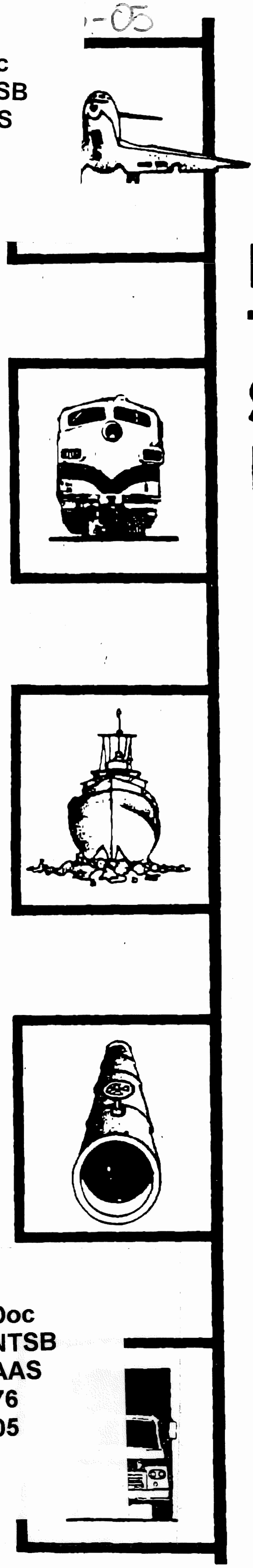

E R R A T A

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SPECIAL STUDY - NTSB-AAS-76-5.
Flightcrew Coordination Procedures In Air Carrier -
Instrument Landing System Approach Accidents.

Please make the following changes to the subject report:

Page ii, Table of Contents and Page 21, the Title change - the word: Instrument to Independent.

Page 6, paragraph 1, line 5: after 14 CFR 91.6 change - the period to a comma, and insert the following -- and in the applicable Operations Specification of each carrier authorized to conduct CAT II approaches.

Page 6, paragraph 4, line 10: change 40 to 50.

Page 31, Case 12, last line: change pilot flying to - pilot not flying.

October 14, 1976

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16. Abstract

This Special Study analyzes air carrier ILS accidents and incidents which occurred from 1970 through 1975. The study discusses air carrier flightcrew coordination procedures, the variations between the procedures of different carriers, and their involvement in ILS approach accidents.

As a result of this study, the Safety Board issued seven recommendations to the Federal Aviation Administration.

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NATIONAL TRANSPORTTION SAFETY BOARD
WASHINGTON, D. C. 20594

SPECIAL STUDY

Adopted: August 18, 1976

FLIGHTCREW COORDINATION PROCEDURES IN AIR CARRIER INSTRUMENT LANDING SYSTEM APPROACH ACCIDENTS

INTRODUCTION

A recent National Transportation Safety Board Staff Study entitled, "A Survey of Low Visibility Approach and Landing Accidents and Incidents Involving Air Carrier, Air Taxi, and Corporate and Executive Aircraft" disclosed that from 1968 through 1972, 47 percent of air carrier accidents occurred while the flightcrew was conducting an instrument landing system (ILS) precision approach. (That is, the ILS was supplying both electronic azimuth and vertical guidance to the aircraft's receivers.) The remaining 53 percent of this type accident occurred in varying percentages during the other types of instrument approaches.

During the conduct of this study, (1) accident and incident data from the Safety Board's narrative accident reports, dockets, and computer data for 1970 through 1975 were reviewed, (2) studies conducted by other Government agencies were reviewed, and (3) air carrier personnel, representatives of the pilots' unions, representatives of the Air Carrier Association, United States Air Force (USAF) personnel, and representatives of various airframe manufacturers were interviewed.

Additionally, the instrument approach procedures of various air carriers were compared so that the differing techniques and requirements could be noted. The crew coordination procedures used by USAF Instrument Pilot Instructor School (IPIS) personnel and pilots to accomplish their landing weather minima investigation were also collected to determine if they used procedures different from those used by the air carriers.

The accident and incident data disclosed that almost every mishap occurred after the flightcrew had seen either the ground, the airport, or the runway environment. Data disclosed that the pilot apparently was unable to assess correctly the flightpath or descent angle of his aircraft during the visual segment of the approach. In almost every case, the visual segment was conducted in meteorological conditions which affected visibility. Since the crew was unable to assess the flightpath visually, an unstabilized approach ensued, despite specific instrument and crew coordination procedures to prevent this.

In this study, the Safety Board sought to determine why accidents and incidents continue although procedures have been instituted to prevent their occurrence. Specifically, the Safety Board attempted to determine if these accidents and incidents were the result of human failures to adhere to procedures or the result of weaknesses in those procedures which led to the flightcrews' failures.

AIR CARRIER ACCIDENT DATA

The accident data in this study have been limited to two types of ILS approaches -- precision and nonprecision. During a precision approach both azimuth information, furnished by the ILS localizer transmitter, and vertical guidance information, furnished by the glidepath transmitter, is used. This approach is flown to a decision height (DH) 1/. During a nonprecision approach, only azimuth guidance from the ILS localizer is used. The nonprecision approach is flown to a minimum descent altitude (MDA) 2/.

The Safety Board examined its accident files for 1970 through 1975 to determine how flightcrews had performed the operational aspects of the ILS approaches. Accidents were reviewed when the failure to complete the landing successfully could be attributed to the manner in which the approach was flown inside the outer marker (OM). Twelve accidents and 5 incidents met these criteria and were examined in depth. (See appendix.) Twelve precision approaches and 5 nonprecision approaches comprise the 17 mishaps. The following elements of each accident were examined:

Visibility and Meteorological Conditions

The reported ceilings on the 17 approaches examined varied from 100 ft with sky obscured to ceilings which were unlimited with no reported obscuration. The reported visibilities ranged from 7 mi to 1/4 mi or less; however, each approach was flown in weather conditions which restricted visibilities -- fog, snow, drizzle, rain, or combinations of these. Several approaches which were begun either with the runway in sight, or in view at least 4 mi from the threshold, and were ended in visibilities that were either at or near published minima. (See case histories 7, 8, 10, and 13.) The major hazard to flight was not the height of the ceiling, but, rather, the restrictions to visibility.

1/ Decision height (DH) is the height in feet above the touchdown elevation point at which a decision must be made during an ILS approach to either continue the approach to a landing or to execute a missed approach.

2/ Minimum descent altitude (MDA) is the lowest altitude in feet above mean sea level to which a descent is authorized on final approach during execution of a standard instrument approach procedure where no electronic glidepath is provided.

Fifteen of the mishaps examined occurred after either the ground, the approach lights, or the runway environment had been called "in sight." Some evidence indicates that, once visual cues had been acquired, neither pilot returned to scanning the instruments, especially after the aircraft had reached DH or MDA. (See case histories 9, 10, 11, 12, 15, and 17.)

Flightcrew Coordination Procedures

The procedures involved in the 17 cases were similar to those used currently by most air carriers.

