practice permits several cross-checks that reduce human error during approach-altitude observations. The difference between the setting of the two main altimeters and that of the third altimeter is the published field elevation.

In the Board's view, the advantages in QFE usage are: (1) Elimination of the need for the pilot's mental calculation and visualization of height in terms of field elevation versus the dynamically reducing flight elevation and (2) the adaptability to gross cross-checking of height above terrain by use of radio altimetry or direct cross-checking in the case of uniform oı level terrain or water under the approach path.

Human Performance

Based on accident data and on the statements of several participants in the Forum, human factors constitute a consistently predominant proportion of the causal factors in both initial and final approach accidents. The inverse, however, is indicated by initial and final approach incidents. One participant indicated that when significant incident and defect reports were analyzed, about 80 percent of the reports involved mechanical defects, and only about 20 percent covered human failures or operational errors.

The Board has experienced the same difficulty in communication as that expressed by one participant, who stated:

> "... we have a tremendous communication problem facing us ... in our remedial and preventive tasks. We ... are trying desperately hard to engender the right sort of atmosphere between ourselves and the operating crews so that we can get in more reports of human factor errors."

Another participant, who represented the Lovelace Foundation for Medical Education and Research, is conducting, under a NASA contract, a human-factors system analysis evaluation in order to construct a human-error accident model to demonstrate critical event information graphically. NASA will use this information to establish future human factors research programs in aeronautics.

Risk Management

The four basic concepts of Managing aviation risks are:

- Build the safest possible aircraft in terms of technological and economic limitations.
- Identify hazards and how they can be controlled.
- Eliminate hazards, rather than react to failures.
- Use aircraft safely and properly within operational and environmental limits.

The Board agrees with several Forum participants who believe that general aviation manufacturers should provide aircraft owners with adequate information about an airplane's performance limitations, particularly that information related to flight hazards and to procedures to avoid or control those hazards. Many new general aviation aircraft are marketed with a minimum amount of user information on such areas as aircraft loading and c.g. computations, required takeoff and landing distances, checklists, stall and angle of attack data, emergency procedures, and operating limitations.

Accidents cannot be prevented by continually blaming the pilot for not using good judgment in cases in which his lack of knowledge of aircraft capability or of the environment limited his capacity for good judgment.

Recent FAA FAR Part 91 rulemaking concerning general aviation qualifications requires improved training and proficiency. These improvements should also result in a significant reduction in approach and landing accidents.

Crew Discipline

The Board supports the view of one participant at the Forum who stated:

> "There is a great need for management and awareness programs that emphasize the requirements for pilot adherence to approach procedures."

Although the Board's accident investigations have revealed that some pilots did not follow prescribed operating procedures, most crewmembers resist the temptation to deviate from standard operation procedures. Needless to say, all flightdeck crewmembers should strictly follow such procedures, which were developed to ensure safety.

ILS See-to-Land Concept

The transition from instrument conditions to visual flight conditions is required of all Category I, II, and III landings with the exception of Category III-C. The pilot must see to land in these categories. The ILS, is an aid in reaching that point in the approach at which the visual segment begins. At that point, the pilot must determine whether to land or to abandon the approach.

The experience of the U.S. Air Force Instrument Flight Center, in flying more than 300 approaches in visibilities below current minima, disclosed several significant considerations with respect to low-visibility environments and the see-to-land concept:

- The visibility conditions caused by fog were less restrictive than Category I (200 feet DH and ½ mile visibility), or more restrictive than Category III-A (700 feet RVR), which means that actual Category II conditions very seldom existed.
- At least 3 seconds were required for a pilot to orient himself in visibilities between 600 and 800 feet, if a sudden transition was made to visual flight.
- When visual range decreased from 600 to 200 feet, a new problem developed—insufficient visual cues were available to flare the aircraft whether it was day or night.
- As visibility approached 200 feet, recognition of lateral movement became extremely difficult and therefore, extremely hazardous with present runway lighting and markings.

The VHF instrument landing system is not reliable enough to be used as a precision guidance system below 100 feet. Yet, in Category II conditions, this is precisely the point at which the pilot is required to see the approach lights or to see a sufficient amount of the threshold to be able to continue the approach. However, vertical guidance from the instrument landing system is still required since there are insufficient vertical cues available.

The Board agrees with several Forum participants who expressed the view that 1,200-feet RVR visibility provides a marginal visual segment to control an aircraft's flightpath. At a decision height of 100 feet, a pilot with 1,200 feet RVR would have a visual segment of only 600 to 800 feet to make his decision to land or go around. The nose of an aircraft with a 14-degree, downward vision angle at 100 feet above the surface will obstruct about 400 feet of intervening terrain.

Some participants at the Forum expressed the belief that 1,600 feet is the lowest practical visual range that can be safely assigned to a decision height of 100 feet to enable a pilot to maneuver visually for landing. It was stated that landings in visibilities below 1,600 feet should be approached only with the philosophy of a fully automatic landing capability. This includes an automatic flare and rollout capability.

Crew Workload

Single pilot, IFR approach and landing operations are reasonably safe with adequate pilot training, practice, and proficiency. Establishment of approach minima, however, should consider the inherent human performance capabilities and limitations in this type of operation. The increased capacity of two qualified pilots could account for lower approach and landing criteria's being equally safe in the same environment.

Air carrier training and operational philosophies vary to the extent that crew workload distribution varies from one operator to another, even with identical equipment and operating conditions. The Training Standards/Requirements Committee of the Type Certification Board approves the minimum training required for operation of each new air carrier aircraft. The operators comply with these standards in different, but acceptable, ways. Although there is no evidence that crew workload distribution is in any way responsible for air carrier approach and landing accidents, the most successful techniques should be shared among operators. Such an exchange of ideas could be accomplished by an industrywide exchange program.

Stall/Spin Accidents During Landing Approaches

Stall or spin accidents involving general aviation aircraft have accounted for more fatal and serious injuries than any other single type of accident. Several Forum participants discussed the stall-spin problem, particularly as it involved hard landings and undershoots.

The Board has released a special stall spin accident study in which it recommended a number of actions that could reduce significantly the number of stall spin accidents, including those accidents associated with approach and landing.

Management

In the current era of an unparalleled safety record, it often seems unjustified for management to use much needed economic resources for added safety. However, to improve or to maintain a status quo on the present safety plateau of air travel – be it in general aviation; in air taxi operations; or in large, medium, or small air carriers – management must be the catalyst of safety awareness and provide needed safety impetus to its operations.

Development of Automated Landing System

As early as April 1964, the Civil Aeronautics Board (CAB) commented on the proposed U.S. position on the three-category approach to all weather operations. According to the CAB, the U.S. position is based on questionable assumptions relative to development of all weather operations. The CAB stated:

> "... we question the practicability of the current approach not only in regard to its adequacy from the safety standpoint, but also in regard to its necessity from an economic standpoint. As long as the human response time problem is involved, as well as the variability of runway visual range, we have serious reservations concerning the gradual reduction of operational minima. . . ."

The Board still supports the views of the CAB and opposes: (1) Reduction of see-to-land operational minima; (2) determining touchdown, rollout and turnoff visibility by means of transmissometer sensors; and (3) the use of the ILS see-to-land concept inherent in all Category II and III operations, except III-C.

Again, the Board believes that until such time as aircraft are capable of accomplishing fully automated landings, the minima of Category I should be used.

Training: Use of Simulators

Simulation has made enormous strides over the past 20 years. The modern, visual aircraft simulator can duplicate virtually all aspects of an aircraft cockpit environment. A pilot, through the use of flight simulators, can experience equivalent flight-condition characteristics such as motion cues, deck angle, and sink rate; environmental conditions such as ceiling, reduced visibility, turbulence, wind shear, and the effects of ice and snow on the runway; and visual conditions such as terrain features, cutoff angle, and approach and runway lighting aids.

Visual simulators aid teaching by being capable of problem freezing, spatial repositioning, record and playback facility, and malfunction simulation.

One large domestic air carrier attributes its success in flying over 4 million hours, achieving 2½ million landings, and carrying 125 million revenue passengers since 1965 without a fatality, to effective utilization of visual simulators.

The enormous cost of utilizing the Boeing 747, the DC-10, or Lockheed L-1011 for training purposes leads the Board to anticipate a continued increase in the use of simulator training and a concurrent decrease in actual airplane training throughout the next decade.

Incident Investigation Through Communication

Today's approach or landing incident may be tomorrow's accident if information on it is not shared with others.

The Board is aware of the many problems involved in obtaining, analyzing, and disseminating incident information; the reluctance on the part of crewmembers to reveal errors; the difficulty in recognizing the importance of vital information; and the legal or other inhibitive influences on prompt dissemination of data. However, practical channels of reporting data can be devised. Some methods are as follows:

- anonymous reports,
- reports to neutral parties,
- guaranteed reasonable immunity from consequences, and
- protection of accident-prevention information from use in litigation proceedings.

The International Air Transport Association (IATA) conducts a safety-information exchange program; however, only 64 of its 107 member airlines participate in the program. The reluctance of air carriers to participate in information exchanges of this type is because of the legal liability aspects of incidents and accidents. Because of the liability aspects, airlines are forced to withhold information which could help to prevent a catastrophy.

The practices of immunity and protection of accident-prevention data employed in the Commonwealth of Australia are highly conducive to continual before-the-fact treatment of air safety problems. A similar treatment exists in certain European countries where prevention is paramount to disciplinary action.

Design and Use of Spoilers

The Board's investigation of approach and landing accidents revealed that improper activation of spoilers has been either a cause or a contributing factor in many approach and landing accidents. An accident at Toronto International Airport, Ontario, Canada, on July 5, 1970, resulted in 109 fatalities. The accident occurred during the final approach, when the first officer inadvertently activated the ground spoilers while the aircraft was still in flight.

The ground-spoiler system on many turbojet aircraft can be operated manually from the cockpit when the landing gear is extended or automatically, depending on main wheel spin-up and nose strut compression. These two means of operation have proven hazardous in some conditions such as wet runway landings, and loose rigging of the spoiler controls, premature touchdown of the upwind main gear during crosswind landing, or a bounced landing.

Environmental Aspects

Accuracy and timeliness of measuring and reporting approach-zone and runway visibility, runway surface conditions, and precise barometric pressure, which are among the most critical factors affecting approach and landing operations, need to be improved. Technology either exists or is easily within reach to provide the improvements, but no priorities have been set to update facilities and techniques.

Techniques to improve slant range, approach zone, and runway visibilities have been tested in a variety of technical schemes; however, no single method has been found to be acceptable.

Wind Shear

Some approach and landing accidents have occurred which have been attributed to wind shear as a cause or contributing factor. There is no standard definition of wind shear in terms of its effect on aircraft performance, nor is there a standard or procedure for requiring ATC personnel to warn pilots of known wind shear conditions.

Terminal Area Weather Evaluation

Despite great technological strides, problems related to the observation of weather in terminal areas still exist. Terminal weather observations are a mixture of instrumentally measured and visually acquired values. Although some elements of the weather can be accurately measured and reported, other elements need more accurate and automatic measurement and definition for meaningful reporting.

Some areas in which improvements can be made are:

- Techniques and procedures for automatically evaluating total sky cover and for determining prevailing visibility.
- Means to observe and predict wind shear up to 3,000 feet AGL.
- Means to provide slant visual range for the final approach.
- Technology for automatically determining precipitation types.
- Technology for detecting freezing precipitation.
- Technology for differentiating between liquid and dry obstructions to visibility.

One participant at the Forum discussed in detail certain environmental factors related to the change in density of an air mass because of dilution with moisture. For example, if a tower gave a density reading of one value to an airplane that is flying in an air mass of another density value, there could be a margin of altitude error detrimental to an approaching aircraft.

This error is dependent upon the saturation of the air mass. A 1-percent change in density could result in a barometric altimeter reading which is 55 feet in error. Greater saturation differences in air masses could account for greater errors in altimetry.

Runway Marking System

The present runway marking system has many inherent weaknesses and is inadequate for use during actual all-weather approaches and landings.

Runway markings during low visibility are extremely important because they provide essential visual patterns for crewmembers. When other obstructions appear during marginal approaches, such as rain or snow on the windshield, or when wheel-to-cockpit heights are from 40 to 50 feet, interpretable runway markings become very essential.

In this regard, the Board was particularly impressed when the USAF's Instrument Flight Center at Randolph AFB, Texas, recommended the following criteria:

- Provide lateral guidance toward centerline.
- Identify left or right runway side.
- Provide distance used and remaining during takeoff and landing rolls.
- Provide a touchdown zone marking pattern 3,000 feet long.
- Provide a 500-foot internal marking pattern for touchdown zone area.
- Identify runway edge.
- Identify the threshold.
- Widen the distance between inner markings to reduce wear.
- Provide runways with better light reflecting characteristics for wet or low-visibility conditions.

The provision of runway markers to indicate used and remaining distance—such as centerline diamonds—would provide valuable information to crewmembers for low-visibility landings, for takeoffs in all types of visibility, and for takeoff-acceleration checks.

Incorporation of this feature in instrument runway-marking patterns would also satisfy a Board recommendation made in the report concerning the Pan American World Airways, Boeing 747 accident at San Francisco, California, on July 30, 1970. This recommendation suggested that runway distance markers be installed at all civil airports where air carrier aircraft are authorized to operate. This was a restatement of several previous recommendations concerning this subject.

Wake Turbulence

Wake vortex turbulence, which is generated in the approach and landing zone by low-speed, high-wing-loaded jet transports, particularly those with dimensions as gross as the wide-bodied and stretch jet aircraft, has been of critical concern as a hazard to landing. Wake vortex turbulence is generally invisible, but the circumstances under which its hazardous conditions develop and its general behavior are known. Instrumentation for the detection of vortices which may remain on a runway for an extended period is under development. Research is being conducted concerning methods of dissipating the vortices. A perpendicular cross-wind component condition of approximately 5 knots is particularly conducive to holding a vortex laterally stationary in space. This then extends the period of the existing hazardous condition for several minutes. After some random period of time, the intensity begins to decay or the core moves away.

Although air traffic controllers are required to provide some notice to pilots operating in such an environment, more definitive information concerning this vortex hazard is needed by the pilot to assess the threat before he penetrates zones of recent wake turbulence generation.

CONCLUSIONS

The consensus of the participants in the Forum, corroborated by accident history, indicates a need for vertical guidance assistance to the pilot as a priority improvement of all runways capable of supporting instrument landing operations. The same vertical guidance would facilitate and improve the safety of VFR operations. However, the Board recognizes that accomplishment of such an effort continues to be relatively long range and may not represent the total solution.

Accordingly, other areas which can reduce the probability of approach and landing accidents are considered, as follows:

Approach and Landing Guidance

Three-Dimensional Area Navigation Hazard Analysis

There has been no evidence that a critical-event, system-hazard analysis for three-dimensional area navigation has been undertaken. The failure to define and identify inherent potential hazards and to provide means for their prevention while this system for approach and landing is used could result in serious environmental airspace hazards.

Cockpit Vertical Guidance Displays

Airborne systems which display vertical-guidance-control information during the visual segment of an approach are operational. These systems, which can improve approach techniques, aid in preventing approach-undershoot accidents caused by sensory illusions, errors in visual judgment, and degraded visual conditions.

Altitude-Alerting and Terrain-Proximity Warning Devices

There is a lack among crewmembers of standard knowledge and information on the limitations of altitude-alerting devices. A need still exists for a terrain-proximity warning device.

Terminal Instrument Procedures (TERPS)

Certain parts of TERPS need to be revised, particularly those concerned with visibility minima, establishment of descent fixes, definition of DH and MDA, and definition of what constitutes a clearly defined runway threshold.

Two-Segment Approach

The two-segment approach is a marked departure from existing approach and landing techniques. Before this procedure is implemented, descent profiles should be precisely defined on the basis of safety, pilot acceptance, and noise reduction. Nonprofile variables should be adequately assessed.

All-Weather Landing Development Plan

FAA planning calls for an operational MLS by 1977. VHF/ILS capability, as presently developed, does not compare with the MLS capability to meet Category III operations. It is doubtful that refinements in the VHF/ILS can provide the required reliability and maintainability needed for Category III operations. Therefore, unless the FAA development of MLS or some other comparable system, is energetically increased, anticipated all-weather approach and landing operations will be delayed. Development planning should concentrate on airborne and ground systems which will not become obsolete in the foreseeable future and will encompass the needs and economics of the majority of users and airports. One such system is discussed in the next paragraph.

Nuclear Guidance Landing System

Efforts by the FAA and the aircraft industry to decrease the minimum visibility and ceiling requirements for landing aircraft under instrument conditions have created a need for an accurate and reliable aircraft guidance system. Current ILS systems have failed to meet the accuracy and reliability requirements in the last phases of flight.

The nuclear guidance landing system has considerable potential as a new concept in landing guidance, is reportedly equivalent in cost to the VHF/ILS system, requires no external energy, and is virtually interference- and maintenance-free.

Altimeter Settings (QFE)

A uniform system of using and setting altimeters to QFE would greatly reduce approach altitude errors, would substantially reduce calculations for runway approach, and would provide a cross-check for crewmembers in vertical guidance during approach.

Visual Approach Indicator Lights (VASI)

VASI is being installed within the limits of FAA funding capability.

Human Performance

ILS See-to-Land Concept

When going from Category I to Category II-B to Category III-A, there are many problems related to the time to identify and correct lateral, vertical, and longitudinal excursions of an instrument-guided aircraft and for the pilot to determine his land or go-around decision. Accordingly, 1,600 feet appears to be the lowest visual range that can be assigned to a decision height of 100 feet to maneuver visually for landing with reasonably consistent safety.

The Board is concerned about the increasing risk assumed by pilots attempting landings in ever-lowering visibility conditions, wherein an ILS see-to-land visual concept must be used.

Training Requirements

Visual simulators available today can duplicate virtually all aspects of the aircraft cockpit. They can greatly aid the teaching process by simulating actual flight situations where judgment and timely decisions are mandatory. Learning can be accomplished less expensively, more effectively, and with more safety than possible in an airplane.