Each procedure involved in these cases required the pilot flying to change from instrument flight to visual flight techniques upon receipt of the nonflying pilot's call that the runway environment was in sight. If the aircraft was positioned at a point on the approach where further callouts based on instrument readings were required, the pilot not flying would have to relinquish his visual scan, return his attention to the flight and engine instruments, and produce these callouts. In those instances where the captain was flying the aircraft he would have been required to assume visual flight, evaluate the available cues, and make the decision to either land or to execute a missed approach.

Altitude Callouts

Required altitude callouts were usually made until visual cues were acquired, after which, flightcrews transitioned to visual flight and cockpit coordination procedures associated with that flight condition. On several of the approaches examined, neither the DH nor MDA was called since these altitudes were reached after the ground had been sighted and the sighting call had been made. (See case histories 1, 3, 5, 12, 15, and 16.)

On three of the approaches examined, no callouts were made after the DH or MDA was called. As a result of the flightcrew's failures to monitor flight instruments after the aircraft descended to an MDA, ground objects were struck at altitudes well below the published MDA's. On one of these approaches the runway environment had not been sighted. (See Case History 11.) In another instance, the pilot lost sight of the runway in a rainshower. (See case history 13.)

Accident records indicate that once visual contact had been called by the pilot not flying, the pilot flying transitioned, or attempted to transition, to visual flight and relinquished his scan of the flight instruments. However, the pilot not flying did not return to scanning flight instruments. Consequently, since the approaches were being flown by visual reference, any warning that the aircraft was low was based on the nonflying pilot's observations and evaluations of visual cues. In all instances, the visual warnings were too late to prevent the aircraft from striking the ground, or objects on the ground.

Deviation and Displacement Callouts

Most carriers require that the pilot not flying callout all deviations from target airspeeds and descent rates, and excessive displacements of the localizer or glidepath indicators. In eleven of the approaches examined, none of the deviations were called after DH or MDA had been reached, even though the evidence was conclusive that the limitations which necessitated the callouts had been exceeded. In some instances, only one of two deviations or displacements were called out. Thus, on one approach the pilot not flying called minimums, and then called an increasing descent rate to the flying pilot's attention. (See case history 6.) However, he did not callout an increasing glidepath displacement nor did he callout that the aircraft was too low. The accident investigation revealed that the increasing descent rate may have been acceptable to the pilot flying since it did not conflict with the pictorial presentation he was receiving from the visual cues, and, therefore, he did not take corrective action to arrest the descent.

Third Crewmember Participation

Twelve of the 17 approaches involved flightcrews with three members. Most carriers require that the third crewmember monitor certain instruments; however, there was little evidence of his exercising these duties. In fact, there were only two instances in which a third crewmember helped to alert the pilot flying of either a deviation or a displacement. (See case histories 7 and 14.)

Missed Approach Procedures

Several of the accidents examined might have been avoided had the flightcrews executed timely missed approaches. In two instances, the flightcrew had lost, or was losing, visual contact with the runway when their aircraft entered rain showers (See case histories 13 and 16); in another instance, the flightcrew lost sight of the runway when their aircraft entered a fog bank (See case history 7.) All approaches were continued.

Air carriers' procedures also direct that a missed approach be made if the aircraft is not stabilized on the descent between 300 and 500 ft above ground level (AGL). Three of the approaches were continued under conditions which did not meet the carrier's criteria for a stabilized approach. On one approach the aircraft was too high, and on others, it was too fast. (See case histories 5, 9, and 17.)

Coupled Approaches

Four of the 10 precision approaches were made using the autopilot approach coupler. (See case histories 3, 6, 12, and 14.) The four aircraft hit short of the runway. Two of the approaches were to be flown using Category II autocoupled procedures. (See case histories

3 and 12.) In both accidents, the autopilots were disconnected above Category II minima; one was disconnected because of an autopilot malfunction and the other was disconnected because the pilot elected to do so. Both were disconnected after the pilot not flying had called a portion of the runway environment in sight; neither pilot not flying had called the DH, or deviations from the glidepath during the latter portions of the approach.

Causal Areas

The probable causes cited by the National Transportation Safety Board for the case histories in this study included, among others: autopilot malfunctions, wind shears, visual illusions, and inadequate altitude awareness. However, in all but one of these determinations the Safety Board also identified the flightcrew's failure to adhere to prescribed crew coordination procedures, their failure to cross-check flight instruments, or their decision to continue to land with inadequate or marginal visual cues as primary or contributory causal factors.

FLIGHTCREW COORDINATION

The ILS procedure affords flight to lower minima than any other instrument approach. A Category I (CAT I) facility usually provides minima of 2,400 ft RVR [3/], or 1/2-mile visibility, and a DH of 200 ft A Category II (CAT II) facility provides minima of 1,600 ft RVR or less and DH's of 150 ft or less. A CAT II approach must be flown autocoupled -- the autopilot is engaged and is receiving flight guidance from the ILS facility -- to the DH. A Category IIIA (CAT IIIA) facility provides minima of 700 ft RVR; however, the aircraft must have automatic landing capability (autoland) to operate to these minima. As of March 1976, there were four operational CAT IIIA facilities in the United States. One U.S. carrier has received and another has requested operations specifications to operate to CAT IIIA minima.

The limitations on the use of all instrument approach procedures, except for CAT II facilities, are set forth in 14 CFR 91.117. Paragraph (b) of the rule prohibits any person from operating below the prescribed MDA or continuing an approach below the DH unless:

"(1) The aircraft is in a position from which a normal approach to the runway of intended landing can be made; and

"(2) the approach threshold of that runway or approach lights or other markings identifiable with the approach end of that runway are clearly visible to the pilot."

3/ Runway visual range -- An instumentally derived value that represents the horizontal distance a pilot will see down the runway from the approach end. It is based on the measurement of a transmissometer and, in the United States, is reported in hundreds of feet.

The rule also requires the pilot to execute an immediate missed approach if any of the above conditions are not met upon the aircraft's arrival at the DH or missed approach point, or at any point thereafter. Similar provisions governing the conduct of a CAT II approach are set forth in 14 CFR 91.6. The FAA issued Advisory Circular (AC) 91-25A, "Loss of Visual Cues During Low Visibility Landings" on June 22, 1972. The AC contains information concerning the importance of maintaining adequate visual cues during the descent below MDA or DH; the AC warned that several accidents had occurred when, "required visual reference was apparently lost after descending through DH/MDA."

The AC advises the pilot to execute the appropriate missed approach procedure if visual cues are lost after the aircraft reaches the DH or MDA. Paragraph (b) of the AC recommends that the pilot be alert to any deterioration in the "total pattern of available visual cues after leaving DH or MDA." It further recommends that a missed approach procedure be executed whenever there is a deterioration or loss of essential cues, if the aircraft is not positioned for a safe landing or if "the runway threshold or threshold lights are not visible from a height of 100 feet above the elevation of the touchdown zone during all precision approaches except Category III and from a height of 150 feet on all nonprecision approaches."

The AC addresses itself to the area of the ILS approach procedure which begins after the runway has been sighted and can be described as the "visual segment" of the approach.