Management

Autospoiler Operation

The manner of operation of the spoiler system in turbojet aircraft has resulted in hazardous occurrences, some of which have caused fatalities. There is a need for more hazard analysis of in-flight deployment of ground spoilers and implementation of more strict design safety criteria related thereto.

Airplane Manuals

User information provided for many general aviation airplanes which weigh 6,000 pounds or less is inadequate. Simple, easy-to-understand information is needed on such subjects as aircraft loading and center-of-gravity data, required takeoff and landing distances, checklists, stall and angle-of-attack data, emergency procedures, and operating limitations.

Environmental Aspects

Wind Shear

Wind shear needs to be defined in terms of its effect on aircraft performance. Pilots should be encouraged to report wind shear encounters. ATC personnel should advise crewmembers of known wind shear conditions.

Runway-Marking System

The runway-marking system has many inherent weaknesses and is inadequate for use during actual all-weather approaches and landings. A new marking system should include interpretable markings to indicate runway end, direction to centerline, threshold, runway edge, and show distance remaining.

Terminal-Area Weather

Detection technology and automatic evaluation of sky cover, visibility, wind shear, slant range visibility, precipitation, and turbulence at terminal areas should be improved.

Wake Turbulence

The Board forwarded several letters to the Administrator, FAA in which our concern about the vortex turbulence phenomena is indicated and the following recommendations are contained:

1. Revise appropriate publications to assure that they describe more specifically the desirable avoidance techniques (e.g., following aircraft maintain approach path above VASI or ILS glide slope, extending downwind leg, etc.).
2. Define and publish the meteorological parameters which cause trailing vortices to persist in the vicinity of the landing runway.
3. Include wake turbulence warnings on the ATIS broadcasts whenever such meteorological conditions indicate that vortices will pose an unusual hazard to other aircraft.
4. Develop, immediately, new ATC separation standards which consider relative span loadings of the vortex-generating aircraft and the following aircraft (under meteorological conditions defined as being conducive to the persistence of trailing vortices).
5. Pending development of these standards, instruct controllers to increase separation times of controlled aircraft to at least 3 minutes whenever the specified meteorological conditions prevail.

RECOMMENDATION

The Board has reviewed each of its previous approach and landing recommendations and the status of the action taken by the recipient. These recommendations pertain to such subjects as nav-aid operation, ATC communications and radar coverage, undershooting on approach, exposed runway lips, landing minima, simulated engine(s)-out operations, installation of ILS and VASI, malfunction of flap actuators, and conflicting and possible misidentification of approach plates. More recent recommendations were submitted on such subjects as crew coordination, wake turbulence, extraneous harmonics of doppler signals, scanning of cockpit instruments, and altitude awareness during instrument approaches. Summaries of these recommendations are contained in Appendix C.

After analyzing the papers, discussions, and suggestions presented throughout the Approach and Landing Accident Prevention Forum, the Board believes that numerous areas require further consideration.

Accordingly, the Board recommends that: The various responsible agencies and segments of the aviation community evaluate and comment to the Safety Board on the following proposals which evolved from the Forum and which can potentially lead to the prevention of approach and landing accidents.

Approach and Landing Guidance Area

1. A critical-event, system-hazard analysis of the three-dimensional area navigation system and procedures for approach and landing guidance should be undertaken. (Recommendation A-73-79)

2. Airborne cockpit vertical guidance displays should be integrated into all air carrier cockpit approach procedures as part of the normal instrument scan for visual approaches. (Recommendation A-73-80)

3. Air carrier training programs should be reevaluated continuously to assure adequacy of training of crewmembers in the use, operational limitations, and understanding of altitude-alerting devices, especially in the descent-approach phase of flight. (Recommendation A-73-81)

4. Ground-proximity warning devices should be required for use in all commercial passenger flight operations, particularly during nonprecision approaches. Standard procedures for their use should be established. (Recommendation A-73-82)

5. High priority should be given to the planned revision of the TERPS Manual. (Recommendation A-73-83)

6. A critical-event, system-hazard analysis should be conducted of the two-segment approach procedure. (Recommendation A-73-84)

7. In the developmental stage the two-segment approach system should be evaluated not only for passenger response and equipment requirements, but also to ensure that approach descent profiles are precisely defined on the basis of safety, pilot acceptance, and noise reduction. The profiles should be in accordance with the long-recognized need for descent stability in jet operations, and they should ensure that the approach environment is compatible with general aviation operations. (Recommendation A-73-85)

8. To minimize the proliferation of many alternative and incompatible systems, a single microwave-landing system should be selected as a standard interim system until such time as a common civil/military all-weather landing system is developed to replace the VHF/UHF instrument landing system. (Recommendation A-73-86)

9. Research and development programs for nuclear, all-weather landing systems should be given higher priority. (Recommendation A-73-87)

10. Air carriers should be encouraged to use the combined QFE-altimeter setting on two crewmember altimeters, and the QNH-altimeter setting on the third, standby, altimeter for approach operations. Radar altimeter backup and cross-check verification procedures should be encouraged. (Recommendation A-73-88)

Human Performance

11. Standardized, expanded, airplane flight and owners manuals should be furnished with all general aviation aircraft—particularly with those aircraft which weigh 6,000 pounds or less. (Recommendation A-73-89)

12. Safety education and classroom instruction which cite actual accident and incident experience so that the importance of crew coordination, discipline, and adherence to standard operating procedures, should be stressed. (Recommendation A-73-90)

13. Because of reaction time and limited visual range segments on visibility-criteria approaches, landing minima should be limited to 1,600 feet for a decision-height of 100 feet. (Recommendation A-73-91)

Management

14. Category II, III-A, and III-B minima should be restricted to experimental use. Cate-

gory I minima should be used until facilities, equipment, procedures, and training are available to conduct fully automated landings safely – then proceed to Category III-C operations. (Recommendation A-73-92)

15. As simulators become more capable of simulating actual aircraft performance and flight environment, more substitution of simulator should be encouraged for training. (Recommendation A-73-93)

16. All air carriers should be urged to update their simulators' visual capabilities as expeditiously as possible or, to obtain training from companies that can provide visual simulation trainers. (Recommendation A-73-94)

17. Pilot and air carrier organizations should develop procedures for reporting, analyzing and categorizing incident information. These organizations should consider the benefits of immunity to punitive or violation consequences and advise the Board of methods to overcome the problems which deter dissemination of these data. (Recommendation A-73-95)

18. A formal, system-hazard analysis should be conducted on all aircraft with automatic, ground spoiler systems to determine whether there is a need for designed safeguards against inadvertent or inappropriate in-flight ground spoiler deployment by crewmembers. (Recommendation A-73-96)

Environment

19. A standard definition of wind shear, particularly with reference to approach, should be developed. (Recommendation A-73-97)

20. ATC personnel should be required to notify pilots of any known local wind shear or wake turbulence during approach and landing operations. (Recommendation A-73-98)

21. More emphasis and higher priority should be given basic research to provide new means of automatically evaluating sky cover, prevailing visibility, and slant range visibility, and of detecting and determining types of precipitation, turbulence, and wind shear. (Recommendation A-73-99)

22. Efforts should be made to get accurate, readily available, and timely terminal information to crewmembers for departure and arrival planning. (Recommendation A-73-100)

23. A new runway marking system should be developed which will provide distinct, interpretable runway markings for use in all types of visibility. (Recommendation A-73-101)

24. Distance remaining information should be visually presented on airport runways so that indicators are readable only from the direction in use. (Recommendation A-73-102)

25. Dry and moist air masses should be researched to determine whether the dilution or saturation of them by water as a gas can cause significant density variations between approach environment and terminal environment air masses which would adversely affect barometric altimeter system accuracy. (Recommendation A-73-103)

The Board awaits the responses of the aviation community to these proposals and will develop further recommendations, as appropriate.

Improvements and actions suggested at the Forum, which are not specified above, should also be thoroughly considered and analyzed by the aviation community.

APPENDIX A
GLOSSARY OF TERMS

AIRPORT TRAFFIC AREA

Unless otherwise specifically designated, that airspace within a horizontal radius of 5 statute miles from the geographical center of any airport at which a control tower is operating, extending from the surface up to, but not including, 3,000 feet above the elevation of the airport.

AIR ROUTE TRAFFIC CONTROL CENTER (ARTCC)

A central operations facility in the air route traffic control systems using air/ground communications and/or radar, primarily providing en route separation and safe, expeditious movement of aircraft operating under instrument flight rules within the controlled airspace of that center.

ALTIMETER SETTING

Local Station Pressure (QFE)

An altimeter set to local station pressure which will provide the indicated height above the station, whether airborne or on the ground. (Without such correction made for temperature as may be necessary, this is not a true height.)

Local Station Pressure (QNH)

An altimeter set to local station pressure which will provide the indicated MSL altitude of the airplane, whether airborne or on the airport. (Without such correction made for temperature as may be necessary, this is not a true altitude.)

Standard Altimeter Setting (QNE)

An altimeter set to the "standard" pressure of 29.92 inches of Hg. or 1013.3 Mb. En route altitudes based on this setting will provide accurate separation of all traffic using QNE, but will be proportionately higher or lower than the indicated altitude as the ambient barometric pressure is higher or lower than standard. Cruising altitudes will be called "flight levels" and abbreviated "FL" followed by the indicated altitude in hundreds of feet.

APPROACH CONTROL (APP)

A service established to control IFR flights arriving at, departing from, and operating in the vicinity of airports by means of direct and instantaneous communication between approach control personnel and all aircraft operating under their control.

APPROACH SEQUENCE

The order in which aircraft are positioned while awaiting approach clearance or while on approach.

AREA POSITIVE CONTROL (APC)

Designated airspace on certain airways and in certain areas wherein IFR clearance is mandatory for flights penetrating or operating in this airspace.

AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS)

A continuous broadcast of recorded non-control information in selected areas of high terminal activity. Information such as: Ceiling, visibility, wind, altimeter setting, instrument approach and runways in use. These data are broadcast over the voice feature of VOR, VOT, or ILS located at or near the airport, or by a discrete VHF tower frequency.

APPROACH FIX

The fix from which or over which final approach (IFR) to an airport is executed.

AREA NAVIGATION (RNAV)

A method of navigation that permits aircraft operations on any desired course within the coverage of station-referenced navigation signals or within the limits of self-contained system capability. Three-dimensional RNAV offers continuous guidance on any track to the end of the runway; continuous measurement of distance along a track to the end of the runway; and continuous vertical guidance to the end of the runway with selectable glide slope capability.

BACK COURSE (BC)

Localizer systems which employ a second antenna system to give 360-degree coverage giving course signals which overlap in the opposite direction of the front course, forming a back course.

CATEGORY I OPERATIONS

An instrument approach procedure which provides for approaches to a decision height (DH) of not less than 200 feet and visibility of not less than ½ mile or RVR 2400 (RVR 1800 with operative touchdown zone and runway centerline lights).

CATEGORY II OPERATIONS

An instrument approach procedure which provides approaches down to minima below 200 feet decision height (DH) and 2400 RVR to as low as 100 feet decision height and 1200 feet RVR.

CATEGORY III OPERATIONS

An instrument approach procedure which provides for approaches from 100 feet decision height (DH) and 1200 RVR to and along the surface of the runway and taxiways without external visual reference. This category involves three "stairsteps": 700 RVR; 150 RVR; and zero.

CIRCLING APPROACH

A descent in an approved procedure to an airport for a circle-to-land maneuver or a maneuver authorized when the final approach course alignment does not meet the criteria for a straight-in landing. The size of the circling approach area radii varies with approach category from 1.3 to 4.5 miles.

CEILIOMETER

A ceiling height detection device which consists of a projector, detector, and indicator, works on a triangulation principle. The projector is located 300 to 1,000 feet from the detector. The beam of light from the projector is rotated continuously in a vertical plane. The field of view of the detector is vertical as the beam of light from the rotating projector intersects the base of a cloud, a part of the reflected light is reviewed by the detector, a signal is sent to the indicator where it is measured and a reading is given.

DECISION HEIGHT (DH)

The height, specified in MSL, above the highest runway elevation in the touchdown zone at which a missed approach shall be initiated if the required visual reference has not been established. This term is used only in procedures where an electronic glide slope provides the reference for descent, as in ILS or PAR.

DUCK UNDER

An abrupt attitude change downward, during approach or after reaching DH, in an attempt to bring the projected touchdown point into the pilot's visual segment, or in attempting to land within the first 500 or 1,000 feet of the runway after breaking out of an overcast during a low visibility approach. This maneuver produces high sink rates and thrust/lift management problems at a critical time in the approach.

FINAL APPROACH FIX

The fix from which or over which final approach (IFR) to an airport is executed.

FINAL APPROACH

The segment between the final approach fix (FAF) or point and the runway, airport, or missed-approach point (MAP).

FORCE WHEEL STEERING (FWS)

A control element of autopilots to allow pilot inputs into the computer which operates the autopilot, so that the pilot can provide inputs to the automatic control system during approach and landing.

FINAL APPROACH (IFR)

The flight path of an aircraft which is inbound to the airport on an approved final instrument approach course. This path begins at the final approach fix and extends to the airport or the point where circling for landing or missed approach is executed.

FINAL APPROACH (VFR)

A flight path of a landing aircraft in the direction of landing along the extended runway centerline from the base leg to the runway.

FINAL CONTROLLER

That controller who provides final approach guidance through use of radar equipment.

FLIGHT LEVEL

A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet.

FLIGHT VISIBILITY

The average forward horizontal distance from the cockpit of an aircraft in flight at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.

GLIDE SLOPE

The slope determined by an instrument-landing facility to govern the glide path of an aircraft or other object coming in for landing.

GROUND VISIBILITY

Prevailing horizontal visibility near the earth's surface as reported by the U.S. Weather Bureau or an accredited observer.

HEIGHT ABOVE AIRCRAFT ELEVATION (HAA)

Indicates the height of the MDA above the published airport elevation. This is published in conjunction with circling minima.

HEIGHT ABOVE TOUCHDOWN ZONE ELEVATION (HAT)

Indicates the height of the DH or MDA above the highest elevation in the touchdown zone.

This is published in conjunction with straight-in minima.

HEADS-UP DISPLAY (HUD)

The use of a combining glass and image display focused at infinity to delineate certain parameters for specific flight maneuvers. In the case of low-visibility landing, the display depicts the relationship of the aircraft to the runway centerline with qualitative parameters to indicate vertical and lateral deviation.

INTERMEDIATE FIX (IF)

A terminal area fix or geographical position on a defined course formed by the intersection of courses or radials from two stations and based on similar navigation system.

INSTRUMENT FLIGHT RULES (IFR)

When weather conditions are below the minima prescribed for visual meteorological conditions, pilots must fly in accordance with IFR. Pilots may elect to fly an IFR flight plan during visual meteorological conditions.

INSTRUMENT LANDING SYSTEM (ILS)

A system in the aircraft which provides the lateral, longitudinal, and vertical guidance necessary for a landing. The ground equipment consists of two highly directional transmitting systems and, along the approach, three (or fewer) marker beacons. The directional transmitters are known as the localizer and glide slope transmitters. The system may be divided functionally into three parts:

(1) Guidance information-localizer, glide slope,
(2) Range information-marker beacons, and
(3) Visual information-approach lights, touchdown and centerline lights, and runway lights.

ILS REFERENCE DATUM

A point at a specified height located vertically above the intersection of the runway centerline (localizer centerline) and the threshold and through which the downward extended straight portion of the glide path passes.

INDEPENDENT LANDING MONITOR (ILM)

A device or system, completely independent of the electronic guidance used by the autopilot and that displayed on the navigation instruments, to confirm or deny an acceptable lateral and longitudinal dispersion during the period from short final to touchdown. Its purpose is to determine the integrity of an ILS localizer and glide path signal during low visibility conditions.

ILS SEE-TO-LAND CONCEPT

Maintaining instrument flight while attempting to establish visual contact with the runway environment at DH or some point thereafter, and then transferring to visual flight to complete the approach and landing.

LOCALIZER (LOC)

The component of an ILS which provides lateral guidance with respect to the runway centerline.

LOCALIZER-TYPE DIRECTIONAL AID (LDA)

A facility comparable in utility and accuracy to a LOC, but is not part of a full ILS and may not be aligned with the runway.

MISSED APPROACH POINT (MAP)

A point of intersection of an electronic glide path with a decision height (DH), a navigation facility, a fix, or a specified distance from the final approach fix.

MINIMUM DESCENT ALTITUDE (MDA)

The lowest altitude to which descent shall be authorized in procedures not using a glide slope. Aircraft are not authorized to descend below the MDA until the runway environment is in sight and the aircraft is in a position to descend for a normal landing.

MISSED APPROACH

The segment between the missed-approach point (MAP), or point of arrival at decision height (DH), and the missed-approach fix at the prescribed altitude.

NONDIRECTIONAL RADIO BEACON (NDB)

A surfaced-based radio facility which broadcasts a carrier wave in all directions simultaneously and whose electronic signal is detected with airborne automatic direction finding (ADF) equipment.

NONPRECISION APPROACH

A standard instrument approach procedure in which no electronic glide slope is provided such as a localizer approach, a VOR or DME approach, or an approach which uses a nondirectional beacon.

OBSTACLE

An existing object, object of natural growth, or terrain at a fixed geographical location, or which may be expected at a fixed location within a prescribed area, with reference to which vertical clearance is or must be, provided during flight operation.

PRECISION APPROACH

A descent in an approved procedure where the navigation facility alignment is normally on the runway centerline, and glide slope information is provided.

RADAR

Airport Surveillance Radar (ASR)

A relatively short-range radar used by control tower personnel for arrival and departure control within a 30-mile area or for radar instrument approaches. Only range and azimuth information is available.

Precision Approach Radar (PAR)

Radar which provides positive position of aircraft in range, azimuth, and altitude, that the controller can accurately guide aircraft to touchdown on runway.

Plan Position Indicator (PPI)

Radar scope which provides position of aircraft by range and azimuth data but not by altitude data.

Ground Control Approach (GCA)

Instrument approach directed by ground personnel who observe the position of the aircraft by the use of radar. Either Precision Approach Radar (PAR) or Airport Surveillance Radar (ASR) may be available.

RUNWAY ENVIRONMENT

The runway threshold or approved lighting aids or other markings identifiable with the runway.

RUNWAY VISUAL RANGE (RVR)

An instrumentally derived value, based on standard calibrations, that represents the horizontal distance a pilot will see down the runway from the approach end. It is based either on the sighting of high intensity runway lights or on the visual contrast of other targets, whichever yields the greater visual range. RVR values are expressed in hundreds of feet.

RADAR IDENTIFICATION

The process of ascertaining that a radar target is the radar return from a particular aircraft.

RADAR FLIGHT FOLLOWING

The general observation of the progress of identified aircraft targets sufficiently to retain their identity or the observation of the movement of specific radar targets.

RADAR SERVICE

A term, which encompasses one or more of the following services based on the use of radar, provided by a controller to a pilot of a radar-identified aircraft.

RADAR SEPARATION

Radar spacing of aircraft in accordance with established minima.

RADAR NAVIGATION GUIDANCE

Vectoring aircraft to provide course guidance.

RADAR MONITORING

The radar flight following of aircraft, whose primary navigation is being performed by the pilot, to observe and note *deviations from its authorized flight path,* airway, or route. As applied to the monitoring of instrument approaches from the final approach fix to the runway, it also includes the provision of advice on position relative to approach fixes and whenever the aircraft proceeds outside the prescribed safety zones.

RADAR SURVEILLANCE

The radar observation of a given geographical area for the purpose of performing some radar function.

RADAR VECTOR

A heading issued to an aircraft to provide navigational guidance by radar. May be expected through any position of the nav-aid approach except final.

ROLLOUT RVR

The Runway Visual Range (RVR) readout values obtained from RVR equipment located nearest the end of the runway.

RUNWAY REFERENCE POINT

The point on the runway where the effective visual glide slope intercepts the runway surface.

RTCA Special Committee 117

A special committee formed by the Radio Technical Commission for Aeronautics and charged with the responsibility of developing standards for a Microwave-Landing System.

STANDARD TERMINAL ARRIVAL ROUTE (STAR)

A preplanned coded air traffic control IFR arrival routing, preprinted for pilot use in graphic and textual forms, or textual form only.

STRAIGHT-IN APPROACH (IFR)

An instrument approach wherein final approach is begun without first having executed procedure turn.

STRAIGHT-IN APPROACH (VFR)

Entry of the traffic pattern by interception of the extended runway centerline without executing any other portion of the traffic pattern.

SURVEILLANCE APPROACH

An instrument approach conducted in accordance with directions issued by a controller referring to the surveillance radar display.

SLANT RANGE

The line-of-sight distance between two points not at the same elevation.

THRESHOLD-CROSSING HEIGHT

The height of the straight line extension of the visual or electronic glide slope above the runway threshold.

TOUCHDOWN RVR

The Runway Visual range (RVR) readout values obtained from RVR equipment serving the runway threshold.

TRANSPONDER

The airborne radar beacon receiver-transmitter which automatically receives radio signals from all interrogators on the ground and selectively replies with a specific reply pulse or pulse group only to those interrogations being received on the mode to which it is set to respond.

TRAFFIC INFORMATION - RADAR

Information issued to alert an aircraft to any radar targets observed on the radar display which may be in such proximity to its position or intended route of flight to warrant its attention.

TOUCHDOWN ZONE (TSD)

The first 3,000 feet of runway beginning at the threshold.

TOUCHDOWN ZONE ELEVATION

The highest runway centerline elevation in the touchdown zone.

TRANSMISSOMETER

A device for measuring visibility by the measurement of the extinction coefficient. The transmissometer system consists of a source light (projector) and a photometer (receiver) which are separated by a variable baseline. (The baseline may be 200, 500, or 700 feet.) The projector is usually at a constant intensity. Light emitted is attenuated as it passes along the baseline. The amount of light reaching the receiver theoretically represents the light leaving the projector minus the losses along the baseline and, therefore, becomes an indication of visibility.

VISIBILITY, PREVAILING

The horizontal distance at which targets of known distance are visible over at least half of the horizon. It is normally determined by an observer on or close to the ground viewing buildings or other similar objects during the day and ordinary city lights at night. Reported in miles and fractions of miles.

VISIBILITY, RUNWAY VISIBILITY VALUE (RVV)

The visibility determined for a particular runway by a transmissometer, a photoelectric device calibrated in terms of a human observer. A meter in the control tower provides a continuous indication of the visibility (reported in miles or fractions of miles) for the runway. RVV is used in lieu of prevailing visibility to determine minima for a particular runway. This program is gradually being replaced by RVR transmissometer locations.

VISIBILITY, RUNWAY VISUAL RANGE (RVR)

An instrumentally derived value, based on standard calibrations, that represents the horizontal distance a pilot will see down the runway from the approach end. It is based on the sighting of either high intensity runway lights or on the visual contrast of other targets, whichever yields the greater visual range. RVR, in contrast to prevailing or runway visibility, is based on what a pilot in a moving aircraft should see looking down the runway. RVR is horizontal, not slant, visual range. It is based on the measurement by a transmissometer made near the touchdown point of the instrument runway and is reported in hundreds of feet. RVR provides an additional operating minimum at fields equipped with specified navigational aids.

VISUAL APPROACH

An approach wherein an aircraft on an IFR flight plan, which operates in VFR conditions under the control of a radar facility and has an air traffic control authorization, may deviate from the prescribed instrument-approach procedure and proceed to the airport of destination by visual reference to the surface.

VISUAL FLIGHT RULES (VFR)

When weather conditions are above the minima prescribed for visual meteorological conditions, pilots may fly with visual reference to the ground and without reference to radio navigational aids.

WAKE TURBULENCE

The disturbance to the surrounding atmosphere created by an operating aircraft (airplane, rotorcraft, etc.) and may be used to refer to any or all of the following: Thrust stream turbulence, prop wash, wing tip vortices, or rotor vortices.

APPENDIX B
NTSB DOCUMENTS CONCERNING APPROACH AND LANDING ACCIDENTS

1. Letter dated January 17, 1969, addressed to Mr. David D. Thomas from Chairman Joseph J. O'Connell, Jr., National Transportation Safety Board
2. Press Release No. SB-70-93, dated December 3, 1970
3. Telegraph message dated December 20, 1972, addressed to various aviation organizations

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C. 20591

January 17, 1969

Mr. David D. Thomas
Acting Administrator
Federal Aviation Administration
Department of Transportation
Washington, D. C. 20590

Dear Mr. Thomas:

Accidents which occur during the approach and landing phase of flight continue to be among the most numerous. They are again highlighted by some of the events of the past month that have aroused nationwide interest in air safety. Most approach and landing accidents have been attributed to improper operational procedures, techniques, distractions, and flight management. In many cases vertical/horizontal wind shear, forms of turbulence, and altimetry difficulties were, or could have been contributing factors. The phenomenon of breaking out into visual flight conditions and subsequently becoming involved in patches of fog, haze, rain, blowing snow and snow showers and other visibility obscuring forms of precipitation seems to be fairly common occurrence. The sensory illusion problem associated with night approaches over unlighted terrain or water is another likely factor about which more is being learned daily.

Other related factors are the handling characteristics of our transport type aircraft in day-to-day operations, the absence or outage of glide slope facilities, cockpit procedures, possible effects of snow or rain on dual static port systems as they could affect altimetry accuracy, and altitude awareness. These are all factors which may exist singularly or in combination. The inability to detect or obtain positive evidence, particularly such evidence as ice accretion or moisture which becomes lost in wreckage, makes it difficult, if not impossible, in many cases to reach conclusions based upon substantial evidence. It is clear that had all ground and airborne navigational systems been operating accurately *and* had the flight crews been piloting with meticulous reference to properly indicating flight instruments, these accidents would not have occurred.

In this light, and with the number and frequency of approach and landing phase accidents under similar weather and operating environments, we believe that certain immediate accident prevention measures need to be taken. We believe that preliminary to the successful completion of our investigations into the factors and causes of the recent rash of accidents, renewed attention to, and emphasis on, recognized good practices will tend to reduce the possibilities of future accidents.

Pilots, operators and the regulatory agencies should renew emphasis on – and improve wherever possible – cockpit procedures, crew discipline, and flight management. It is recommended that both the air carrier industry and the FAA review policies, procedures, practices, and training toward increasing crew efficiency and reducing distractions

Mr. David D. Thomas

and nonessential crew functions during the approach and landing phase of the flight. It is specifically recommended that crew functions not directly related to the approach and landing, be reduced or eliminated, especially during the last 1000 feet of descent. Accomplishment of the in-range and landing check lists as far as possible in advance of the last 1,000-foot descent will allow for more intense and perhaps more accurate cross checking and monitoring of the descent through these critical altitudes.

It is also recommended that during the final approach one pilot maintain continuous vigilance of flight instruments - inside the cockpit - until positive visual reference is established.

In order to induce a renewed altitude awareness during approaches where less than full precision facilities exist, it is recommended that there be a requirement that during the last 1000' of final approach the pilot *not* flying call out altitudes in 100-foot decrements above airport elevation (in addition to airspeed and rate-of-descent). To further enhance altitude awareness within the cockpit, it is recommended that there be a requirement to report indicated altitude to Air Traffic Control at various points in the approach procedure such as the outbound procedure turn and at the outer marker position.

Consistent with and in support of the concept inherent in your Notice of Proposed Rulemaking No. 67-53, the Board urges the aviation community to consider expediting development and installation of audible and visible altitude warning devices and the implementation of procedures for their use. Additional improvements, although desirable now, are attainable only through continued research and development.

The reassessment of altimetry systems with particular regard to their susceptibility to insidious interference by forms of precipitation needs to be the subject of attention by the highest level of aeronautical research facilities and personnel. Toward this end, we are meeting with members of your staff, the National Aeronautics and Space Administration and various segments of the aviation community to initiate an assessment of possible failure modes and effects within the static system.

The possibility of development of additional altitude warning systems - external to the aircraft - needs to be explored by the aviation community. One such possibility would be a high intensity visual warning red light beam - projected up along and slightly below the desired approach glide slope - to warn of flight below the desired path.

Likewise, development is needed in the fields of radio/radar, and inertial altimetry and CRT/microwave pictorial display approach aids as possible improved replacement of the barometric altimetry system in the near future.

Modified use of existing approach radar should be further studied with regard to its adaptability as a surveillance–accident prevention–tool for nonprecision instrument approach.

Mr. David D. Thomas

During the time that we press for answers as to the causes of a number of these recent accidents, the Board urges increased surveillance, more frequent and more rigorous inspection and maintenance of altimetry systems by both the air carrier operators and the FAA; and urges also that the FAA reexamine certification requirements and procedures to determine if there is a possibility of a single failure mode of nominally dual systems which, when combined with an already existent passive failure or inadequate cockpit procedures, can invalidate dual failure protection features.

Whereas, these problems have been highlighted by air carrier accidents, they should not be construed as being unique to air carrier aviation. The Safety Board considers that they are applicable to all forms of air transportation.

We know that your Administration, as well as other responsible segments of the aviation community, have been working extensively in all of these areas.

We appreciate your continuing emphasis on the safety of air carrier operations as evidenced by recent communications with your inspectors and airline management.

Your views regarding the implementation of our suggestions will be welcome.

Sincerely yours,

/s/

Joseph J. O'Connell, Jr.
Chairman

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.--20591

Safety Information

For Release:

SB 70-93
(202) 426-8787

IMMEDIATE
Thursday, Dec. 3, 1970

Office of the Chairman

The National Transportation Safety Board urged the aviation industry today to develop "a sustained education program" for pilots to help prevent approach and landing accidents caused by visibility restrictions and illusions in bad weather.

Safety Board Chairman John H. Reed made the appeal in identical letters to 10 airline and private flying organizations. They are the Air Line Pilots Association, International; Allied Pilots Association; National Pilots Association; Aircraft Owners and Pilots Association; Air Transport Association of America; Association of Local Transport Airlines; National Air Carrier Association; National Air Transportation Conferences; National Business Aircraft Association; and Flight Safety Foundation.

The text of the letter follows:

Several recent approach and landing accidents emphasize the need to give even more attention to the prevention of that kind of accident.

Four approach accidents occurred during the first half of the month of November 1970. The first three involved aircraft under 12,500 pounds, maximum certificated weight engaged in air taxi service, while the fourth involved a large jet transport engaged in a passenger operation.

In one recent accident, the aircraft struck the water one-fourth mile short of the runway approach lights during an ILS approach to an airport whose weather at the time was partial obscuration, 300 feet scattered clouds, 1-1/2 mile visibility in ground fog and smoke.

A second accident involved a VOR approach to an airport during which the aircraft crashed one-half mile short of the runway. Weather at the time was indefinite 500-foot obscuration, visibility one-half mile in fog.

A third accident involved an ILS approach which was abandoned. The aircraft was given vectors for another ILS approach during which the aircraft crashed approximately one-fourth mile short of the runway. Weather was partial obscuration measured 200 feet variable overcast, one-half mile visibility in fog, overcast variable from 100 to 300 feet.

The last accident involved a large jet aircraft which crashed while executing an approach to an airport which had a low, marginal ceiling, and low visibility restriction due to light rain, fog, and smoke.

Although the findings are incomplete in all of these cases, it is significant that in each, there was either a partial or complete obscuration reported because of fog.

There exists, more than ever, a need for a comprehensive analysis of low visibility approach and landing accidents by safety officials in government and industry as well as by pilots to find the answer to the question: How can these accidents be prevented? The Safety Board is continuing its priority attention to this safety problem.

The National Transportation Safety Board's review of these and other approach and landing accidents shows that they occur with needless regularity and they they are not confined to a single segment of aviation. It is evident that there are a number of factors which must be considered in preventing this type of accident, namely, airborne and ground equipment, procedures and piloting techniques and judgment. It is clear that safety in this regime of flight can be and should be continually improving the quality and increasing the quantity of landing aids and weather reporting facilities and services. It is equally clear that none of us in the aviation community can relax our attention with respect to the emphasis on effective education programs. Such programs must bring to the personnel involved the lessons to be learned from the unfortunate experiences of others. It is in this connection that we suggest that you support our objective with an educational program designed to reinforce those safety factors emanating from pilot awareness, flight management, operating procedures, skill and judgment.

The Safety Board particularly believes that all pilots should be thoroughly instructed in the hazards associated with shallow fog penetration. Under such conditions, pilots should be prepared to make the missed approach decision and execute it without delay whenever that alternate course of action is required.

Illusions tending to disorient the pilot during the final phases of the landing approach and the limitations of various systems are but two of the areas bearing upon such a decision . . . . hazards really, which must be recognized.

Safety can be improved by better and more airborne and ground facilities and services. The Safety Board has made numerous recommendations to the FAA relative to the provision of such facilities and services. In the meantime, however, pilots have to operate aircraft safely in the existing operating environment. We, therefore, believe that a sustained education program as discussed above is a specific action that industry organizations such as yours could now take that would tend to reduce the number of accidents in this category.

We appeal to your organization to contribute to safety by bringing this accident prevention message to the attention of operations managers and pilots who are themselves best able to implement it in exercising their operational decision-making responsibilities.

TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NATIONAL TRANSPORTATION SAFETY BOARD, BUREAU OF AVIATION SAFETY - BAS-30 WASHINGTON, D.C. 20591	ACTION: INFO:	
ACCOUNTING CLASSIFICATION D 3 50 07.00.00 51100 2323	DATE PREPARED	TYPE OF MESSAGE ☐ SINGLE ☐ BOOK ☒ MULTIPLE-ADDRESS
FOR INFORMATION CALL		
NAME	PHONE NUMBER	

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED *(Use double spacing and all capital letters)*

TO:

DURING THIS HOLIDAY SEASON, WHICH BRINGS INCREASING DEMANDS ON THE NATION'S AIR TRANSPORTATION SYSTEM, THE NATIONAL TRANSPORTATION SAFETY BOARD, IN VIEW OF RECENT APPROACH AND LANDING ACCIDENTS, AGAIN REEMPHASIZES THE CONTINUING NEED FOR STRICT IMPLEMENTATION OF OPERATIONAL CONTROL RESPONSIBILITIES BY ALL SEGMENTS OF THE AVIATION INDUSTRY ENGAGED IN THE CARRIAGE OF PASSENGERS AND CARGO. EXPERIENCE SHOWS THAT APPROACH AND LANDING ACCIDENTS INCREASE DURING ADVERSE ENVIRONMENTAL CONDITIONS ASSOCIATED WITH WINTER WEATHER AND PEAK TRAFFIC DEMANDS UPON AIR CARRIER OPERATORS.

THE BOARD STRONGLY URGES YOU TO IMPRESS UPON YOUR MEMBERSHIP THE IMPORTANCE OF STRICT ADHERENCE TO ESTABLISHED OPERATIONAL PROCEDURES.

THE BOARD IS CONFIDENT THAT JUDICIOUS OPERATIONAL DECISIONS, SUPERVISION AND PROFESSIONALISM OF YOUR SKILLED AND COMPETENT MEMBERS DURING THIS HOLIDAY SEASON OF INCREASED TRAVEL WILL ASSURE THAT ALL TRAVELERS WILL REACH THEIR DESTINATION SAFELY.