Additional guidelines for the air carriers are contained in FAA Handbook 8430.6A, "Air Carrier Operations Inspector's Handbook." Chapter 7, para 951d. (4)(f) directs principal inspectors to determine if their assigned carriers have procedures in their training programs and in their operations manuals which pertain to instrument approaches, altitude awareness, and ascent and descent rate management. The paragraph also lists acceptable examples for inclusion in the carrier's manual, among which are the following: Acceptable rates of descent; altitude callouts at 1,000 ft above field elevation, 100 ft above DH, DH, at 40 ft on the radio altimeter and then down to touchdown at 10 ft increments; ILS raw data displacements (one-third dot on the localizer, one dot on the glide slope); and sighting callouts. Chapter 7 also sets forth guidelines for checklist accomplishment and division of flightcrew duties.

Within the framework of these rules and guidelines, the individual air carriers have established cockpit procedures to govern their flightcrews' conduct of the approach. These procedures may vary from carrier to carrier; however, they are designed to insure that all aspects of the approach are monitored continuously from the OM to touchdown. They are designed to insure that the pilot flying the approach will receive timely warnings at any point during the procedure should his aircraft depart from prescribed parameters. The carriers train their flightcrews in these procedures, and their abilities to carry out the procedures are evaluated by company and FAA check airmen -- both in flight and in aircraft simulators.

For this special study, the Safety Board examined the approach procedures of 10 U.S. air carriers and 2 foreign air carriers.

The Board examined only those procedures from at, or inside, the OM to touchdown. Particular emphasis was directed to that portion of the approach wherein the visual segment could logically be expected to begin -- from just outside the middle marker (MM) to touchdown.

All U.S. air carrier approach procedures are designed to provide a "team work" technique for the approach. Crewmembers are united to perform one task: Navigate the aircraft from the OM to touchdown. The procedures are designed to apportion the numerous tasks and monitoring techniques between the two pilots so that the pilot flying the aircraft can concentrate on his primary job -- flying the ILS approach. If a flightcrew consists of three crewmembers, some carriers have allocated monitoring responsibilities to the additional crewmember.

Almost every air carrier's instrument procedure aligns its crew duties in accordance with the task to be performed. The pilot's duties are based upon whether he is the pilot flying the aircraft or the pilot not flying the aircraft. Almost every air carrier's instrument approach procedure reiterates, usually verbatim, the statements concerning DH and MDA contained in 14 CFR 91.117(b). There can be no doubt what the companies intend their crews to do when their aircraft has reached published minima.

All U.S. carriers charge their captains with the responsibility for the safe conduct of the flight and most require that the captains perform the landing when the weather is reported to be below 4,000 ft RVR, or 300 ft ceiling and 3/4 mile visibility. Further, every U.S. carrier holds their captains responsible for evaluating the available visual cues at DH and for deciding either to continue to land or to execute a missed approach. All U.S. carriers' procedures, except one, designate the captain as the pilot flying and the first officer as the pilot not flying. In those instances where the first officer is permitted to fly the approach, the respective duties are reversed.

The procedural and callout requirements for the approaches can be divided into three sections: (1) Altitude callouts, (2) deviation callouts, and (3) the DH or MDA callouts.

Virtually all carriers require that the pilot not flying make the altitude callouts during the descent to DH or MDA. Some carriers require that these callouts begin at 1,000 ft above ground level (AGL) and almost all require a callout at 500 ft AGL. Some require callouts every 100 ft from 500 ft AGL to the ground. Virtually every carrier that requires these 100-ft incremental callouts insists that they be made on all approaches, both visual and instrument.

The requirement to call out altitude between 500 ft AGL and DH or MDA varies among carriers. Some require callouts at various altitudes above minima and require these callouts to be expressed in feet above DH or minimums (e.g. "200 above minimums"; "200 above DH"). Under these circumstances, these callouts do not appear to be required on a visual approach since there would be no need for the flightcrew to check, brief, or monitor instrument minima.

All carriers require that the pilot not flying monitor the approach and call any discrepancies or displacements to the attention of the pilot flying. These discrepancies and displacements are excess airspeed, descent rates, and excessive displacement from the localizer path and glide slope. In the latter instances, these displacement values are derived from the ILS raw data displays.

Most carriers require that the pilot not flying make an altitude callout at 100 ft above DH or MDA. All require a DH or MDA callout by either the pilot flying or the pilot not flying. The purpose of the callouts is to alert the pilots and the remainder of the crew that the decision altitude is being approached and that the decision either to land or to abandon the approach must be made.

As the aircraft approaches minima, the pilot not flying is required by these procedures to scan for visual cues and to call these cues as they are sighted -- "approach lights in sight," "runway lights in sight," "runway in sight." Since the captain must decide to accept or reject the remainder of the approach based upon the criteria set forth in 14 CFR 91.117(b), the captain, or pilot flying, must raise his head, acquire the visual cues sighted by the pilot not flying, and then, based upon his assessment decide either to land or to execute a missed approach.

As soon as the visual cues are sighted and called the aircraft is on the "visual" segment of the approach. Most carriers' procedures do not require that the pilot not flying either monitor the instruments to touchdown, or direct his primary attention to the flight instruments to touchdown. However, since the approach is considered to be a visual approach from DH to the runway and the callouts associated with visual approach are applicable, there is no further requirement for altitude callouts, or to monitor localizer and glidepath displacement. Only deviations from programmed airspeed and excessive descent rates must be called.

One of the carriers whose approach and landing procedures differed from the others requires that the pilot not flying make altitude callouts every 100 ft, between 500 ft AGL and the DH, and, starting at 50 ft AGL on the radio altimeter (RA), in 10 ft increments to touchdown. These callouts are standard on both the instrument and the visual approach. Both pilots are required to monitor the autopilot (if applicable) and instruments. Backup monitoring tasks are assigned to the additional crewmembers. In addition to altitude callouts, the pilot flying will be informed of and must acknowledge the call when the airspeed varies from programmed values, when an excessive descent rate exists, when the glide slope displacement exceeds 1 dot, or when the localizer displacement exceeds 1/3 dot.

The captain must land the aircraft when the reported weather is below 4,000 RVR: however, he "may allow the first officer to fly the approach (coupled or manual) to DH." The carrier concludes its generalized coverage of their procedures with the statement, "F/O remains on instruments throughout the approach and landing, and makes all callouts below 500' (ft)."

The carrier's procedures require the first officer to maintain the airspeed manually (monitor autothrottle control of airspeed when applicable) and make the callouts, and the captain must guard the throttles. At not less than 100 ft above the DH, the captain is required to direct his attention outside the aircraft to seek visual references. If the captain determines that he can land, he calls "I've got it" and simultaneously lifts the first officer's hand from the throttles. If at DH the captain has not assumed control of the aircraft, the first officer will execute a missed approach; verbal directions or commands are not required. Interviews with the flightcrews indicated that as a matter of practice the first officer is almost always directed to fly the approach (coupled or manual) to DH.