JOHN H. REED
CHAIRMAN
NATIONAL TRANSPORTATION SAFETY BOARD

426-8900

	PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
John H. Reed, Chairman *National Transportation Safety Board*	*1*	*1*	*December 19, 1972 4:00 p.m.*

STANDARD FORM 14
REVISED AUGUST 1967
GSA FPMR (41 CFR) 101-35.306

★ GPO : 1967 OF—300-456 (9-H)

14-306

APPENDIX C

APPROACH AND LANDING RECOMMENDATIONS

SUBMITTED

BY

NATIONAL TRANSPORTATION SAFETY BOARD

1968 to 1972

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
10/29/68 Not. 160 69-13 — Northeast Airlines, Inc. Fairchild Hiller FH-227C, N38ONE, Near Hanover, New Hampshire, 10/25/68 Erratic operation and false reversals. Wilcox 806A VOR navigation receiver. The aircraft had been cleared for an approach to the Lebanon Regional Airport. It crashed 3.8 nautical miles northeast of the VOR station at an altitude of approximately 2,237 ft. m.s.l. At this point in a standard instrument approach, the aircraft should have been no lower than 2,800 ft. m.s.l. During the investigation it was found that some aircraft, equipped with Wilcox VOR Model 806A receivers, while making approaches to Lebanon, reported false station passage by omni bearing indicator reversals before reaching the VOR station. Some air lines operating in other areas using this equipment also reported erratic operation occurrences and false records. The Board recommended that the FAA: "take immediate precautionary action to restrict all operators using this type of Wilcox VOR receiver equipment to visual approaches where radar or DME is not available and require visual flight during en route operations where an exact fix requirement is necessary for terrain avoidance, if DME or radar verification is not available."	11/7/68 Response from the FAA to say that a telegraphic operations and maintenance alert had been sent to all regions, area offices, and Flight Standards offices, requesting that all known users of the Wilcox 806A VOR navigation receiver be advised that erratic operation and false reversals had been reported and that the use of the receiver for en route operations and VOR instrument approaches be restricted. The manufacturer had also been requested by telegram to alert all known users of the equipment as soon as possible. 12/6/68 On this date the FAA issued Avisory Circular No. 91-18 on the subject of "Course Needle Oscillations on VHF omnidirectional Range (VOR) Receivers." Pilots were cautioned to use a solid TO-FROM reversal to determine positive station passage. The circular also outlined a laboratory test procedure to determine whether a VOR receiver was susceptible to reflection interference. 1/1/69 On this date and again on 1/31/69, Wilcox issued service bulletins modifying the 806A & 806C receiver. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
12/13/68 Northeast Airlines, Inc., Not. 175 Fairchild Hiller FH-227C, 69-17 N380 NE, Near Hanover New Hampshire 10/25/68 Signal interference to VOR and navigation aids. An earlier recommendation on this accident was forwarded to the FAA on 10/29/69. (See Rec. No. 69-13). During the investigation the Board also forwarded the following 5 part recommendation to the FAA. A. FAA monitor Lebanon, N. H. VOR area for signal interference. B. Install dual navigational aids in certain areas. C. Review airworthiness of Wilcox 806A radio. D. Develop operational incident reporting system. E. Define positive VOR station passage.	1/14/69 The following is a summary of the FAA's response: A. FAA considers signal interference is minor, however, FAA will consider long term frequency monitoring. B. FAA considers Lebanon, N. H., VOR performs within tolerances. FAA must allot facilities within budget limits. C. Wilcox is now developing a design change. FAA will request all VOR receiver manufacturers to test their units for susceptibility to ground reflected signals. AC-91-18 issued 12/6/68 depicts action taken. D. The FAA will conduct a review of current incident reporting procedures. FAA also recommended that the NTSB revise its Regulation 430.5(a) and add a new term: "(6) To require reporting any irregularity of a navigation facility." E. FAA feels that information in Airmen's Information Manual, AC 61-27, Instrument Flying Handbook, and Air Carrier Training Manuals is adequate. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
9/20/68 ATC System – Communications, Radar Not. 120 Coverage – IFR Standards and 69-10 Proficiency Checks The Board recommended that the FAA – 1. Improve ATC communication methods and procedures for IFR in nonradar environment. 2. Expedite increases in ATC radar coverage. 3. Establish more stringent requirements for pilots using IFR system. 4. Require an annual proficiency flight check for all IFR pilots. 1/9/69 The Board restated its position making the following comments: a. Further studies and developments will result in more effective communications. b. Lower levels of instrument proficiency be detected and raised to insure the safest degree of pilot responsiveness with the system. c. FAA's efforts in encouraging voluntary refresher and proficiency training programs are commendable. However, in such programs, there was no assurance that the pilots who needed the training most actually receive it. d. It is realistic to press for instrument proficiency requirements even if field office workloads have to be adjusted to comply with the need to upgrade safety. CONTINUED	12/10/68 The FAA responded stating: 1. Current ATC procedures are within the present state of the art and communications facilities. 2. A substantial expansion of radar facilities is planned within the budgetary limits. 3. They have reviewed and updated minimum levels of experience and skill of instrument pilots in the past. 4. A similar proposal was made in 1967 and met with strong opposition from the public. Their field offices are not staffed to undertake the workload requirements indicated in the proposal. 2/6/69 FAA replied that voluntary pilot education programs and upgrading of pilots' skills will improve safety in general aviation operation. FAA also reiterated that lack of qualified personnel was the main reason for not acting upon recommendation for proficiency checks of instrument rated pilots. 4/2/69 FAA agreed that accelerated action is now warranted. They are developing an NRPM to require periodic proficiency checks for all instrument-rated pilots. They request analysis of Board's statistics on IFR accidents involving instrument-rated pilots where lack of competence or proficiency was involved; and the Board's specific recommendations for changes to standards. 8/13/69 The FAA requested additional data to assist in the preparation of an NPRM requiring periodic proficiency checks of instrument rated pilots. 2/25/70 Verbal information from the FAA to say that the NPRM is expected to be issued by 5/1/70 (per W. Lamb). CONTINUED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
3/24/69 The Board informed the FAA that the safe operation of the airspace system could be no better than the proficiency and capability of the users. Moreover, if the IFR system traffic loads increased as predicted, the disparity in the user pilot proficiency levels could only continue to widen, and the task of system modification would become more difficult. The Board recommended that the FAA reconsider mandatory periodic proficiency checks for instrument rated pilots and that initial qualifications for instrument rating be reevaluated with a view to upgrading the certification standards. 5/14/69 The Board agreed to compile and send the accident data as requested. The Board also recommended that the minimum standards for the initial issuance of an instrument rating be made compatible with the instrument qualifications required for the issuance of an airline transport pilot certificate. 7/16/69 The Board provided the FAA with the statistical data of IFR accidents. 9/15/69 Board letter to the FAA stating that a computer print-out of the additional information will be forwarded shortly. 9/26/69 Computer printout forwarded to FAA.	3/18/71 FAA issued NPRM 71-8 proposing experience and qualification requirements for pilots serving as second in command and annual proficiency checks for pilots in command of U. S. registered aircraft type certified for more than one required pilot. **CLOSED**

NTSB Form 6100.2 (Rev 3/70)

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION

1/10/69 Fatal Accident Piedmont Airlines Fairchild Hiller
Not. 192 FH227B. On Final Approach to Kanawha County
69/25 Airport, Charleston, West Va., Aug. 10, 1968

Air Carrier Undershooting in IFR Conditions

The Board determined that the probable cause of the accident was:

"... an unrecognized loss of altitude orientation during the final portion of an approach into shallow, dense fog. The disorientation was caused by a rapid reduction in the ground guidance segment (segment of approach lights visible) available to the pilot at a point beyond which a go-around could not be successfully effected."

From findings of the above and four other Approach and Landing accidents in 6 months, the Board recommended:

A. FAA amend FAR 91.117 and 121.649 to prohibit any approach below 200 feet unless runway threshold is in sight.
B. FAA increase their educational efforts to pilots concerning the hazards of shallow penetration of fog.
C. Shallow penetration of fog, the effect upon the guidance segment and potential illusions be included in curriculum of air carrier training programs and instrument flight schools.
D. FAA expedite their research project to develop slant visual range information.
E. FAA establish standards, specification, and encourage the development of synthetic trainers for realistic low visibility approach simulation.
F. Improve approach zone lighting in the last 1000 feet of the approach at airports with a history of frequent heavy fog.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

1/28/69 While agreeing with the basic intent of the Board's recommendations, FAA made following specific comments:

A. Considering rule making to eliminate VFR provision of FAR Section 121.649(b). Do not intend to amend FAR 91.117. Requiring pilots to maintain 200′ until they have the runway threshold in sight could lead to high rate of descent problems. For precision approaches, approved minimums are runway visual range (RVR) 1800′, decision height (DH) 200′. Pilot may not have runway threshold in sight at these minimums but may continue approach provided the approach lights or other markings are clearly visible.

B and C:
An Air Carrier Operations Bulletin stressing the importance of visual cues prior to and during descent below MDA (minimum decision altitude) or DH (decision height) has been issued. Bulletin emphasizes requirement that a missed approach must be executed when visual cues are lost after MDA or DH. The Bulletin requires review of operators' training programs and operational procedures pertinent to low visibility approaches. Regions are to ensure subject is covered in all FAA approved instrument flight schools.

D. FAA Systems Research and Development Service is planning instrumentation of a tower at National Aviation Facilities Experimental Center which will be used in research on slant visual range.
E. FAA actively engaged with air carriers simulator manufacturers and the Air Transport Association Training Committee in developing standards and specifications for simulator visual systems capable of providing low visibility approach simulation.
F. The U. S. Standard configuration "A" ALS (Approach Landing System) is acceptable for minimums as low as 1200′ RVR (Runway visual range). FAA has adopted ICAO Standard ALS for standardization of the last 1000′. As funds become available the new ALS will be installed on new Category II runways.

CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	1/28/69 Cont'd. Note: FAA responded affirmatively to five of the Board's six recommendations. The Board did not agree with the FAA's contention that FAR 91.117 adequately provides the safety protection needed for approaches involving the shallow fog phenomenon. The continuance or discontinuance of instrument approaches as governed by FAR 91.117 to be further studied. **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
1/17/69 Not. 197 69-26 — IFR – Approach and Landing Accidents Accidents that occur during the approach and landing phase are amongst the most numerous. The Board made the following 13 part recommendation after several such air carrier accidents during the winter of 1968-1969. 1. Pilots, operators, and the regulatory agencies should renew emphasis on – and improve wherever possible – cockpit procedures, crew discipline, and flight management. 2. That FAA review policies, procedures, practices, and training toward increasing crew efficiency and reducing distraction and nonessential crew functions during the approach and landing phase of the flight. 3. That crew functions not directly related to the approach and landing be reduced or eliminated especially during the last 1000 feet of descent. 4. That during the final approach one pilot maintain continuous vigilance of flight instruments–inside the cockpit–until positive visual reference is established. 5. Where less than full precision facilities exist, it be a requirement that during the last 1000 feet of final approach the pilot *not* flying call out altitudes in the 100-foot decrements above airport elevation. 6. That there be a requirement to report indicated altitude to air traffic control at various points in the approach procedure such as the outbound procedure turn and at the outer marker position. 7. That the aviation community consider expediting development and installation of audible and visible altitude warning devices and the implementation of procedures for their use. 8. Reassess altimetry systems with particular regard to their susceptability to insidious interference by forms of precipitation.	2/6/69 The following is a summary of the FAA's response: 1. The FAA reiterates their immediate concern and has initiated a program of follow-up action in the areas of procedures, and cockpit discipline and vigilance. 2. FAA inspectors have been directed to review, on a continuing basis, cockpit checklists and procedures to assure that minimum checking will be done during the more critical periods of flight, such as departures, approaches, and landings. 3. FAA believes the airlines require all cockpit check procedures to be completed well before the last 1000′ of descent; however, the FAA inspectors are to double check and take action where warranted. 4. FAA inspectors have been directed to assure that cockpit check procedures are arranged so that the pilot flying devotes full attention to flight instruments. In an FAA wire to all U. S. Airline presidents, 12/30/68, FAA stressed crew vigilance and cockpit discipline. 5. The FAA had asked the air carriers to adopt a requirement that the pilot not flying call out, during the final 1000′ of the approach, 500′ above field elevation, 100′ above minimums, and minimums. The FAA believes this procedure is preferable since it serves to keep cockpit conversation to a minimum, assure pilot altitude awareness, and reduces pilot workload. 6. The FAA indicated that the pilot reporting of altitudes during instrument approaches would significantly increase radio frequency congestion and increase crew and controller workload. The FAA believes their efforts in pilot training and education will prove to be the most beneficial course of action. 7. The FAA adopted a rule, Sept. 1968, requiring altitude alerting devices in jet aircraft by Feb. 28, 1971. 8. The FAA plans to participate with NASA and the aviation industry in an assessment of possible failure modes of the altimeter static systems. The FAA reported that development and testing is required for approval of system modifications and at this time they know of no practical replacement for the barometric altimeter. CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
9. That the development of additional altitude warning systems external to the aircraft needs to be explored by the aviation community; such as a high intensity visual warning red light beam on approach and glide path. 10. That development is needed in the fields of radio/radar and inertial altimetry and CRT/microwave pictoral display approach aids as possible improved replacement of the barometric altimetry system. 11. That modified use of existing approach radar should be further studied with regard to its adaptability as a surveillance – accident prevention – tool for nonprecision instrument approach. 12. That the FAA and air carriers increase surveillance, more frequent and more rigorous inspection and maintenance of altimetry systems. 13. That the FAA reexamine certification requirements and procedures to determine if there is a possibility of a single failure mode of nominally dual systems which, when combined with an already existent passive failure or inadequate cockpit procedures, can invalidate dual failure protection devices. 6/19/69 The Board provided the FAA with additional information as in "11" above. This related to details on modified use of existing approach radar, envisaging automated (unmanned) functioning to monitor and warn of descent below glide path during nonprecision approaches.	9. The FAA reported that a high intensity visual warning red light beam on approach and glide path would not provide complete information concerning the optimum glide path as does the visual approach slope indicator (VASI) system which is installed at many runways throughout the country. The FAA plans to continue to install these systems in accordance with current criterial within the limits of funds appropriated for this purpose. 10. The FAA reported that the use of inertial altimetry could be investigated, but must be considered as a long range research and development program. The cathoderay tube (CRT)/microwave pictorial display (radar mapping) has been evaluated by the military as an additional approach aid monitor but as yet the FAA does not have the detailed information because this equipment had been classified until recently. The FAA plans to look into the matter further. 11. The FAA requested additional information to clarify this part of the recommendation. (On March 17, 1969, Bureau personnel informally clarified intent to FAA Flight Standards personnel via telecon). 12. The FAA Flight Standards Service, the Airline Transport Association's Engineering and Maintenance Advisory Committee met to review and discuss altimetry problems. Air Transport Association (ATA) advised the FAA that few troubles are being experienced or reported by the flight crews. This was confirmed by the FAA analyses of the maintenance reliability reports. The Air Transport Association had agreed to reactivate its altimetry and static system maintenance subcommittee to further explore this area and review and update material previously published on this subject. 13. The FAA indicates that a Notice of Proposed Rule Making was issued on August 6, 1968, proposing revisions to Part 25 of the Federal Aviation Regulations to require in systems design means to assure continued safe operation following any single failure or combination of failures not shown to be extremely improbable. Industry comments to this proposal are now being reviewed and analyzed. CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	7/28/69 The FAA did not concur in the use of modified Precision Approach Radar (PAR) for nonprecision approaches because of added cost. ($760,000 as opposed to low cost ILS at $81,000) Also, installation of PAR at non-ILS airports would be limited to airports with a control tower. Data collected on altimetry system errors, or suspected areas of possible system failure were presented to NASA for study, research, flight test evaluation and analysis on 3/26/70. **OPEN**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
3/17/69 Not. 220 69-31 **Puerto Rico Int. Airlines, Flight 277 De Haviland Heron IFR from St. Thomas, Virgin Islands to San Juan Int. Airport. Accident 14 miles Southeast of San Juan VORTAC on March 5, 1969.** **Concerning ATC Restrictions at San Juan.** The Board recommended: A. All aircraft not transponder or DME equipped operating in instrument flight conditions at the San Juan, Puerto Rico approach control area be required to maintain the highest minimum obstruction clearance altitude (MOCA) for that area until over the VORTAC. That such flights descend to approach minimums within 5 miles of the VORTAC while under radar control or be allowed to descend following the standard instrument approach procedure. B. That the FAA review approach control procedures at other locations where similar topography exists and apply the foregoing procedure where warranted.	3/21/69 The FAA responded stating they agree with the Board's facts as reported. Prior to the receipt of this recommendation they had placed a limitation on the use of the San Juan ASR system in that aircraft were not to be vectored below a line five nautical miles south of the centerline of Route 2. This procedure would accomplish the intent of the Board's recommendation relating to San Juan, and would provide operational flexibility. FAA also stated they had issued instructions nationally, stressing controllers use extreme caution when reidentifying an aircraft after radar contact is lost. The procedure requires that when a heading is issued for reidentification the controller will ensure that the heading will not place the aircraft in an area that will require an increased minimum IFR altitude. FAA stated they had issued a notice to all facilities stressing the importance of accuracy obstructing altitude information displayed on radar video maps and overlays. Since this accident the radar at San Juan had been thoroughly checked. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
4/23/69 Not. 233 69-35 **Instrument Approach Procedure Charts** From a study of air carrier accidents during the landing phase of flight. The Board recommended: 1. Another fix be depicted on the VOR/DME approach chart between the final approach fix and the airport/minimum descent point and a minimum crossing altitude restriction should be associated with this fix. 2. That the height above ground at the final approach fix be depicted in the profile portion of the instrument approach chart adjacent to the minimum sea level attitude prescribed over each fix displayed on the profile.	5/5/69 The FAA stated that implementation would require changes in the Terminal Instrument Procedures (TERPS). Will be presented to DOD/FAA Committee prior to presentation to industry user representatives for comment. After group review, Board will be informed of action FAA will take. 4/13/70 FAA responded stating that comments to the Board's recommendation have been received from the DOD, pertinent civil organizations and FAA technical specialists engaged in this activity. Comments received were strongly opposed for the following reasons: 1. The pilot who deliberately "pushes over" during execution of a non-precision approach will not be prevented from doing so by the addition of a third fix as recommended. This practice can only be cured by additional training. The problem is being attacked by increased surveillance of non-precision approaches during en route inspections and by increased emphasis of this type approach in approved air carrier training programs. In lieu of adding a third fix, emphasis is being given to the installation of additional precision approach aids (ILS) to provide more accurate guidance throughout the final approach. 2. Depiction of radio altimeter reference points on instrument approach charts for all non-precision approach procedures would certainly be desirable; however, at the majority of locations the underlying surface is either irregular, sloping or built up. Therefore, radio altimeter readings fluctuate rapidly and give misleading information. In view of this, it is impractical to depict accurate reference points on most instrument approach charts. There are some locations where the final approach area overlies water or where the terrain is extremely flat and level and reference points could be depicted. Consideration was given to publishing reference points for such locations; this was not found desirable since publication of this type data on some charts, but not all, created a non-standard presentation which could be confusing to pilots. In view of FAA's alternative action, recommendation treated as CLOSED.

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
9/4/69 290 (70-6) Public Aircraft, National Aeronautics and Space Administration, TF-8A, NASA 666, Cleveland Hopkins Airport, Ohio, July 14, 1969 **Exposed Runway Lip** While pilot was making touch-and-go landings, the aircraft hit a raised exposed near vertical-faced Lip of 4" to 6" at end of runway. Impact blew out the right main gear tire. Pilot endeavored to go around. Insufficient airspeed and over rotation of the aircraft caused it to stall. Impact, and fire after impact, destroyed aircraft and seriously injured pilot. The Board requested the FAA to locate exposed runway lips at all airports and exercise its influence to have this undesirable condition removed.	9/24/69 The FAA responded stating: (a) They have advised the City that unless the hazard is removed, further grants under the Federal Aid Airport Program will be suspended. (b) Advisory Circular 150/5200-5, already issued, requires airport management to conduct safety inspections of eroded runway lips and other such hazards. (c) FAA field personnel will inspect and identify potentially hazardous conditions at other airports. (FAA's action in full compliance with the Board's Recommendation - **CLOSED**)

SOURCE AND NATURE OF RECOMMENDATION

11/26/69 Avion Inc., DC-3 N142D, New Orleans, Louisiana, March 20, 1969.
Not. 337
70-16

Changes and Additions to FAR Part 91 – Takeoff and Landing under IFR's

The accident resulted from an attempt to land in weather below RVR minima for an ILS approach.

Under FAR's secs. 121.653, 123.27 and 135.111 air carrier pilots are not permitted to begin an instrument approach if the visibility is below the landing minima. The restriction is on the approach as well as the landing. However, in entirely the same conditions a pilot may operate under sec. 91.116 and not be restricted in his approach. In fact, he may be encouraged to "take a look."

Under sec. 91.117(b) descent is apparently permissable to Cat. II limits with a non Cat. II aircraft and/or a non Cat. II pilot.

The Board recommended:

1. Sec. 91.116 of the FAR be changed to agree with the provisions of Sec. 121.653 and the similar requirements of Parts 123 and 135 in order that the approach is restricted as well as the landing.

2. Sec. 91.117 be amended to the effect that in no event should descent below 200 feet be made unless landing minima are present.

3. An additional condition be added to Sec. 91.117(b) to the effect that if landing minima cannot be maintained, a missed approach be executed.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

12/12/69 The FAA thanked the Board for this timely recommendation regarding the need to amend section 91.116 of the FAR to be compatible with the restrictions in Sections 121.653, 123.27 and 135.111 and indicated they have been cognizant of the need to make amendments along the lines suggested by the Board. Action is being taken to accomplish this, and towards this end, a Notice of Proposed Rule Making is being issued.

NOTE: Recommendation OPEN pending receipt of the NPRM and further evaluation.

11/17/70 FAA responding to the Board Report on the JAL accident in San Francisco Bay on 11/22/68 took this occasion to state that they intend proposing a rule to:

Prohibit any person who begins the final approach segment of an instrument approach procedure from descending below the authorized MDA or continuing the approach below the DH unless after that person has clearly in view the approach threshold of the runway of intended landing, or the approach lighting system or other marking or lighting system intended to identify the threshold of that runway and has determined that:

1. The aircraft is in a position from which a normal approach to that runway can be made; and

2. Descent below the MDA or continuance of approach below the DH can be safely accomplished in the existing weather conditions using those visual aids.

The purpose of this change is to emphasize pilot responsibility to determine that the visual cues are clear and that the approach may safely continue.

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
12/18/69 Not. 328 70-18 **TWA B-707-331C NAFEC Experimental Center, Pomona, N. J., July 26, 1969** Simulated Engine(s)-out Operations Since Sept. 13, 1965, the Board has investigated five major air carrier accidents that have occurred during the conduct of simulated engine(s)-out training close to the ground. Present generation flight simulators now provide the capability for simulating virtually every flight situation, including controllability characteristics of specific aircraft in flight with one or more engines inoperative. The Board recommended the following regulatory changes: 1. All maneuvers requiring simulated engine(s)-out operation of aircraft close to the ground be conducted in simulator training devices where possible. 2. The Administrator establish a minimum altitude above the terrain for those simulated engine(s)-out maneuvers that must be performed in flight. 3. Crewmembers not directly involved in the training operation be prohibited from the flight deck on all proficiency flight checks.	12/30/69 1. The FAA concurred with the first part of the Board's recommendation stating that their philosophy, as regards utilization of flight simulation training devices, coincided with the Board's thinking and was so reflected by the amendments and changes in the training requirements stipulated in the FAR's. 2. In response to the second part of the recommendation, the FAA stated that an actual visual system is required to simulate maneuvers such as engine failure on takeoff and the circling approach for landing. (The Board does not disagree to the need for such training in actual flight, but questions the necessity of creating hazardous conditions in training by enforced simulation engine-out maneuvers at low altitude. Such training should be carried out at an altitude to provide the time necessary for emergency recovery.) 3. Commenting on the third part of the recommendation the FAA stated that one accident may have involved distraction during training but there had been other instances where additional crewmembers have alerted the pilot to an unsafe condition. Flight training of crewmembers in pairs was highly desirable and advantageous to the pilots concerned and was intentionally arranged. Nevertheless, Principal Operations Inspectors will be advised to ensure that adequate members on the flight deck do not interfere with the performance of the crew. (Apparently the thrust of the Board's recommendation was misunderstood. The amount of training a highly trained airline captain receives by observing one equally competent is highly questionable.) Members of the staff will meet with FAA's Flight Standards Service to exchange views and obtain a better understanding for the resolution of this recommendation. CONTINUED

NATIONAL TRANSPORTATION SAFETY BOARD

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	NOTE: (7/29/70) Meetings were held between FAA and BAS. The FAA insists upon retention of engine(s)-out training maneuvers in flight and will not agree to a minimum altitude restriction on all initial and upgrade – flight checks. Waiver of this maneuver on later flight checks is at the option of the flight examiner, and dependent on the existence of a suitable visual simulator. The FAA has issued a warning directive to the carriers, and several carriers have implemented their own corrective action. Regulatory action would result in a blanket exclusion which would far exceed the scope of the Board's proposal. The Bureau concurs. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
3/4/70 Board Report CY70-12 — Aircraft Accident Report Allegheny Airlines, Inc. Convair 580, N5802, Bradford, Pa. 12/24/68. Approach and Landing Accident – Board Report Recommendation. 1. The Board urged the FAA to expedite the installation of ILS at qualified fields currently equipped with non-precision approaches within the limits of available resources, and 2. to consider installation of approach lights to improve safety of non-precision instrument approaches at those airports where the installation of a full ILS is not feasible.	3/10/70 The FAA concurred with the Board's recommendation and stated: 1. Their goal is "to provide non-visual vertical and lateral guidance equipment for all runways serving air carrier turbojet aircraft or where weather or safety of flight conditions warrant. This program has already commenced with the installation of 10 Airborne Instrument Laboratories "turnkey" ILS's at air carrier locations plus the additional purchase of approximately 100 ILS's. 2. Their criteria provides that "airports with a non-precision approach aid and activity levels of 300 or more annual instrument approaches or 2,725 annual passenger originations are eligible for a medium intensity approach lighting system (MAIS), provided visibility minimums will be reduced." These policies are reflected in Airway Planning Standard No. 1 effective 12/19/69. Administrators reply fully responsive. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
3/12/70 Not. 372 CY70-13 — **Den 70-A-36. Lear Jet N714X Salt Lake City, Utah, 12/3/69** **Controller Fatigue/Work Rotation Schedule** The approach controller and local controller failed to provide the minimum horizontal separation between N714X and a preceding Boeing 737. Apparently during the approach, N714X encountered the left wing tip vortex generated by the B-737 and went out of control. Apart from the fact that inadequate separation (less than the required three miles) seemed to be the primary cause of the accident,. investigation revealed that the controller's work rotation schedule was not conducive to maximum rest and operational efficiency, and may well have induced fatigue affecting work performance. In light of the Corson Committee Report, which speaks at considerable length on the subject of the effects of rotation shift work on controller's well being and performance, the Board recommended, that the shift rotation as practiced by the controllers at Salt Lake City be discontinued and that "short turnarounds" between 8-hour shifts be limited to unusual circumstances. 5/8/70 The Board restated its belief that the "short turnarounds" between 8-hour shifts should be limited to unusual circumstances. Expressing pleasure at FAA's intentions to give this recommendation very careful consideration, the Board said that it would await with interest the conclusions and recommendations of the task force set up to work on the Corson Committee Report.	3/24/70 The FAA stated that they had no solid evidence at the present time upon which to base an elimination of the shift rotation practices and the "short turnarounds" such as being used at Salt Lake City Tower. Over the past three decades, air traffic control facilities have been given considerable leeway in setting up their work schedules. The "short turnaround" schedule is one of the most preferred and widely used. Notwithstanding this controller preference, if a safety issue is involved, they will face up to the issue. A task force is examining the Corson Committee Reports and recommendations. The Board's recommendation will be given very careful consideration by the group working on this matter. **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
5/22/70 Not. 433 CY70-23 — Review of Several Cessna 150 Accidents in Power-on Go-around Configuration Malfunction of Electrical Flap Actuators The inadvertent retraction of flaps on certain Cessna single-engine aircraft with electrical flap actuators is strongly suspected as a cause factor in a number of fatal Cessna 150 (Model F or later) aircraft accidents. The Board recommended that until a more complete preventive action can be determined, all operators of appropriate Cessna single-engine aircraft with electrical flap systems be advised immediately of the potential hazard and appropriate piloting techniques, to assure adequate control of the aircraft in the event of flap system malfunction. 6/26/70 The Board recommended more detailed information be included in FAA's alert and disseminated to operators; for without this knowledge the importance of following service instructions and the need for appropriate piloting techniques would very likely be missed. Although the failures of the flap actuators could not be reproduced in the laboratory, it was the Board's opinion that corrective or preventive action prescribed by Cessna appeared suitable, provided the preventive maintenance was made mandatory at reasonable inspection intervals. The Cessna Company's findings that "shellacking" of the jack-screw drive induced slippage was valid. Preventive maintenance did not preclude recurrence for an unlimited time, neither did it resolve the precise mechanism of failure. CONTINUED	6/4/70 FAA stated they were in the process of developing a telegraphic alert notice when they received the Board's recommendation. Within a matter of hours a notice was dispatched to FAA offices having an interest in the matter. The notice alerted them to the problem, prescribed adherence to Cessna Service Letter SE68-33 which provides specific remedial action to prevent this malfunction, and recommended that, in the event of such an occurrence, appropriate piloting techniques be emphasized. Flight Standards personnel were requested to promptly disseminate this information to all affected operators. Note: On 7/21/70 the FAA issued an AD (70-15-16 Cessna Amdt. 39-1050) requiring periodic inspections of the actuator jack screw for condition of lubricant and presence of contamination in accordance with Cessna Service Letter SE-70-16, Supplement #1, dated 7/10/70. 7/27/70 In response to the Board's letter of 6/26/70 the FAA stated that they were "unable to substantiate or compile any history or known problems of pilots relative to accidents or incidents where the pilot inadvertently retracted the flaps." They believe that their action taken in Notice dated 5/22/70, and the issuance of AD 70-15-16, Amendment 39-1050, dated 7/17/70 was timely and effective in precluding unwanted flap retraction of the type mentioned in the Board's correspondence. The FAA further stated that they have advised their field personnel of the Board's concern that they merely inform operators and flight instructors regarding proper flap operating procedures and of the Boards suspicion that improper or inadvertent flap retraction at low altitudes could be a cause factor in a number of fatal accidents. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
The Board further stated that it was not satisfied that the inadvertent retraction of flaps due to jackscrew drive slippage was exclusively the major causal area. Unwanted flap retraction could well be operational, or system design/operator induced. It was in the latter area that the Board believed that assurance was required that a hazardous condition would not arise because of inadvertent flap retraction resulting in sudden loss of altitude in a low go-around regime with the risk of an inexperienced pilot at the controls. The issuance of an AD to require preventive maintenance to preclude mechanical failure would not in itself solve the operational problem, the Board reiterated its recommendation that all operators and owners be advised of the hazards associated with inadvertent flap retraction at low altitude and the appropriate operational techniques to cope with the problem.	

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
5/28/70 Lear Jet N1021B, Lake Michigan. Not. 423 Horlick-Racine Airport, Racine, Wisconsin 11/6/69 CY70-25 **Instrument Approach to Horlick-Racine. Additional Means of Identifying the Marion Fix** The aircraft crashed into the lake while executing an ADF approach on the 206° bearing to the Horlick-Racine RBn. At 3.6 nautical miles from the RBn, the Marion Fix is utilized to determine the minimum altitude for the approach. The Marion Fix can only be determined by radar assistance from Milwaukee Approach Control and/or an ADF bearing from the Outer Marker of the General Mitchell Airport ILS. To use this fix, the descending aircraft must have either dual ADF capability and/or receive an assist from Milwaukee Approach Control. The capability of the Marion Fix can be expanded by designating a radial of the Milwaukee VORTAC (MKE) to support further the fix. Adoption of this suggestion would permit this fix to be utilized by aircraft with single ADF and VOR capability, and serve as an additional backup to dual ADF equipped aircraft. The question to be resolved would be the ability of the MKE VORTAC to supply sufficient signal strength to support this requirement. The Board, therefore, recommended that the FAA investigate the feasibility of designating a radial of the MKE VORTAC as an additional method of identifying the Marion Fix. Should the MKE VORTAC possess the capability of supporting this requirement, this radial should be made a part of the Marion Fix, and all procedures should be modified accordingly.	6/15/70 The FAA responded stating: The Marion Fix on the final approach course is a stepdown fix to provide a 100′ lower minimum descent altitude (MDA) when the fix is identified. FAA Handbook 8260.3A, paragraph 288c, U. S. Standard for Terminal Procedures (TERPS), specifies a maximum accuracy of plus or minus 2 miles for this fix. They are presently utilizing an ADF bearing from the Milwaukee LOM which is 6.1 miles from the final approach course with a fix accuracy of .7 of a mile. The fix accuracy when utilizing a radial from the Milwaukee VORTAC would be 2.1 miles due to the distance of 29 miles from the VORTAC to the final approach course. The VOR located on the Timmerman Airport at Milwaukee is close enough (1.7 mile fix accuracy) and could be used for this purpose. Although any aircraft may request that the fix be identified by RADAR, they concur that the utility of the approach procedure would be improved by permitting aircraft with VOR and ADF receivers to use the lower MDA since duel ADF receivers are now required. However, this addition would not improve the safety of the procedure. The Board's recommendation is being forwarded to the FAA Central Region, who are being asked to add a radial from the Timmerman VOR as a method to identify the Marion Fix providing flight inspection and procedures criteria are met. **TOTAL COMPLIANCE – CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/13/70 Board Report CY 70-36 Not. 230 — SAS DC-8-62, LN-MOO, Santa Monica Bay Near Los Angeles, Calif. 1/13/69 (DCA 69-A-12) The probable cause of this accident was the lack of crew coordination and the inadequate monitoring of the aircraft position in space during a critical phase of an instrument approach which resulted in an unplanned descent into the water. Contributing to this unplanned descent was an apparent unsafe landing gear condition induced by the design of the landing gear indicator lights, and the omission of the minimum crossing altitude at an approach fix depicted on the approach chart. On 1-12-70 (Not. 357 Rec. No. CY 70-2) the Board recommended a "fail safe" nose gear position light indication. The following two additional recommendations were included in the Board Report. 1. **Altimeter Setting** The Board recommended that when use of the transition altitude is required or opted, the controllers again give the current altimeter setting as the aircraft is cleared to descend below 18,000 feet. This procedure should obviate any possible chance of overlooking or forgetting to set the altimeters properly. 10/26/70 The Board requests the Administrator to reconsider his decision on this recommendation. 2. **Position Approach Radar** The Board recommended that, if the PAR listing is to be carried on all approach charts for the facility where it is installed, the number of the runway(s) served by that PAR be added to the legend.	8/25/70 1. The FAA responded stating that the Board's recommendation that controllers again give the current altimeter setting as an aircraft is cleared to descend below 18,000 feet is not considered necessary, as current procedures require the approach information. The approach control facility is required among other items of landing information to give "the altimeter setting at the airport of intended landing," unless a pilot states the appropriate ATIS code (Handbook 7110.8A, paragraph 533) or states he has received it from the center or another source. The FAA further stated that they did not believe an additional requirement for a third relay of altimeter setting would be of any material benefit to pilots and, in fact, could tend to clutter up an already burdened communications system. 2. The FAA stated that the U. S. Coast and Geodetic Survey instrument approach procedure charts are a common product for use by both civil and military operators. The chart specifications are developed by the Inter-Agency Air Cartographic Committee (IACC) composed of the FAA, DOD and Department of Commerce. In addition, the FAA coordinates all proposed changes to these specifications with industry. They will take action to make this recommendation concerning PAR an agenda item on the appropriate cartographic committee. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/18/70 (Board Report) Not. 451 CY 70-38 — Cessna 310N, N4111Q Near Upland, Calif. 4/12/69 **IFR – Approach and Landing Accident** The probable cause of this accident was the radar vectoring of the aircraft below terrain clearance level following target misidentification by the FAA controller. The Board recommended that the FAA conduct an analysis of the air traffic control system to identify critical procedures, particularly in geographic areas where little or no margin for safety exists. These hazardous situations should then be eliminated by implementing suitable corrective action, or at least the potential danger could be reduced by establishment of vigorous programs to educate controllers and pilots alike to the problem. Obviously, the constantly changing environment of the system dictates that periodic updating of the analysis would be required. The Board acknowledges that such an analysis of the air traffic system represents a major challenge, and if a lack of methodology exists on how to conduct such a study, then research and development on the subject should begin immediately. 11/3/70 The Board expressed two areas of concern: 1. The need to confirm radar identification in terminal areas and 2. The amount of time during which a controller "may safely ponder" whether or not radar contact has been lost. In the Board's view, these two "critical procedures" dramatized the need for the "analysis of the air traffic control system." The Board further presented arguments to support its findings incorporated in the Board Report.	9/11/70 The Administrator stated that the FAA conducts a continuing evaluation of all the air traffic control procedures and revises them as appropriate to provide a safe, orderly and expeditious flow of air traffic. Expressing disagreement with the accident report the Board was asked to identify air traffic control procedures considered critical so that these may be reviewed and responded to by the FAA. 11/23/70 The FAA informed the Board that they are initiating a study to specifically analyze the procedures relating to confirmation of radar identification in terminal areas and the procedures relating to action to be taken when radar contact is lost. The Board will be advised. The FAA expressed disagreement with some of the Board's interpretation of eye witnesses' testimony, and stated that had more weight been given to the evidence of two experienced pilots, the Board would have found that pilot error was at least a contributing factor. **OPEN**