A comparison of the provisions of this procedure with those in use by the other carriers reveal several significant differences. For example, this procedure:

1. Does not require that both pilots alter their scan responsibility. Only the captain is required to change his scan pattern from instruments to visual references as the DH is approached. The first officer's scan is within the aircraft throughout the procedure.

2. Requires the captain to begin his visual scan before the aircraft reaches the DH and before the "continue to land" decision must be made. He must maintain his visual references throughout the period the the aircraft must be flown visually.

3. Removes the first officer from the "continue-to-land-decision" at DH. He must execute the missed approach if the captain does not command otherwise.

4. Assures that the instruments are monitored continuously by two pilots from the OM to within 100 ft above the DH, and by one pilot throughout the entire approach from OM to touchdown. All required callouts must be made by the first officer even though the captain takes command of the aircraft and continues to land.

5. Requires that, although the first officer must fly the aircraft either manually or autocoupled to DH, he also makes the altitude callouts.

The carrier varies these procedures slightly when the reported minima are above 4,000 ft RVR. The flightcrew's duties remain the same as those cited above in the first procedure until the aircraft descends to 100 ft above the DH or MDA, at which point the first officer directs his attention outside the aircraft to seek visual cues. When he has the runway in sight, or enough of the approach runway environment in sight for the captain to land, he will advise him, "runway in sight." The captain then acquires visual reference and lands the aircraft. The first officer returns to monitor the instruments, and continues to make callouts to touchdown. At the captain's discretion, these duties may be reversed. The wording of the duties assigned to the pilot not flying differs for the latter portion of the approach. In the first procedure, he remains on instruments, "throughout the approach and landing." In the latter, he is required to direct his "primary attention" to monitoring instrument displays to touchdown.

In 1964 the USAF Instrument Pilot Instructor School (IPIS) began to investigate the problems of low visibility landings. The results of their investigation, "Landing Weather Minimums Investigation, (IPIS-TR-70-3)" were published in January 1972. The publication reports the experience acquired from over 250 approaches and landings in visibilities below 1,600 ft RVR and, in some instances, below 800 ft RVR. The approaches were flown both coupled and manual.

The test flights were flown in a modified North American Sabreliner (T-39) which was manned by a three-man flightcrew. The aircraft modifications permitted the automatic flight control system (AFCS) to fly the aircraft on the ILS approach to a landing. The autopilot was configured with dual force wheel steering (FWS) and used flight director computer steering as the approach coupler. Therefore, the autopilot control corrections were based on the same presentation the pilot was observing on his flight director display, and he could make manual inputs into the autopilot at any time during the approach without causing the autopilot to disconnect. The modifications also augmented the flightcrew's ability to monitor the aircraft's flightpath and provided a landing flare presentation. Therefore, the pilot could either perform or adjust the landing flare maneuver manually, if desired.

The specific titles, tasks, and responsibilities assigned to the three crewmembers from OM to touchdown were as follows:

a. Heads-down pilot normally occupies the left seat and will:

(1) Fly aircraft with AFCS or manually;

(2) Make landing or go-around decision predicated on instrument displayed information;

(3) Perform emergency procedures; and

(4) Execute a missed approach if:

(a) Commanded by heads-up or third pilot,

(b) flightpath limits are exceeded or

(c) emergency or system failure occurs.

d. Heads-up pilot normally occupies the right seat and will:

(1) Monitor AFCS's performance

(2) Assume visual scan at 150 ft AGL

(3) Decide to execute missed approach, if required. This action would be predicated on visual cue verification.

(4) Calls visual cues as they become available using following terminology:

(a) "Cue" - some portion of approach lighting or runway in view.

(b) "Lateral" - sufficient visual cues to control the aircraft laterally.

(c) "Visual" - sufficient visual cues are available to land the aircraft.

(d) "Go-Around" - Self explanatory.

(e) "I Have The Aircraft" - assumes control of all axes

c. The third pilot will:

(1) Monitor engine and flight instruments

(2) Call "approaching 400" "approaching 300 ft" AGL

(3) Monitor landing sequence indicator; call lights which do not illuminate.

(4) Command a go-around if:

(a) flightpath limits are exceeded,

(b) an emergency or system failure occurs

Examination of these procedures discloses that each pilot is assigned a specific area of responsibility and specific tasks within that area of responsibility. While the areas of responsibility are shared, the areas are never exchanged. The heads-up pilot and the heads-down pilot may both be monitoring instruments until 150 ft AGL, but only the pre-designated heads-up pilot is allowed to lift his head to seek visual cues. One pilot is responsible for monitoring the instruments throughout the entire approach and for flying the aircraft. Although control of the aircraft may be taken from him, he must remain heads-down and on instruments.

Throughout the tests, no single crewmember was designated as aircraft commander; insofar as a missed approach call was concerned, any one of the three pilots could command a missed approach. The term used to initiate the missed approach was not descriptive, but authoritative, "go around."

The IPIS study, in presenting possible solutions for crew procedures, considered the aircraft commander to be a manager who directs the crew effort, assigns duties, and makes critical decisions, and the report states, "in the case of the low-visibility landing, the aircraft commander would assume a visual posture at some predetermined altitude, evaluate the visual environment and make the land or go-around decision. Since he would have access to the visual environment, he could assist with path control when able, or monitor the co-pilot during the entire touchdown and landing."

In another of its studies (Crew Duties, Mode and Function Study IPIS-TN-71-4) it was noted that pilots have landed short of runways simply because the visual references were not sufficient for adequate depth perception, or that they created illusions which lead to error. The study noted that this could also be the case during approaches in snow, rain, fog, etc., where the visibility is somewhat obscured, and then stated: "The solution to preventing these types of accidents is to maintain composite flight 4/. Also, one pilot, in dual aircraft, could be tasked to specifically monitor instrumentation. This type of

4/ Aircraft control is maintained by visual information supplemented by performance information from the engine and flight instruments.

task allocation could possibly prevent premature descents or large excursions from instrument flight paths when the visual references create illusions of false heights or present ill-defined cues."

During a subsequent interview, IPIS personnel stated that they believed that there was an "attraction" once the ground is sighted and that it would be difficult for a pilot to release his visual contact with the ground and return to the cockpit duties.

IPIS personnel believed that there was a need for stringent and rigid crew procedures. A crewmember should always hear the same thing at the same time. They must know what visual scene is either available or unavailable from the callout. In that respect they noted that visual cue callouts should be limited to the airport or runway environment. Random ground sightings should not be announced.

Various air carrier flight managers, training supervisors, instructor personnel, and flightcrew members were interviewed during the course of this study. The views and opinions of the IPIS personnel, as well as those obtained from other carriers, were presented to them in order to promote a free exchange of information. There was general acceptance of the principle of rigid checklist procedures, although several questioned the efficacy or need for making altitude callouts once the runway environment had been sighted.

Flightcrews and management personnel generally believed that their own procedures were the best although they admitted possible advantages of other types of procedures. Personnel of those carriers which required the captain to fly the approach in the low minima environment believed it was the better procedure because it placed the most experienced man in the cockpit at the controls.