NTSB Form 6100.2 (Rev 3/70)

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/31/70 Caribair DC-9, Charlotte, Amalie, Not. 476 St. Thomas, Virgin Islands, 8/12/69 CY70-43 Runway Slipperiness – Wet Runway Requirements The Board expressed concern at the apparent increase in the number of wet runway overrun accidents (9 accidents/incidents in 1970). The most recent when an Airlift- Int. DC-8-63 went off the end of a 9,400 feet wet runway at Houston International Airport. Present FAR's require a safety factor of 1.67:1 for dry conditions. However, NASA and other test results have indicated that wet runway stopping distances vary considerably due to differences in surface materials and surface characteristics. The safety factor had proved inadequate. The Board therefore made the following two recommendations to the FAA: 1. Reevaluate the adequacy of the wet runway stopping distance requirements of FAR's, and 2. Consider the feasibility of incorporating the NASA traction test procedure in revised wet runway length requirements for air carrier and other appropriate aviation operations.	9/18/70 The FAA stated they have been working with NASA, USAF and the air transport industry to establish appropriate criteria and standards regarding wet runway traction and its application to aircraft stopping distances. They have also been closely associated with NASA test activities and are closely following the work NASA is doing on wheel spin-up under hydroplanning conditions and correlation of rain rate with depth of water on a runway surface. With regard to the Board's recommendations, they propose to utilize the results of NASA tests with the diagonal-braked vehicle to: 1. Reevaluate FAR's wet runway stopping distance requirements. 2. Establish the NASA traction test procedure, i.e., diagonal-braked vehicle, as an acceptable procedure for establishing runway characteristics under dry and wet conditions. The runway texture aspects, i.e., grooving and porous surfaces as tested and reported by NASA, are being considered for application in forthcoming airport certification rules. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION

10/20/70 Boeing Company, B-747, N732PA,
Not. 440 Renton Airport, Renton, Wash.
CY70-52 12/13/69

Approach and Landing Techniques & Procedures – Visual Approach Indicator (VASI) lights

The Board determined that the probable cause of this incident was the premature touchdown of the aircraft during a visual approach to a relatively short runway, induced by the pilot's not establishing a glidepath which would assure runway threshold passage with an adequate safety margin, under somewhat unusual environmental and psychological conditions.

As a result of its study of the evidence the Board made the following 5-part recommendation to the FAA:

1. Require the installation and use of a VASI system at all airports used by large, wide-bodied jet transport aircraft.

1/20/71 The Board requested information regarding locations where ILS and VASI are programmed.

2. Initiate action to insure that modifications are made to the present VASI system so as to make the system more compatible with the characteristics of large, wide-bodied jet transport aircraft, yet retaining its utility for the smaller aircraft. Consideration of the pulsed light concept is particularly encouraged.

CONTINUED

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

11/9/70 FAA responded to the Board's five part recommendation stating:

1. They agree that vertical guidance is an important added safety feature. Their major thrust has been to equip as many runways as possible with ILS in order to assure positive vertical guidance. This has been subject to availability of funds. Airports served by turbojet aircraft are getting top priority. They do not concur that VASI be made a firm requirement for all large, long-bodied turbo jets. This especially applies to the Boeing 747. The B-747 has design improvements over previous turbojet airplanes, such as better over-the-nose visibility and improved dual radio altimeter installations which compensate for the larger size of the airplane. There have been no problems in FAR 121 operations caused by a lack of approach guidance or by pilot difficulty in adjusting to the increased height of the cockpit above the runway.

3/11/71 FAA stated no funds for installation of VASI's were included in their FY 1970 or 1971 congressional appropriations. They enclosed a list of all currently programmed full and partial instrument landing systems.

11/9/70

2. A 3-bar VASI system is in existence which was developed for use by long-bodied turbojets. The criteria has been developed and published and the system has been accepted internationally. One of these systems is to be installed at Los Angeles. The FAA has programs to provide this equipment for as many runways used by long-bodied jets within funding capabilities. This procedure was used to equip runways with the original VASI equipment for previous families of airplanes.

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
Part 3 of 5 to Not. 440 3. Undertake quantitative research into the effect of rain on the windshield in order to determine more accurately the finite relationships between the amount of rain and the degree of displacement between the real and apparent positions of objects viewed through a water-covered windshield.	11/9/70 3. Research such as that recommended would, from a practical standpoint, be limited to investigations of finite numbers of windshield configurations. Such research would not significantly improve safety, inasmuch as each windshield would still have to be individually evaluated to ensure that some unforeseen factors had not been introduced. Rain removal systems have been developed which effectively provide both adequate visibility and lack of undue image displacement. FAA does not believe that further research in these areas can be justified since these factors have not been identified as contributing in accidents, nor have present techniques for design and evaluation been found unsatisfactory.
Part 3 of 5 to Notation 440 (continued) 5/2/72 The Board referred to this recommendation dated 10/20/70 and stated there was no doubt that the accumulation of water on a windshield would distort images and create the illusion that an aircraft is flying higher than its actual altitude. Such an illusion could cause a pilot to initiate a higher rate of descent, which, in turn, could lead to an aircraft landing short of the runway. Being of the opinion that distortion caused by water on the windshield contributed to the undershoot accidents of the DC-8 at Okinawa on 7/27/70, and the FAA DC-3 at La Gudadia, on January 4, 1971, the Board urged the FAA to reconsider its position and undertake the research program as resources and priorities permit.	3/11/71 FAA is not aware of testing methods which would produce quantitative results for this environmental condition and intend only to continue qualitative evaluation of windshield behavior with their related protection systems in the actual conditions. The necessary windshield design data for strength and quality control for production articles is also necessary along with engineering data as to heat and airflow levels which ensure adequate protection for adverse weather operation. FAA is ready to meet with the Board's staff to discuss specific details. 5/17/72 FAA responded stating they agree that accumulation of water on the windshield will distort images, however, they cannot conceive of a regulatory application developed from information gained by researching the variations in distortion due to variations in water quantity. They believe that the requirement under FAR 25.773 to maintain a clear portion of the windshield for a sufficiently clear view for both pilots is a reasonable airworthiness standard. It was pointed out that in both accidents cited, the pilots not only failed to properly utilize precision glide path available to them but had failed to use the rain removal systems. They see no reason to change their position from that expressed in their letter of November 9, 1970.
Part 4 of 5 to Not. 440 4. Undertake research to determine the effect of curved windshields and the possibility of false visual cues from multiple lights in the peripheral visual areas. 1/20/71 FAA requested to brief the Board's staff in respect to the research carried out on curved windshields. CONTINUED	Rejected – CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
Part 5 of 5 to Not. 440 5. Develop and require "in the cockpit" devices which would display the approach path to the pilot, in the absence of externally originated information such as ILS, VASI, etc. Such devices, however, must not appreciably increase the crew cockpit workload, nor distract the pilot from proper use of his flight instruments.	11/9/70 4. The FAA was concerned with the large curved windshield on the 747. An extensive evaluation was conducted, specifically directed toward both normal and varying conditions of adverse conditions including day, night, rain, peripheral lights and icing. It was FAA's findings that the 747 windshield fully complies with airworthiness requirements, in addition, creates no undue hazards with respect to amounts of rain or lightning conditions. 3/11/71 FAA stated they do not feel the need for research in this area, unless novel or unique designs are in the offing since the properties in this form and the resulting refractions of light and the impingement patterns of rain are well known. 11/9/70 5. "In-the-cockpit" devices which display the approach path to the pilot have been developed and are being evaluated by certain manufacturers and operators. The present devices have not been accepted by the operators to date. Additional development and evaluation work is underway. **OPEN**

SOURCE AND NATURE OF RECOMMENDATION

11/20/70 Texas Int. Airlines, Inc., DC-9 N1308T,
Not. 501 Harlingen, Texas Airport Jan. 11, 1970
CY70-59

Different Atlimeters – Need to Standardize Instrument Presentations

Aircraft struck powerline poles on an ILS approach in heavy fog at night.

DC-9 aircraft of Texas Int. Airlines fleet have two different types of Kollsman altimeters with a very similar outward appearance. However, one type altimeter has a cross-hatching presentation for height below 1000 ft. The other type has no cross-hatching to serve as a low altitude warning indicator. A pilot not used to the latter type could mistakingly descend below a safe altitude.

81 The Board recommended that the FAA:

Consider appropriate action to assure standardization, within each air carrier, of critical flight instrument presentations.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

12/1/70 The FAA responded stating they agree that flight crews assigned to different aircraft, of a fleet of the same model, should expect standardization of critical flight instrument presentations. Accordingly, they are carefully considering means by which this standardization can be effected.

OPEN

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
12/3/70 Not. 540 CY70-63 — Board Press Release. Addressed to Aviation Industry. Following Four Approach and landing accidents in early November 1970.	No reply required. CLOSED

To Prevent Approach and Landing Accidents: Need for a Sustained Educational Program.

The Board appealed to 10 airline and private flying organizations urging the aviation industry to develop a sustained educational program for pilots to help prevent approach and landing accidents caused by visibility restrictions and illusions in bad weather. Reference was made to four approach accidents in the first half of Nov. that were under investigation. In each case there was either partial or complete obscuration because of fog.

The Board's review of these and other approach and landing accidents show that they occur with needless regularity and that they are not confined to a single segment of aviation. It was emphasized that there were a number of factors which must be considered in preventing this type of accident, namely, airborne and ground equipment, procedures and piloting techniques and judgement. Safety should be in continually improving the quality and increasing the quantity of landing aids and weather reporting facilities and services. It was further emphasized that all pilots should be thoroughly instructed in the hazards associated with shallow fog penetration and be prepared to make the missed approach decision and execute it without delay whenever the alternative course is required. Illusions tending to disorientate the pilot during the final phases of the approach and the limitations of various systems are but two of the areas bearing upon such a decision which must be recognized.

SOURCE AND NATURE OF RECOMMENDATION

1/12/71 Gary Municipal Airport
Not. 548 Gary, Indiana
A-71-1&2

Control Zone – Conflicting Information in Approach Plate and Chicago Sectional Chart

The instrument approach plate for the Gary Airport published by the Coast and Geodetic Survey dated 11/27/69 indicates that there is a control zone which is effective during certain unspecified hours. There is no indication of a control zone in the Chicago sectional chart. The Board considered this confusing and not conducive to safe flight and made the following two recommendations:

1. That the Administrator concurrently effect a clarification of the status of the airspace area immediately encompassing the Gary Municipal Airport and an expeditious dissemination of the factual information to the aviation public.

Part 2 of A-71-1&2

2. That the Federal Aviation Administration review its procedures for updating airport data on flight information publications, and accomplish the necessary measures to preclude the publication of contradictory information on correlated publications.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

2/4/71 FAA responded stating that representatives of their Air Traffic Service met with NTSB staff on 1/18/71 and explained:

1. The approach plate VOR RWY–2 of 11/28/69 was superseded by a new approach plate, VOR-A; on 11/12/70.

With respect to the status of a control zone for Gary Airport, on 8/27/69, a Notice of Proposed Rule Making was issued announcing that the designation of a control zone at Gary, Indiana, was under consideration. On 8/24/70, this NPRM was withdrawn because it had been determined that the weather reporting requirements for designation of a control zone could not be met. Therefore, a control zone was never established and hence was never depicted on the applicable sectional chart.

The reference to a control zone on the 27 November 1969 approach plate was predicated on the establishment of a part time control zone described in the NPRM. The current approach plate dated 11/12/70 deletes any reference to a control zone and was initiated as a result of FAA's review process.

The Chief of the Chicago Flight Service Station states that all employees are well aware that Gary Airport has no control zone and pilots are not informed that one does exist.

Part 2 of A-71-1&2

2. FAA agreed that contradictory information in flight information publications is not conducive to the maintenance of a safe flight environment. Because of the dynamic nature of aviation, they constantly review their procedures for updating airport data in flight information publications and accomplish the necessary measures to preclude the publication of contradictory information in correlated publications. They are presently exploring improved methods of charting data concerning the existence of services/equipment directly related to instrument approach procedures.

CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
2/5/71 North Central Airlines, Convair 580, N2045, Not. 527 O'Hare Chicago, Ill., 12/27/68 A-71-4 Instrument Approach Regulations The aircraft crashed while it was on an instrument approach. The probable cause was spacial disorientation of the captain precipitated by atmospheric refraction of either the approach lights or landing lights at a critical point in the approach wherein the crew was transitioning between flying by reference to flight instruments and by visual reference to the ground. The Board recommended: "Section 121.652 of FARs be amended to prohibit a captain from being removed from "high" minimums until he has accrued 100 hours as pilot-in-command in type and that 50 percent of this time may be reduced by one hour for one landing that is made by conducting a published instrument approach procedure. Actual or simulated IFR approaches accrued under the Part 121 Training Program would be accepted for such substitution cited." 3/16/71 Letter from the Board agreeing to the meeting and proposed suggestion.	3/1/71 FAA responded stating that they do not believe this requirement would substantially improve pilot familiarity with the aircraft and, therefore, do not believe that it would be practical to add this requirement to the present regulation. They suggest more emphasis be placed on the problem of spacial disorientation instead. They also suggest a meeting with Flight Standards Service to discuss this matter and explore alternatives. NOTE: On 2/22/72 Bureau of Aviation Safety and Federal Aviation Administration staff met. The following two factors considered: a. There were no accident statistics to indicate a significant problem relating to captain time qualifications. b. The proficiency requirements of a captain already called for such high standards that any such restriction as recommended would impose a penalty without an apparent reduction of the hazard exposure. Rejected CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
4/16/71 MIA 71-A-71. Southern Airways DC-9 Not. 597 Gulfport, Mississippi, 2/17/71 A-71-19 **Aeronautical Charting. Premature Publishing of Instrument Approach Plate.** The Board recommended to the FAA: That a policy be established that no instrument approach procedure chart be published in advance of the successful completion of a commissioning flight check of the facility on which the procedure is based.	4/20/71 – FAA concurred with the need for improved control over facility commissioning and the publication of new flight procedures. They are exploring several ways to improve the correlation of the procedure effective date with the facility commissioning date. The Board will be advised. 11/1/71 Letter from the FAA that an agency order is being coordinated internally prior to issuance, which will accomplish in its entirety the actions recommended by the Board 11/20/72 Letter to say that FAA issued Order 8260.26, dated September 27, 1972. The order established procedures which will prevent public release of an IAP until it is known that the supporting NAVAID(s) will perform satisfactorily, and all procedures are accurate and have been confirmed by flight check. It requires the scheduling of facility commissioning dates and airspace designations to conincide with the effective date of the IAP. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION

4/27/71 WAL Boeing 707/720B Ontario Int. Airport,
Not. 611 Ontario, Calif., 3/31/71
A-71-22&23

Failure of Rudder Actuator Support Fitting

Accident occurred during a "high drag" approach with a simulated inoperative engine. Complete loss of rudder control resulted from the failure of the rudder actuator support fitting. The Board made the following two-part recommendation.

1. The FAA reevaluate the mandatory inspection time periods and procedures required in Airworthiness Directive 69-13-2 and Amendment 39-1174 and make modifications as deemed necessary to assure an adequate level of safety.

2. All Boeing 707/720 operators be informed of the potential hazard involved in low-altitude, high-asymmetric thrust conditions in the event that failure of the rudder actuator support fitting should occur.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

4/30/71

1. The FAA stated they are in the process of further amending the AD to reduce the initial and repetitive inspection time intervals and to specify revised inspection procedures as follows:

a. Compliance with initial inspection to be done using ultrasonic techniques reduced from 600 hours to 100 hours.
b. Within 1,200 hours, the bushings be removed, the internal bore of the fitting inspected using eddy current technique, and the fitting comprehensibly protected against corrosion in the reinstallation of the bushing.
c. To continue with either ultrasonic inspections each 650 hours or eddy current inspection, with the bushing removed, each 1,200 hours.
d. That at not later than 5,400 hours or Oct. 1, 1972, fittings be replaced with 7075-T73 material or a new steel design fitting.
e. That dye penetrant inspections have been deleted from the inspection procedures.

4/30/71

2. The FAA issued Operational Alert Notice No. 8430, dated 4/9/71, informing affected aircraft operators of the failures and advising that simulated engine failures at low altitude not be performed in Boeing 707/720 aircraft until either a 7075-T73 support fitting is installed in accordance with Airworthiness Directive 69-13-2 or an inspection has been performed within the previous 100 hours in accordance with revision No. 5, dated 2/3/71, to BACO Service Bulletin 2903 (AD Amendment 39-1174).

Total Compliance – **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
6/28/71 Not. 558 A-71-34 — Mississippi Valley Airways, Inc. DHC-6, N956SM, LaCrosse, Wisc. 11/9/70 CHI-71-A-31 **Approach and Landing Accident** While executing a nonprecision approach in instrument flight conditions, the aircraft struck trees approximately 4,000 feet from the runway threshold. For reasons unknown, the Captain failed to maintain altitude at minimum descent altitude. The Board recommended to the FAA that: "Flightcrew techniques be developed for use during the execution of nonprecision instrument approaches that will require continued altitude reference callouts by the nonflying pilot during the time the aircraft is maintaining the minimum descent altitude. These callouts should be made at reasonable time intervals until the aircraft crosses the runway threshold, or until a missed approach procedure is commenced."	7/9/71 The FAA concurred with the recommendation and stated their program will go beyond that recommended by the Board. They believe the altitude callouts should be made during precision as well as non-precision approaches and that such callouts should begin prior to reaching the minimum descent altitude. Procedures will be instituted whereby altitude callouts will be made by the nonflying pilot and will be included in training programs and operator manuals. **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
7/13/71 Not. 601A A-71-35 — FAA DC-3, N7, LaGuardia Airport, N. Y., 1/4/71 **Removal of Runway Approach Obstructions** The aircraft crashed approximately 2000 feet short of the approach threshold of Runway 4 at LaGuardia. The Board noted the numerous obstructions in the approach area to Runway 4 that intrude into the airspace. Although not a direct causal factor in this accident, their lack of conspicuity may have shortened the warning time available to the crew. The Board recommended that: "The FAA, in conjunction with the appropriate local and Federal agencies, initiate a program to remove these obstructions. Pending this removal, these obstructions should be marked and lighted so as to be clearly detectable day and night."	On 7/26/71 the FAA responded stating that the approach clearance to Runway 4 met the minimum standards. However, prior to this accident, the FAA was working with the Port of New York Authority in an effort to mark and light or remove various obstructions in the approach. The telephone poles cited in the accident report have already been removed and the lines placed underground. The street light has been replaced at a lower height and no longer penetrates the approach surface. **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
11/3/71 Not. 665 A-71-53 thru 55 — MIA 71-A-71, Southern Airways DC-9, Gulfport, Mississippi 2/17/71 **Approach Accident** During an improperly executed VOR/DME daylight approach in poor visibility the aircraft descended below the minimum descent altitude and struck a cable. A successful go-around was made but aircraft received substantial damage. The Board recommended that the FAA: 1. Develop a ground proximity warning system for use in the approach and landing phases of operation. 2. Develop operational procedures to give pilots such warnings. 3. Complete the necessary actions to commission the Instrument Landing System equipment for Gulfport's Runway 13.	11/15/71 The FAA responded stating that they believe that: 1 and 2. The present instrumentation and procedures are safe and adequate provided cockpit disciplines are maintained. 3. Work is in progress and commissioning of a full ILS expected in early 1972.

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
11/17/71 Not. 707 A-71-60 thru 62 — Beech B-99 Bethlehem – Eastern Airport, Allentown, Pennsylvania 10/24/71 **Review of VOR Instrument Approach Plates** The twin turboprop air taxi crashed 10 miles north of the airport and 5 miles north of the Allentown VOR at an altitude of 1,600 ft. There are two 'VOR-1' approaches in the Allentown area, one for each of the two municipal airports. The crew may have erroneously used the approach plate for the East Texas VOR approach and descended to 1,600 ft. resulting in the accident. The Board recommended that the FAA: 1. Require some conspicuous and distinctive markings to be affixed to the Allentown approach plates to enable pilots to identify the proper plate quickly and positively. The words "CAUTION–VERIFY PROPER APPROACH" or similar phraseology may be appropriate. 2. Promptly review all instrument approach plates to determine instances of potential approach plate misidentifications in other locations and if found, institute the same remedial action. 3. As an interim measure, notify the public of this potential hazard by whatever means you deem most expenditious and effective. CONTINUED	11/26/71 The FAA responded stating that they did not consider that the VOR approach plates were a contributing factor in this accident nor did they consider the recommended actions appropriate. ATC recordings indicated that the pilot was fully aware of his position, the navigation facilities he was utilizing and that he was familiar with the destination airport. In view of the pilots voice transmissions and the location of the crash site they do not believe that he used the incorrect chart. This was a routine taxi operation by a pilot who flew regularly into the Allentown, Bethlehem-Eastern Airport and was familiar with the route and airport environment. 5/25/72 Responding to the Board's letter of 5/3/72, the FAA stated that there was no factual evidence to support the belief that the pilots had selected the wrong chart. The FAA agreed that the accident would not have occurred if the pilot had adhered to the authorized VOR approach procedure to Allentown but differed to the cause of the deviation. Towards fulfilling the Board's recommendations, the following actions were proposed: "1. The Eastern Region will increase the altitude over the East Texas VOR since it will not derogate this particular approach procedure. 2. The method of numbering circling approaches will be amended to eliminate any duplication of the alphabetical suffix at any one airport or between airports listed under one city name. This will be accomplished as the affected approach procedures are revised. 3. Government approach charts are identified by the airport name and city at the top of the page and by city and airport name at the bottom of the page, with the airport name in bold type. This method has provided a satisfactory method of identification and we plan no change at this time." Note: No. 1 and 2 accepted No. 3 rejected – **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
5/3/72 The Board reviewed the FAA's letter of 11/26/71, and in responding, restated its belief that a hazard existed in Allentown, Pennsylvania, as well as other airport complexes. The Board further reemphasized the need for implementation of the three recommendations. It was learnt that the FAA was giving consideration to amending the minimum altitude over the East Texas VOR to 2,200 feet m.s.l., the same as the Allentown VOR minimum altitude. The Board considered this revision in essential consonance to its first recommendation. This was however, a localized solution to the Allentown problem and there were other airport complexes that had instrument approach plates requiring review.	

SOURCE AND NATURE OF RECOMMENDATION

2/25/72 Aircraft Accident Report Northeast Airlines, Inc.
Not. 650 DC-9-31, N982NE, Martha's Vineyard, Mass.
A-72-19&20 6/22/71

Ground Proximity Warning Device

The flightcrew were making a straight in VOR approach through the overcast and fog with one mile visibility and an indefinite ceiling at 300 ft. The aircraft struck the water 3 miles short of Runway 24.

The Board determined that the probable cause of the incident was . . .

". . . the lack of crew coordination in monitoring the altitude during the performance of a nonprecision instrument approach, the misreading of the altimeter by the captain, and a lack of altitude awareness on the part of both pilots."

In reporting a similar Gulfport, Mississippi near-catastrophic accident, the Safety Board last November 10 had recommended that FAA develop a ground proximity warning system – preferably building upon equipment already in many airliner cockpits. FAA responded that it believed current instrumentation and procedures to be "safe and adequate," but that it was reassessing requirements for nonprecision approaches to give "additional assistance to the pilot in the form of more accurate position information."

CONTINUED

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

3/15/72 The FAA referred to their letter of 15 November 71 which was in response to the Board's similar recommendation of November 10, 71 following the Southern Airways DC-9 accident at Gulfport, Mississippi. The FAA state their position is unchanged for they believe that current instrumentation and procedures are safe and adequate assuming that cockpit disciplines are maintained. Had company altitude awareness and callout procedures for nonprecision approaches been followed the latter incident also would not have happened.

Nevertheless, the FAA state they have reassessed their system requirements for straight-in nonprecision approaches and are developing new criteria. One involves establishing a final approach descent fix such as a fan marker or other suitable facility for each straight-in nonprecision approach procedure. This descent fix would be located at a point on the final approach from which a normal descent path of approximately 3° from MDA to touchdown can be commenced, provided the required visual reference is established. The pilot would be required to maintain an altitude at or above the MDA until passing the descent fix. Another criterion would be to provide VASI for each runway served by this type approach. The VASI would provide visual vertical guidance at normal descent rates for the visual segment of the approach. These new criteria should result in a greater degree of altitude awareness throughout the procedure.

CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
Noting that the Northeast DC-9-31 was not equipped with either the radio altimeters or altitude alerting systems to which the Gulfport recommendation referred, the Board urged FAA to (1) "require all air carrier aircraft to be equipped with a functional ground proximity warning device, in addition to barometric altimeters;" and (2) "establish appropriate operating procedures" for such a device.	

SOURCE AND NATURE OF RECOMMENDATION

4/17/72 NTSB-AAR-72-11, Southern Airways, DC-9,
Not. 754 N97S Tri-State Airport, Huntington, West
A-72-34 Virginia, 11/14/70
thru 36

Crew Coordination, Ground Proximity Warning Device, Pilot Qualifications

The flight was chartered by the Marshall University football team. It crashed short of the runway. The probable cause of this accident was:

"... the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent although the two most likely explanations are (a) improper use of cockpit instrumentation data or (b) an altimetry system error."

The Board recommended:

34. All segments of the aviation industry continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Particular emphasis should be placed on the accelerated development of area navigation systems with vertical guidance capability and on heads-up display systems.

35. The Administrator evaluate the need for the installation and use of ground proximity warning devices on air carrier aircraft.

CONTINUED

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

5/8/72

The FAA pointed out some mathematical errors in the aircraft accident report. They disagreed with some of the conclusions and were of the opinion that a part of the Board's recommendation was inconsistent with the findings. Comments on the recommendations were as follows:

34. FAA agrees that all segments of the aviation industry must continue to focus attention on crew coordination and vigilance and exercise rigid discipline during the conduct of all instrument approach procedures. With respect to the development of area navigation systems (RNAV), they are moving as rapidly as possible. They presently have an industry/agency task force working full time to determine how to implement RNAV systems. However, RNAV is computed data using information subject to certain errors and while the descent geometry will be improved, the key to safe operation is rigid adherence to minimum descent altitudes. Where VOR/DME inputs are involved, the error is magnified as the distance from the station is increased.

With respect to heads-up display systems, they have not yet found that this provides any added capability when transitioning from the instrument to the visual segment. However, they are encouraging the airlines to pursue the feasibility of using optical systems to provide vertical flight path guidance during visual approaches which will assist pilots in touching down on the optimum point on the runway.

CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
4/17/72 Not. 754 A-72-34 thru 36 36. The FAA should continue to emphasize the importance of the provisions of Part 121.445 in its surveillance and inspection of flight operations under Part 121. Such emphasis is needed to assure that operators are (1) using the best means available to enable pilots to qualify under 121.445, and (2) requiring pilots to show that they have acquired the requisite knowledge prior to completion of a flight release. 6/19/72, the Board expressed interest and appreciation of developments in area navigation systems. With respect to heads-up display, it appeared to the Board that a system similar to the visual approach monitor being tested by one air carrier, used in conjunction with other electronic aids, would assist pilots in touching down at the optimum point on a runway, once they attained visual contact with the runway. Regarding a ground proximity device, the Board is aware that such a device is presently being installed by a U.S. manufacturer in aircraft for delivery to a foreign carrier. The Board believes that existing equipment presently required for use as altitude alerting equipment in air carrier aircraft, could be adapted for use as a ground proximity warning device. The Board expressed interest in FAA's program to investigate the feasibility and practicability of implementing a ground based "independent altitude monitor."	35. The FAA have been closely following the development of proximity warning devices. Although off the shelf equipment is not available, there are some developments underway which hold out some promise. For instance, they have a funded program to investigate the feasibility and practicability of implementing a ground based "independent altitude monitor" (IAM) system which will inform the pilot of his altitude and any discrepancy in the altitude information presented to him. Meanwhile, they believe that continued emphasis on crew vigilance and the precision instrument approach criteria, as discussed in Air Carrier Operations Bulletin No. 71-9 and their letter of March 1972, will enhance operational safety. 36. The FAA stated that the implication of this recommendation was that the crew was not familiar with the airport layout and instrument approach procedure. This, according to the FAA, was inconsistent with the Board's analysis that the crew was familiar with the approach procedures at Huntington and with the MDA on the approach being flown. According to the FAA's analysis, there was no justification for this recommendation.

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION

4/14/72
Not. 496
7-72-37
thru 39

UAL Boeing 737-222, N9005U,
Philadelphia International Airport, Pa. 7/19/70

Crew Coordination – Duties and Responsibilities during Critical Phases of Flight

During takeoff the left engine failed when the aircraft was above V_2 speed and about 50 feet above the runway with the copilot at the controls. Believing that both engines had failed, the captain took over and immediately landed the aircraft overshooting the runway.

The Board made the following three recommendations:

That the FAA (1) "reassess the respective duties and responsibilities of the captain and the first officer during critical phases of flight," particularly "where time may not permit the captain to countermand effectively the decision of the first officer who is flying the aircraft;" (2) "reappraise the current training manuals and instructions provided by all airlines with a view toward a positive approach toward emergency procedures" and with amplification and clarafication of emergency procedures including "safety margins and the need for prompt and proper sequencing of each action." (3) that the Air Transport Association bring the report of this accident to the attention of its training committee.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

4/28/72 – FAA responded stating they have continuously emphasized to their field inspectors the importance of each of the three recommendations. Their review and evaluations of field programs have shown that this philosophy is being carried out in the air carrier training programs. Without placing an FAA inspector on board all airline flights, they cannot determine how effective their preaching has been. However, an ever-improving safety record did indicate significant efforts of field inspectors. A sampling of the total revenue flight hours clearly indicated that airline flightcrews usually strictly adhere to established procedures. This has been verified during FAA's observations and conduct of flight checks and surveillance of airline pilot training programs.

5/10/72 – Response from the FAA to say that they will review the industry-wide implications of this accident report at its next regular meeting.

7/6/72 – ATA Training Committee reviewed the Board's recommendation contained in the report and concluded that the report would prove very useful in the Airline's training program.

CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
5/4/72 Not. 495 A-72-42 thru 45 — Flying Tiger DC-8-63F, N785FT, Naha Air Base, Okinawa, 7/27/70 **Altitude Awareness during Instrument Approaches** The aircraft struck the water 2,200 feet short during a precision radar approach. The probable cause was an unarrested rate of descent due to inattention of the crew to instrument altitude references while the pilot was attempting to establish outside visual contact in meteorological conditions which precluded such contact during that segment of a precision radar approach inbound from the Decision Height. The Board recommended that the FAA: (1) reemphasize to air carrier flight supervisory and pilot personnel the pertinent altitude awareness recommendations set forth in the Board's letter of January 17, 1969. (2) issue an Advisory Circular incorporating excerpts of this report, including the findings, stressing to all instrument and airline transport rated pilots the need for continuous surveillance of flight instruments when operating in instrument meteorological conditions. (3) determine that the Operations Manuals of all air carriers, commercial operators, and air taxi operators are explicit, particularly with regard to altitude callouts when the copilot is flying the airplane during an instrument approach. (4) Flying Tiger Line, Inc., amend its flight operations procedures to set forth specifically the responsibilities and duties, particularly with regard to altitude callouts, of both captain and first officer when the latter is flying the aircraft on an instrument approach.	5/4/72 (1) The first recommendation referred to Chairman O'Connell's letter dated January 17, 1969, which also related to the subject of approach and landing accidents. The FAA responded stating: ". . . as indicated in Mr. D. D. Thomas' letter to the Honorable Joseph J. O'Connell, Jr., dated February 6, 1969, we have made altitude awareness a continuous emphasis item since May 12, 1966. Additionally, in May 1969, we made altitude awareness a specific item on FAA 8430-5, Air Carrier Enroute Inspection Report Operations. Accordingly, in addition to certification and proficiency flight checks, compliance with altitude awareness procedures is a specific item to be observed and reported on by FAA Air Carrier Operations Inspectors during each air carrier enroute inspection." Essential compliance CLOSED (2) In response to the second recommendation the FAA stated: "We believe this is so basic that all instrument rated pilots are aware of the criticality of staying on instruments while flying in instrument conditions. It seems to us the basic issue is one of crew discipline, i.e., failure to adhere to procedures established by the Federal Aviation Regulations (FAR's), the company, and good operating practices." Note: Although not stated explicitly, the intent of this recommendation was to have the Advisory Circular explain the effects of the Cansfeld condition, so that pilots would become aware of its existence. Further, it was hoped that they would include sufficient information for pilots to see for themselves the need for some one to stay on the instruments all the way to positive visual contact with the runway. This recommendation will be a topic for discussion at the Board's hearing into approach and landing accidents to be held in September 1972. Rejected–CLOSED CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	5/4/72 (3) In response to the third recommendation, the FAA stated that: "... interviews with Flying Tiger flightcrews and observation of Flying Tiger flight operations by FAA inspectors reveals that the pilot not flying makes the altitude callouts. Nevertheless, to make this crystal clear, the company modified their instructions, effective May 1, 1972, to include more explicit information. We are also asking our field inspectors to again review all air carrier, commercial, air taxi operators, and air travel club operations manuals .... As a general rule, it is rather basic to assume that the pilot-in-command must perform copilot duties when the copilot is manipulating the controls. We do not believe that voluminous data and information in an operations manual is a substitute for good judgement." Essential compliance CLOSED (4) The FAA stated that their interviews with Flying Tiger flightcrews and observations of Flying Tiger flight operations by their inspectors reveals that the pilot not flying makes the altitude callouts. To make this crystal clear, the company modified their instructions, effective May 1, 1972, to include more explicit information. The FAA are asking their field inspectors to again review all air carrier, commercial, air taxi operators, and air travel club operations manuals to assure that adequate instructions are included covering how the airplane will be flown and the duties of the captain when the copilot is flying. Essential compliance CLOSED

SOURCE AND NATURE OF RECOMMENDATION

6/30/72 Delta Airlines, Inc., DC-9, N3305L,
Not. 869 Fort Worth, Texas, 5/30/72
A-72-76&77

Vortex Turbulence

The vortex turbulence, generated by an American Airlines DC-10 which had just completed a "touch and go" landing while the DC-9 was on the final approach, appeared to be the causal factor in this accident.