The procedures of the two foreign carriers examined revealed the same schism in approach procedure philosophy as that exhibited in the U.S. carrier's procedures. While one carrier's procedures were similar to those of most domestic carriers, the other carrier's procedures were very different.

The latter carrier designates its cockpit personnel as captain, P2, and P3. The duty allocations for the ILS approach are the same regardless of whether the approach is flown manually or automatically and are, in general, as follows:

P2 operates the AFCS or flys the aircraft manually. He monitors the approach path and the airspeed to DH. At DH, if the captain has given no instructions to land or to go around, he will execute a missed approach. If the captain calls "land" and takes control of the aircraft, P2 continues to monitor the instrument displays to landing, bringing any discrepancies to the captain's attention.

The captain maintains radio communications and monitors P2's handling of the aircraft. As the aircraft nears DH, he will seek visual references. He will repeat the 300 ft callout, and will make the "continue to land" or "go around" decision at the appropriate altitude above DH. If he decides that he has adequate visual reference, he will call "land", take over control of the aircraft, and continue the approach.

P3 reads the checklists, selects the radio frequencies and after glide slope capture or intercept, he uses P2's instrument display to monitor the approach. He makes the 500, 300, and 50 ft above DH callouts using the appropriate altimeters.

The allocation of duties cited above remains the same for the non-precision approaches. On a nonprecision approach, while the MDA is being maintained, P3 will monitor height against time and call "high" or "low", as appropriate.

STANDARDIZATION OF APPROACH PROCEDURES

The accident and incident data disclosed that one flightcrew procedural factor was common to 16 of the 17 approaches. Once either the approach lights, the runway,or the ground had been sighted and called, there was either a partial or complete breakdown of callout procedures. In some instances, no callouts of any kind were made. Failures to callout altitudes led to the missing of DH or MDA callouts, and possibly failures to recognize the necessity to execute missed approaches. Failures to call ILS discrepancies and airspeed deviations may have led to the inability of the crew to recognize and terminate unstabilized approaches.

Every approach procedure involved in these mishaps required the pilot flying to relinquish his instrument scan and seek visual cues after the pilot not flying called that he had sighted the runway. Except for two approaches, the pilot not flying had made a ground-sighting callout. Therefore, portions of these approaches were flown in visibility conditions which permitted the type of flight described in the IPIS study as "composite flight." The evidence also disclosed that as approaches were continued the aircraft descended into worsening visibilities which affected the crews' ability either to sight the runway, or to retain sight of it, or compromised their ability to recognize that the quality of the visual cues had deteriorated. Under these conditions, the lowering or changing visibilities were in effect depriving the pilots of the cues needed to sustain the visual portion of the composite flight regime and requiring that different priorities be placed on the visual and instrument modes of the flight. The flightcrew had to possess the capability to: (1) Obtain both visual cues and instrument information and integrate them into the composite flight mode, (2) recognize the necessity to revert from visual to instrument information, and (3) to vary their reliance on either mode of flight even to the point of abandoning visual flight for instrument flight.

Therefore, either the pilot flying or pilot not flying would have to insure that information from the aircraft's instruments was used to support the visual flight. If the pilot flying was required to assume a visual scan and acquire outside cues, then, unless he recognized the decay of his visual cues and resumed his instrument scan, he was completely dependent on the pilot not flying to supply him with information from the flight instruments and to warn him that he was departing from the desired flightpath. With such information, he could decide to return to instrument flight.

Safe flight during the transition from instrument to visual flight requires a division of cockpit duties which will insure that both visual and instrument cues are monitored continually. The flightcrew procedures in effect when these mishaps occurred were presumably designed to insure such monitoring. Except for two approaches, the evidence was conclusive that from the time visual contact with the ground or the runway environment had been called both the pilot flying and the pilot not flying were relying upon or seeking visual cues; neither was monitoring the instruments. Both pilots were relying on the same source of external guidance in order to land, and any visual illusions present would be present to both pilots. The question to be resolved is: Were the procedural breakdowns the results of crew error or of an inherent weakness in the procedures? The evidence seems to indicate that the existing procedures, if not totally at fault, did contribute to the breakdowns.

The accident reports on these approaches refer to the failure of the pilot not flying to relinquish his visual scan and monitor the aircraft's instruments after making the sighting callout. There appeared to be a presumption that the procedures required him to do so. The presumption that he was required to return to monitoring the aircraft's instruments seemed to have been based upon the fact that the procedures required him to make deviation or displacement callouts that could only be obtained from the aircraft's instruments. Most present procedures do not specifically assign the pilot not flying either the responsibility to monitor the instruments to touchdown or to return to monitoring the instruments after making the sighting call, but generally rely on the requirement to note and call deviations or displacements to produce adequate instrument surveillance. In short, these procedures rely on the ability of the pilot not flying to apportion his visual and instrument scanning time after he has made the sighting call so that he will be able to detect departures from the desired flightpath and make any required callout. The evidence discloses that not only is the task a demanding one, but that any distraction, however slight, can lead to failure.

The evidence appears to corroborate the IPIS personnel's observation that the ground, or runway, once sighted would be difficult to release visually. In those instances where the runway was lost from view, the evidence seemed to indicate that the pilots continued to fix their scan at the point of disappearance in the hope that it would reappear at the same point. In other instances, the flightpath was altered, unknowingly, in an effort to retain a constant quality of visual cues. If continuous flight instrument monitoring is desirable, the task to monitor them should be assigned to a crewmember, and the assignment should be structured so that he is no longer required to sight and callout the ground or runway. Consequently, he should not be exposed to the attraction. The accident reports also demonstrate the need to incorporate specific wording in the flightcrew coordination procedures designating the period of flight during which he is responsible for that task. The wording used to denote the nature and scope of these duties should be authoritative. For example, the U.S. carrier's ILS flightcrew procedure which does not require an exchange of scanning duties at DH directs the pilot not making the landing to "remain on instruments throughout the approach and landing." This parallels the procedures used by one foreign carrier and those advocated in the IPIS study. The procedure insures that the instruments are monitored by one pilot and relieves him of any necessity to apportion his scanning time between his instruments and outside of the aircraft. There does not appear to be any other U.S. carrier which delineates the pilot not flying's responsibility so positively.

Continuous instrument monitoring must be insured even when the responsibility for this task is to be transferred. Therefore, the manner in which this transfer is made and whether limitations should be placed on the procedure must be discussed.

The majority of air carrier procedures require the pilot not flying to seek the runway environment visually as the aircraft descends and to call out the visual cues as they become discernible. However, there is no requirement for the pilot flying to inform the pilot not flying that he is relinquishing his instrument scan and attempting to acquire the visual cues. The pilot not flying has no idea where the pilot flying is looking and since the visual accommodation time for transitioning from instrument to visual flight may range from 3 to 4 secs, there is an interval during which the aircraft's flight instruments are unmonitored. If visual conditions are marginal, it is essential that the instruments be monitored continually; therefore, the procedures should require a call from the pilot flying to the effect that he is releasing his instrument scan to go "outside". This call should constitute the command for the pilot not flying to assume the responsibility for monitoring the instruments until touchdown or at least until the period of visual acquisition is over and the pilot flying is fully oriented with the outside environment. The critical nature of this area of flight is emphasized by the fact that the aircraft initially departed the desired flightpath at this point on the approach in at least four of the approaches examined.