The Board recommend that the FAA:

1. Reevaluate wake turbulence separation criteria for aircraft operating behind heavy jet aircraft.

2. Issue alert notices to all pilots and aircraft operators that will stress the urgent need to maintain an adequate separation from heavy jet aircraft.

CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION

7/5/72

In response to the Board's two recommendations the FAA stated:

1. ATC procedures are constantly being reviewed for adequacy. Aircraft operating behind heavy jet aircraft require either five miles radar separation or two minutes longitudinal separation. Controllers issue cautionary information if in their opinion wake turbulence will have an adverse effect. Present nonradar VFR procedures place the primary responsibility for separation with the pilot. Two minutes seperation is provided for successive departures. Until such time as a method of detecting and displaying the position of the vortices is devised, the responsibility for adequate separation will be that of the pilot. All controllers have seen the film "wake turbulence." They will also be shown a video tape to emphasize the fact that large aircraft may also be affected by wake turbulence.

2. Advisory Circular 90-23B issued in May 1971 was distributed to about 650,000 persons. Further reprints will be distributed to the aviation community.

Part 1 of the Airman's Information Manual contains detailed information on Vortex Avoidance Procedures. This is republished and widely distributed each quarter. It is intended to provide free distribution of this to all fixed based operators.

The film on wake has been shown to approximately 185,000 pilots. It is intended to show this to more pilots, all FAA inspectors and all tower and approach controllers.

FAA Telegraphic Notice N8400.14, June 2, 1972, Pilot Training Wake Turbulence, points out the hazards of turbulence in all pilot training activities and accident prevention meetings.

CONTINUED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	Extensive efforts are underway to eliminate or minimize wing tip vortices by aerodynamic design changes and to devise ground sensors which will measure vortex system activity in the runway threshold area. NASA is concentrating its efforts on the aircraft research FAA is sponsoring the ground based detection systems. 8/16/72 – From "FAA News" Following the accident on 5/30/72, the FAA conducted special tests involving the DC-10 and L-1011. Preliminary analysis of the data conducted at FAA's NAFEC in June 1972, indicated that the wakes generated by the DC-10 and the L-1011 presented unique problems. The tangential velocities within the vortices generated by these two aircraft were greater than had been encountered previously in tests involving other wide-body jets. Accordingly, on July 28, 1972, the FAA issued special instructions to all controllers which called for new and increased separation for all aircraft operating behind the DC-10 and L-1011. Previously, a wide-body jet following jet required only three miles spacing. These new separation standards are interim in nature and may be revised pending further testing and a more comprehensive analysis of available data. At the present time, FAA is working with aircraft manufacturers and other government agencies on additional testing. **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/28/72 Not. 648A A72-128 thru 140 — Allegheny, Allison Prop Jet Convair 340/440, N5832, New Haven, Conn., 6/7/71	9/14/72 – The FAA responded stating they are already engaged in corrective activities in the areas covered in the report, hence they are not responding to each individual recommendation. Instead they intend to carry on with actions already underway and include the Board's recommendations in the data to be used in arriving at a final decision. **CLOSED**

Instrument Approach Accident

The Board determined that the probable cause of this accident was the captain's intentional descent below the prescribed minimum under adverse weather conditions without adequate forward visibility or the crew's sighting of the runway environment. The captain disregarded advisories from his first officer that minimum descent altitude had been reached. The Board was unable to determine what motivated the captain to disregard prescribed operating procedures and altitude restrictions are found it difficult to reconcile the actions he exhibited during the conduct of this flight.

The Board classified the crash as "survivable" if rapid egress from the fire area had been possible or if flame propogation had been retarded. Also, the probability of survival might have been increased substantially if there had been an additional cabin attendant.

On 11/12/71, the Board recommended (A-71-59) that the FAA require fuel system fire safety devices for the prevention and control of in-flight and postcrash fuel system fires. Also, in response to NPRM 70-35, the Board opposed the proposed increase of passengers to be served by flight attendants. Incorporated in this report are 13 recommendations.

The following 11 recommendations are addressed to the FAA:

a. FAR 121.571 require a crewmember "to physically point out" emergency exits.

CONTINUED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/28/72 Not. 648A A-72-128 thru 140 b. The "chime system or other audible device" be installed in Convair transport aircraft to allow the flight attendant sufficient time to be seated before takeoff and prior to landing. c. That lights or lighted signs be installed and used on the Convair 580 forward galley. d. That FAR's requiring two cabin attendants for more than 44 passengers be "reinstated without waivers." e. That instructions for opening the Convair 580 rear service door be subjected to a thorough study and reevaluation. f. That lights or lighted signs be installed and used on the Convair 580 forward galley. g. That "standardized instructions" to flight attendants be used during training. h. That adequate shoulder harnesses be provided on all airplanes for flight attendants at their assigned seats. i. That emergency "instructions" for the individual airplane be displayed on the back of the seats in eye level sight of the passengers. j. That air carrier management be required to "establish and implement" a method for continual assessment of the pilot-in-command's performance in executing "operational control responsibility" and that air carrier operations manuals clearly state the manner in which each crewmember is expected to execute his duty. k. That combined "efforts and resources" of government and industry be applied to the expeditious use of technological advances in the field of all weather flight navigation and approach/landing systems. CONTINUED	

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
8/28/72 Not. 648A A-72-128 thru 140 To the Air Transport Association 1. That they "review" existing wage agreements which provide any form of monetary reward to the pilot for a faster than scheduled flight operation to assure that they do not derogate safety. To Air Line Pilots Association and Allied Pilots Association. m. That they "implement a program" to provide means for "peer group monitoring and disciplining" any air carrier pilots who may display any unprofessional traits as exemplified by this accident. CLOSED	

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
9/5/72 Not. 897-A A-72-145 — AAR-72-22, EAL, Inc. B-727-100, N8168G, Flight 9701, Atlanta, Georgia, 12/21/71 **Low Visibility Approaches – Scanning of Cockpit Instruments.** The aircraft struck the approach light system while making a "Category II" instrument approach to Runway 9R. The Board determined that the probable cause was ". . . an unexpected and undetected divergence of the aircraft from the glide-slope centerline induced by a malfunction of the automatic pilot. This divergence occurred at an altitude from which a safe recovery could have been made. However, both the pilot and the first officer were preoccupied at the time with establishing outside visual reference under visibility conditions which precluded adequate altitude assessment from external clues. Consequently, the pilot did not recognize the divergence from the glide-slope in time to avoid contact with the approach lights." The Board noted that there is no current requirement for instrument monitoring after approach lights or runway environment are called in sight, and "in a 'see to land' concept it is understandable that a pilot would wish to make a transition from instrument guidance to ground visual guidance as early as possible." Yet in low visibility – particularly in such Category II approaches – the approach lights may be visible above decision height but not give the pilot adequate vertical information. The Board recommended that the FAA require air carriers to write into their operations manuals a requirement that "the pilot who flies an aircraft during approaches in low visibility conditions . . . monitor the instruments continuously" until lights of the runway itself, not just the approach lights, are called in sight.	9/8/72 – FAA advocate there is need to continue monitoring flight instruments in modern turbojet airplanes all the way into the flare. AC 120-29 (Criteria for Approval of Category I and II Operations) requires the establishment of crew member duties for approach monitoring and the maximum deviation of raw data ILS indications. AC 91-25A recommends conditions under which the approach and landing should be abandoned. It speaks to the need for runway threshold or runway lights to be in sight before continuing descent below DH. This does not preclude or prevent monitoring of the flight instruments for glide slope, airspeed and rate of descent control.

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
6/30/72 Delta Airlines, Inc., DC-9, N3305L, Not. 869 Fort Worth, Texas, 5/30/72 A-72-76&77 Vortex Turbulence The vortex turbulence, generated by Pan American Airlines DC-10 which had just completed a "touch and go" landing while the DC-9 was on the final approach, appeared to be the causal factor in this accident. The Board recommend that the FAA: 1. Reevaluate wake turbulence separation criteria for aircraft operating behind heavy jet aircraft. 2. Issue alert notices to all pilots and aircraft operators that will stress the urgent need to maintain an adequate separation from heavy jet aircraft.	7/5/72 In response to the Board's two recommendations the FAA stated: 1. ATC procedures are constantly being reviewed for adequacy. Aircraft operating behind heavy jet aircraft require either five miles radar separation or two minutes longitudinal separation. Controllers issue cautionary information if in their opinion wake turbulence will have an adverse effect. Present nonradar VFR procedures place the primary responsibility for separation with the pilot. Two minutes separation is provided for successive departures. Until such time as a method of detecting and displaying the position of the vortices is devised, the responsibility for adequate separation will be that of the pilot. All controllers have seen the film "wake turbulence." They will also be shown a video tape to emphasize the fact that large aircraft may also be affected by wake turbulence. 2. Advisory Circular 90-23B issued in May 1971 was distributed to about 650,000 persons. Further reprints will be distributed to the aviation community. Part 1 of the Airman's Information Manual contains detailed information on Vortex Avoidance Procedures. This is republished and widely distributed each quarter. It is intended to provide free distribution of this to all fixed based operators. The film on wake has been shown to approximately 185,000 pilots. It is intended to show this to more pilots, all FAA inspectors and all tower and approach controllers. FAA telegraph Notice N8400.14, June 2, 1972, Pilot Training Wake Turbulence, points out the hazards of turbulence in all pilot training activities and accident prevention meetings. CONTINUED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
	Extensive efforts are underway to eliminate or minimize wing tip vortices by aerodynamic design changes and to devise ground sensors which will measure vortex system activity in the runway threshold area. NASA is concentrating its efforts on the aircraft research FAA is sponsoring the ground based detection systems. 8/16/72 – From "FAA News" Following the accident on 5/30/72, the FAA conducted special tests involving the DC-10 and L-1011. Preliminary analysis of the data conducted at FAA's NAFEC in June 1972, indicated that the wakes generated by the DC-10 and the L-1011 presented unique problems. The tangential velocities within the vortices generated by these two aircraft were greater than had been encountered previously in tests involving other wide-body jets. Accordingly, on July 28, 1972, the FAA issued special instructions to all controllers which called for new and increased separation for all aircraft operating behind the DC-10 or L-1011. Specially, the new standards required five miles spacing for all aircraft, with the exception of the 747 or C5A operating behind the DC-10 and L-1011. Previously, a wide-body jet following jet required only three miles spacing. These new separation standards are interim in nature and may be revised pending further testing and a more comprehensive analysis of available data. At the present time, FAA is working with aircraft manufacturers and other government agencies on additional testing. A-72-76 Superseded by rec A-72-213 thru 218 **CLOSED** A-72-77 Accepted **CLOSED**

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
1/8/73 Alaska Airlines, Boeing 727, N2969G, near Not. 746 Juneau, Alaska, 9/4/71 A-72-205 **Misleading Navigational Information Extraneous Harmonics on Doppler Signal** The aircraft crashed while attempting a nonprecision instrument approach. It had been cleared for a Localizer Directional Aid (LDA). The Board determined that the probable cause of this accident was a display of misleading navigational information concerning the flights progress along the localizer course which resulted in a premature descent below obstacle clearance altitude. The origin or nature of the misleading navigational information could not be determined. The Board further concluded that the crew did not use all navigational aids to check the flight's progress along the localizer nor were these aids required to be used. The crew also did not perform the required audio identification of the pertinent navigational facilities. For an earlier recommendation on this accident see A-72-14 of 2/9/72. In its accident report the Board further recommends that: "The FAA continue the tests now in process concerning extraneous harmonics on the Doppler signal and initiate research into their possible hazardous effects on navigational receivers and associated instrument approaches."	1/19/73 Response from the FAA to state that their tests show no effect on a receiver of the type involved in the accident investigation due to extraneous harmonic radiation. A comprehensive report is presently being compiled on these tests and will be available by March 1973. They further state that they are continuously alert to possible detrimental effects to airborne receiver operation caused by modifications to ground facilities. Such investigations will, therefore, continue to be a part of their program for upgrading ground VOR stations to meet further needs. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
12/20/72 Not. 869B A-72-213 thru 218 — American DC-10, Delta DC-9, Fort Worth, Texas, 5/30/72 **Vortex Turbulence** After the accident, the Board made two recommendations (See A-72-76&77 issued 6/30/72). Subsequent to a public hearing on this accident, the Board made the following six recommendations to the FAA: 213 – Revise appropriate publications to assure that they describe more specifically the desirable avoidance techniques (e.g., following aircraft maintain approach path above VASI or ILS glide slope, extending downwind leg, etc). 214 – Define and publish the meteorological parameters which cause trailing vortices to persist in the vicinity of the landing runway. 215 – Include wake turbulence warnings on the ATIS broadcasts whenever the meteorological conditions identified in Recommendation 2, above, indicate that vortices will pose an unusual hazard to other aircraft. CONTINUED	2/9/73 – The following responses were made to the Board's recommendations by the FAA: 213 and 214 – AC 90-23D was issued concerning information on wake turbulence hazards. Airman's Information Manual contents on wake turbulence was also revised. 215 – ATIS broadcasts not appropriate for wake turbulence information but the cautionary advisory procedures outlined in Handbook 7110.8C and Order 7110.29 are timely and a more effective means of warning against wake turbulence. 216 – The development of separation standards based on relative span loading and variable meteorological conditions are not necessary at this time. 217 – The procedure of providing 3-mile radar separation of aircraft following other heavy jets used for more than 20 years has resulted in no known wake turbulence accidents. The FAA knows of no wake turbulence accidents when the pilot was adhering to recommended wake turbulence procedures. 218 – Methods have been developed to aid pilots in avoiding wake turbulence encounters such as "Keep 'em high"; Stage III of the National Terminal Radar Program; segregation, where possible, of small aircraft. AC 90-23D contains descriptive information to avoid wake turbulence encounters. CLOSED

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
12/20/72 Not. 869B A-72-213 thru 218 4. Develop, on an expedited basis, new ATC separation standards which consider the relative span loadings of the vortex-generating aircraft and the following aircraft under meteorological conditions defined as being conducive to the persistence of trailing vortices. 5. Pending the development of the standards referred to in Recommendation 4, above, instruct controllers to increase separation times of controlled aircraft to at least 3 minutes whenever the meteorological conditions defined under Recommendation 2, above, exist. 6. Develop methods for tower controllers to aid pilots of flights in the traffic pattern to maintain adequate separation to avoid wake turbulence encounters. Such methods might include the use of local geographic landmarks, radar or time separation over fixed points.	

NTSB Form 6100.2 (Rev 3/70)

NATIONAL TRANSPORTATION SAFETY BOARD

Status of Board Safety Recommendations

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1/8/73 Not. 746 A-72-205 — Alaska Airlines, Boeing 727, N2969G, near Juneau, Alaska, 9/4/71 **Misleading Navigational Information Extraneous Harmonics on Doppler Signal** The aircraft crashed while attempting a nonprecision instrument approach. It had been cleared for a Localizer Directional Aid (LDA). The Board determined that the probable cause of this accident was a display of misleading navigational information concerning the flights progress along the localizer course which resulted in a premature descent below obstacle clearance altitude. The origin or nature of the misleading navigational information could not be determined. The Board further concluded that the crew did not use all navigational aids to check the flight's progress along the localizer nor were these aids required to be used. The crew also did not perform the required audio identification of the pertinent navigational facilities. For an earlier recommendation on this accident see A-72-14 of 2/9/72. In its accident report the Board further recommends that: "The FAA continue the tests now in process concerning extraneous harmonics on the Doppler signal and initiate research into their possible hazardous effects on navigational receivers and associated instrument approaches."	1/19/73 Response from the FAA to state that their tests show no effect on a receiver of the type involved in the accident investigation due to extraneous harmonic radiation. A comprehensive report is presently being compiled on these tests and will be available by March 1973. They further state that they are continuously alert to possible detrimental effects to airborne receiver operation caused by modifications to ground facilities. Such investigations will, therefore, continue to be a part of their program for upgrading ground VOR stations to meet further needs. CLOSED

SOURCE AND NATURE OF RECOMMENDATION	CHRONOLOGICAL SUMMARY OF STATUS OF ACTION ON RECOMMENDATION
1/26/73 Not. 883 A-72-224 & 225 — EAL Inc., DC-9-31, N8961E, Fort Lauderdale, Florida, 5/18/72 **Approach and Landing Accident** The accident occurred following a straight-in localizer approach. The aircraft touched down hard on the runway resulting in the failure of the main landing gear and the separation of the tail section. There were heavy rain showers associated with thunderstorm activity. The Board determined that the probable cause of this accident was the decision of the pilot to initiate and continue an instrument approach under weather conditions which precluded adequate visual reference and the action of the pilot in employing faulty techniques during the landing phase of the approach. The Board also found that the flightcrew's nonadherence to prescribed operational practices and procedures compromised the safe operation of the flight. The Board recommended that the FAA: 1. Reemphasize to all flight crewmembers the necessity for total crew coordination and adherence to approved procedures. 2. Insure that all flight crewmembers are currently apprised of the contents of Air Carrier Operations Bulletin 71-9, emphasizing that a "nonprecision" approach requires as much, if not more, crew coordination than a "precision" approach because of the lack of precise guidance from electronic navigational aids outside the aircraft.	2/16/73 Response from the FAA to say that they agree with the Board's recommendation. They have always given this matter considerable attention during their inspection and surveillance activities. However, they have instructed their field personnel to reemphasize the need for total crew coordination and strict adherence to approved procedures. They have also requested that flight crewmembers not only become familiar with the Air Carrier Operation Bulletin 71-9, but also become aware of the consequences of not following prescribed procedures. CLOSED