The data disclosed what appears to be another weakness in the area of scan transfer and perhaps further corroboration of the theory that the ground constitutes a visual attraction that is difficult to release. There were numerous approaches during which callout of the acquisition of visual cues was made above DH or MDA; two of these instances involved a call of visual contact even though neither the airport nor the runway environment was in sight and, in fact, was never sighted. All of these approaches terminated in undershoots. The facts indicated that these calls led to a premature termination of instrument flight procedure by the flightcrew, and subsequent early descents. Procedures which can result in abandoning instrument flight procedures too early in the approach should be prohibited. Sighting calls should be based upon sighting the airport and runway environment on all approaches. Procedures which will delay sighting calls until the aircraft reaches, or just before it has reached, DH or MDA should be considered.

The U.S. and foreign carriers which do not require an exchange of scanning responsibilities between their pilots in their flightcrew procedures have not experienced any accidents or incidents of this type. The statistics seem to indicate that there may be some weakness in the procedure requiring the exchange of scan area. Though the evidence discloses that all 17 mishaps were suffered by carriers using procedures requiring an exchange of scanning duties, there are many U.S. and foreign carriers which use this procedure and have been free of approach and landing accidents and incidents. There is not enough statistical data to state affirmatively that one or the other procedure is superior.

There are numerous other procedural areas which contributed to the breakdowns which ultimately led to the 17 mishaps. The study disclosed that problems exist in altitude callouts, caused in part by differences between the visual approach and instrument approach flightcrew coordination procedures; airspeed and rate of descent callouts; localizer and glidepath displacement callouts; and, the use of the second officer in the approach procedures.

Most air carrier approach procedures do not require the same callouts on a visual approach as they require on an instrument approach. On visual approaches, altitude callouts differ; ILS displacement callouts, even though an ILS is being used for vertical guidance, are not required. In addition, if an approach is visual, DH or MDA callouts are not required. The only callouts common to both approaches are one or two altitude callouts and callouts for airspeed or descent rate discrepancies.

The procedural differences between a visual approach and an instrument are well defined; unfortunately, weather conditions are not always so well defined. Data disclosed that during approaches flown in restricted visibility the aircraft may enter, depart, and reenter instrument conditions. The flightcrews involved did not seem to recognize these changing conditions and, therefore, did not implement the flight procedures designed to cope with these conditions. Therefore, any approach to a runway which has reported meteorological restrictions to visibility should be considered as an instrument approach, regardless of the reported visibility or RVR. Approach procedures should be standardized for both visual and instrument approaches -- especially, altitude callouts.

There are several other arguments for greater standardization of visual and instrument approaches. Many callouts are already required on both approaches. 14 CFR 91.87 (2) requires that an ILS-equipped, turbine-powered, or a large, aircraft which lands on a runway served by an ILS fly at an altitude at, or above, the glide slope between the OM and the MM. Since electronic guidance is used for the approach the Safety Board believes that full instrument procedures should be required even though the approach is conducted in clear weather. Such a requirement might have prevented one of the mishaps examined during this study (case history 7) and might also combat some of the illusory effects prevalent in clear weather such as the "black hole effect." 5/ Several of the carriers already require callouts every 100 ft from 500 ft AGL to the ground on all approaches, whether visual or instrument. Such a practice affords flightcrews the opportunity to form good habits and procedures before the need for them becomes critical.

Most carriers strive to maintain silence in their cockpits during critical phases of flight. Thus, warning callouts are limited to excessive deviations or displacements from the flightpath, descent rates, or indicated airspeeds. Generally, calls denoting glidepath displacements are not required until the displacement reaches or exceeds one dot. Silence in the cockpit, especially when the displacement occurs below 200 ft AGL and indicates that the aircraft is below the glidepath, may be inappropriate. By the time a one dot-low displacement is noted and called, the rate of descent may be difficult to arrest. It may be advantageous to relate callouts required by increasing or excessive descent rates to an immediate inspection of the glidepath raw data display, and to require a warning callout denoting both the undesirable rate and the glidepath displacement if a descent below the glidepath accompanies the increased descent rate.

The glidepath deviation alerting system of the ground proximity warning system (GPWS) will alert the flightcrew to the fact that the aircraft is descending below the glidepath. However, the alerting procedure will not begin until the displacement has reached 1 1/3 dot below the glidepath. Again, a rate that is difficult to arrest may have been established; therefore, flightcrew coordination procedures which will detect and arrest the descent before the GPWS warning could occur would be desirable and should be sought out and implemented.

5/ The "black hole effect" is the illusion of height which occurs on a night approach to a runway which is situated in an area with little or no illumination or lights.

The study disclosed a lack of input from the third crewmember during approaches examined. Most carriers assign some monitoring tasks to him, such as monitoring various instruments and calling out discrepancies. After the final landing check is completed, the third crewmember also should continue to monitor the flight instruments, and specific altitude callouts should be assigned to him.

There is no evidence in the data examined in this study of any accident or incident on a CAT II approach when prescribed CAT II procedures were followed and the approach was flown autocoupled to the CAT II DH. One accident occurred on a CAT II approach; however, the autopilot was uncoupled about 100 ft above CAT II minimums. This might indicate that the longer the aircraft can remain on an autopilot coupled approach, the safer the approach will be. Several carriers recommend that the autopilot remain engaged after DH if sufficient visual cues exist to accomplish a successful landing. In one instance, the carrier indicates that the autopilot may remain engaged until the aircraft reaches the lowest certified altitude of the autopilot.

Down to 100 ft AGL in most cases, the tolerance limits between the generated signals of an operational GAT I and CAT II ILS are small. Therefore, if sufficient visual cues exist to continue a CAT I approach beyond DH, it is advantageous to leave the autopilot engaged until complete visual transition to the runway environment can be achieved. Certainly, the autopilot could remain engaged safely down to 125 to 150 ft AGL and possibly lower. There are, of course, certain ILS installations on any carrier's system that might not support this technique; however, any carrier can, with FAA assistance, research and identify such facilities.

Current air traffic control (ATC) practices which require the flightcrew to maintain excess airspeed to the OM are not conducive to the efficient use of the autopilot when making a coupled approach. The longer the aircraft can be stabilized at the desired approach airspeed, the better the autopilot can adjust to the signal input from the ILS. Use of the autopilot for the coupled approach would be enhanced if ATC would free the flightcrew from all restrictions at least 3 to 4 miles outside of the OM. Efforts should be made to institute these procedures, especially when approaches are to be flown in instrument meteorological conditions.

AUTOLAND SYSTEMS

Crew procedures and cockpit discipline will remain paramount in any low-visibility approach regardless of whether the approach is flown manually or autocoupled. However, the latest aircraft technology and instrumentation, both available and proposed, must be considered as a possible solution to the problem of low-visibility approach and landing accidents, in particular, the use of autoland systems, independent landing monitors (ILM), and headsup instrument displays (HUD).

All three wide-bodied jet aircraft manufactured in the U.S. -- the Douglas DC-10, Boeing 747, and Lockheed-1011 either have, or will have, operational autoland systems. These autoland systems have operated successfully on CAT II ILS facilities, and on many CAT I systems. One manufacturer stated that their aircraft had been flown around the world and had made successful automatic landings at airports where an ILS facility was available. The system did not operate successfully on two facilities, one of which was at Hong Kong. The ILS at Hong Kong was reworked, the aircraft returned, and several successful autolands were made.

Within the United States, those carriers possessing aircraft with autoland capability are using the capability frequently. The FAA operations specifications for air carriers which fly the Boeing 747 require that the flightcrew use the autoland system for all landings when the RVR is between 1,600 and 1,200 ft.

The viability of the autoland concept is demonstrated further by the successful operation of British Airways European Division's Tridents. These aircraft have neither HUD nor ILM displays and are operating successfully to CAT IIIA minima.

The proponents of the autoland system contend that the pilot has little if any place in the evaluation of visibility sectors that are below 1,000 ft RVR. The IPIS study noted that their pilots generally had little difficulty determining lateral and vertical movements in visual segments of 1,200 ft . . . "however, as segments decreased toward 600 ft, visual perception of lateral movement (crosstrack rate) became extremely difficult, and pilots required normally 3 to 4 seconds to interpret effectively visual cues." The study also notes that it is extremely difficult to establish depth perception in a visual segment at or below 600 ft although daylight operation in the same weather allows some use of the runway surface for depth perception; . . . however, the flare must be accomplished on instruments. Of course, these conclusions must not be applied to air carrier operations before the following is considered: The USAF's low-visibility test was conducted in a T-39, a light maneuverable aircraft, which places the pilot's eye level about 7.5 ft above the runway surface. Air carrier operations are conducted in heavier and less responsive aircraft and the pilot's eye level above the runway range varies from approximately 11 ft in the Douglas DC-9 to 29 ft in the Boeing 747. 6/ In addition to this geometric consideration, aircraft are flown into these limited visibility segments at velocities ranging from about 200 fps to 255 fps. Consequently, the visibility values cited above would have to be increased to apply to the air carrier operation. There were several approaches in which the project pilots expressed reservations about their ability to duplicate

6/ Eye levels are based upon estimated cockpit heights with all three landing gear on the ground.

the results with larger aircraft. The available evidence, therefore, appears to confirm the conclusions that any operation into visual segments of 1,000 ft or less compromise, or are beyond, the pilot's ability to evaluate and make a valid or safe "continue-to-land" decision.

The autoland system places the pilot outside the visual evaluation but into the monitoring loop. His decision is based entirely on the monitoring of system performance. Any out-of-tolerance condition, or malfunction, dictates an immediate go-around.

INSTRUMENT LANDING MONITOR

The advent of the autoland system brought about a demand for ILM. In considering an ILM, one must define what purpose it will serve and what will constitute such a system.

The Safety Board has found that most air carriers do not believe that ILM can be used to compensate for shortcomings in basic landing guidance, the flight control system, or the radio channel which transmits the guidance to the aircraft. They believe an assumption that an ILM can substitute for high quality landing guidance is not valid.

Secondly, the system must be independent of the systems being used to drive the airplane and must give the pilot highly reliable information on how his aircraft is performing in relation to desired performance. An ILM which uses the same components and systems used to fly the aircraft and furnishes that data to the crew, in addition to the normal monitoring devices, is not independent; it is merely another redundancy and cannot qualify as an ILM. One promising principle for providing independent information is visibility enhancement either through high-resolution radar, infrared rays, or television. These would permit the pilot to look ahead through the weather and see the landing target.

The views of airline experts, as set forth in an Air Transport Association of American (ATA) paper, were that the various ILM systems, to date, only go part of the way toward the goal. They believe that unless these devices provide data at a glance and at a fair distance from touchdown they can degrade rather than enhance the approach. A radar-like display which requires a pilot to strain to detect runway outlines a half mile from touchdown would not be acceptable. The experts believe that in order to be acceptable an ILM must be so easy to comprehend that its use will not detract the pilot's attention from more pressing duties of system management and failure detection.

An ILM based upon visibility enhancement principles would be of value in a CAT III environment and would serve as an additional check on the reliability of the autoland system and the ILS signal. If a viable ILM can be achieved there are a number of other considerations which could influence its overall acceptance. A primary consideration is that it would provide a monitoring capability for other types of instrument and visual operations. The evidence indicates that an ILM would be desirable; however, the Trident operation cited earlier also indicates that it is not a prerequisite for landing in CAT IIIA visibilitites.

HEADSUP DISPLAYS

The subject of HUD has been before the aviation community for years and has generated much controversy. There are, at present, many HUDs in existence, which range from a simple visual approach monitor (VAM) to the more sophisticated systems incorporating displays of aircraft attitude, ILS data, altitude, airspeed, vertical velocity, velocity vectors, and angle of attack. These displays are generally projected on collimating lenses which project the image in front of the pilot. The system has the capability to display almost any type of information, and in whatever format or symbol desired.

In addition to a dispute over what information the HUD should display, opinion is divided as to whether the HUD symbology should reproduce the flight instrument format or display the information in a format similar to that which the aircraft is actually entering (e.g. a pictorial representation of the runway and the aircraft's positioning relative to the runway and the horizon).

The Air Line Pilot's Association (ALPA) maintains that a properly configured HUD would not only provide the pilot with a means of coping with wind shear, but would also provide him with the means of coping with problems associated with low visibility, transition from instrument to visual flight, abnormalities in the ground based guidance system, vertical guidance on nonprecision approaches, and it would provide an adequate means by which he can supervise the performance of automatic approach and landing system.

Though ALPA has long advocated the installation of HUD; air carrier mangement, some airframe manufacturers, and segments of the military remain unconvinced of the value of HUD.

Numerous air carrier flight managers, directors of operations, and directors of training interviewed by the Safety Board stated that the HUD could serve as a visual approach monitor only after the pilot had acquired visual contact with the runway aiming point. All those interviewed cited problems with the system that require resolution; all stated that a large testing program is required before HUD could be universally accepted. Among those problems cited were: Lack of agreement on symbology; a tendency for the information on the HUD to blend with ground cues; difficulty in deciding when to relinquish the HUD for visual cues; turbulence effect; and crosstrack effect (i.e., the HUD platform does not align with the actual runway) among others.

One airframe manufacturer after evaluating HUD stated, in part: "We have generally concluded that the HUD with associated computers and sensors in its present state of development is not suited for use as a primary reference for the pilot during approach and landing." They maintained that it could be of value as a visual aid during the approach to unimproved runways which are not equipped with VASI or ILS and where visual perception is poor; they concluded, "Additional study would be required if other potential uses were to be considered."

Currently, the FAA in conjunction with NASA, has a research and development project to evaluate and determine the role of the HUD.

CONCLUSIONS

1. Most of the accidents or incidents occurred after the pilot not flying called that he had either the ground, the approach lights, the runway lights, or the runway "in sight," and the pilot flying the aircraft transitioned, or was trying to transition, from instrument to visual flight.

2. Low visibilities compromise the quality and reliability of the visual cues on which the pilot flying relies for vertical guidance; therefore, only the timely and proper integration of flight instrument data into the flight can detect or prevent undesired excursions from the correct flightpath.

3. Continuous monitoring of the aircraft's flight instruments is necessary from the OM to landing. The duty to monitor these instruments should be assigned as a specific task to specific crewmember.

4. Instrument flight procedures should be maintained to the lowest possible altitudes commensurate with the approach procedure. Callouts which can result in a premature abandonment of instrument procedures during the approach should be prohibited. Sighting calls should be limited to visual acquisition of either the airport, the approach lights, the runway lights, or the runway. This is particularly applicable to nonprecision approaches.

5. Altitude callouts for both visual and instrument approaches should be standardized within each air carrier's procedures.

6. Greater use of the autopilot approach coupler will augment instrument approach safety. Depending upon the reliability of the ILS facility, if sufficient visual cues exist to continue a CAT I approach, the autopilot should remain engaged, if feasible, until descending to the autopilot's minimum certified altitude.

7. ATC procedures which would release the flightcrew from all airspeed restrictions at least 3 to 4 miles outside the OM on all ILS approaches would enhance the efficiency of the autopilot autocoupler operation.

8. The Safety Board could reach no conclusions regarding the advantages or disadvantages of HUD in the low-visibility environment.

RECOMMENDATIONS

As a result of this study, the National Transportation Safety Board recommends that the Federal Aviation Administration:

"Expedite evaluation and developmental programs for advanced landing systems. (Class II - Priority Followup) (A-76-122)

"Institute procedures which require air traffic controllers to release an aircraft from all airspeed restrictions at least 3 to 4 miles outside of the outer marker on all ILS approaches when the reported weather is below basic VFR minima. (Class II -Priority Followup) (A-76-123)

. . . In conjunction with the air carriers:

"Implement flightcrew coordination procedures which will insure continuous monitoring of the aircraft's instruments from the OM to landing. The wording of monitoring tasks should be specific. Flightcrew procedures which require a transfer or exchange of visual scanning responsibilities should require that the appropriate crewmember announce that he is relinquishing previously assigned duties or responsibilities. (Class III - Longer Term Followup) (A-76-124)

"Develop flightcrew coordination procedures which will limit sighting callouts to those visual cues which are associated with the runway environment. Unrequired callouts which can result in the premature abandonment of instrument procedures should be prohibited. (Class III, Longer Term Followup) (A-76-125)

"Develop a standard flightcrew coordination procedure within each carrier for altitude callouts to be used on all approaches under all conditions. (Class II - Priority Followup) (A-76-126)

"Encourage flightcrews to keep the autopilot-coupler engaged until its minimum certified altitude has been reached. (Class II - Priority Followup) (A-76-127)

"Include in air carrier training programs flightcrew discussions of formal reports involving approach and landing accidents or incidents. Special emphasis should be placed on those mishaps involving human limitations. (Class III - Longer Term Followup) (A-76-128)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Member

WILLIAM R. HALEY, Member, did not participate in the adoption of this study.

August 18, 1976

APPENDIX

ACCIDENT CASE HISTORIES

Case histories for the 12 selected accidents and 5 incidents are set forth below. The 17 accidents and incidents resulted in 340 fatalities and 142 injuries. Seven aircraft were destroyed, five were damaged substantially, and five were either undamaged or damaged slightly.

Case 1

A Boeing 727 was on a day, nonprecision approach at Toledo, Ohio. The captain was flying the aircraft. The approach minima were 360 ft and 3/4 mile; the reported weather was: Partial obscuration, scattered clouds at 1,100 ft, ceiling 2,500 ft overcast, visibility 2 1/2 miles with light snow showers. This was an undershoot.

The pilot not flying said that he acquired visual contact with the ground at 400 ft AGL; the runway was never sighted.

The required 1,000 feet AGL call was made by the pilot not flying, and he made a callout at 600 ft AGL (which was not required). The following required callouts were not made: 500 ft AGL, 100 ft above MDA, and MDA.

Case 2

A Boeing 737 was on a day, nonprecision approach to Midway Airport, Chicago, Illinois; the captain was flying the aircraft. The approach minima were 400 ft and 1 mi; the reported weather was: Ceiling 500 ft overcast, visibility 1 mi. This was an undershoot.

The flightcrew did not report visual acquisition of ground cues, although the passengers stated that they could see the ground during the latter portions of the flight.

The required altitude callouts were not made. Minimum was called after the aircraft descended below the MDA and leveled off. Airspeed deviations callouts were not made although the airspeed was below the computed approach speed, and the stall warning device was eventually activated.

Case 3

A Boeing 707 was on a night precision approach to John F. Kennedy Airport, Jamaica, New York. The captain was flying the aircraft.

The approach minima were RVR 1600 ft, DH 150 ft; and the reported weather was: Indefinite ceiling 200 ft, sky obscured, visibility 1/2 mile with light drizzle and fog. The RVR was 4,500 ft, variable to 6,000 ft. This was an undershoot.

The approach was made on a CAT II facility, and the captain stated that he intended to make a CAT II autocoupled approach using the autopilot to the CAT II DH of 150 ft.

The autopilot was disconnected between 300 and 400 ft AGL. The pilot not flying called the approach lights in sight at about 250 ft AGL, just before the 100-ft above minimum callout.

The required 1,000 ft AGL, 500 ft AGL, and 100 ft above DH callouts were made. The DH callout was not made. The pilot not flying warned the captain that the aircraft was low, but the warning was based on his sighting of the runway. The pilot not flying stated that he saw, "a flattening of the scene with the aircraft descending rapidly towards the red approach lights."

Case 4

A DC-9 was on a day, precision approach to Logan Airport, Boston, Massachusetts. The first officer was flying the aircraft. The approach minima were 200 ft and 1/2 mile and the reported weather was: Partial obscuration, ceiling 400 ft overcast, visibility varying from 1/2 to 1 mile. This was an undershoot.

None of the required altitude callouts were made. The flightcrew was aware of airspeed deviations and displacements from the localizer course and glidepath. No sighting callouts were made.

Case 5

A Boeing 737 was on a night precision approach at Greensboro, North Carolina. The captain was flying the aircraft. The approach minima were 200 ft and 1/2 mile and the reported weather was: Ceiling 400 ft broken, visibility 1 1/2 mile with heavy rainshowers and fog. The approach was made with a tailwind component and resulted in an overshoot.

The pilot not flying called, "lights in sight," about 400 ft AGL, and the captain said that he made, "a visual" approach after that callout.

The pilot not flying called 500 ft above DH and 200 ft above DH, followed by the sighting callout. No further altitude callouts were made. The pilot not flying called out airspeed and descent rate deviations shortly after the sighting call, but did not call out any glide slope displacements. Both pilots stated that they knew the aircraft was above the glidepath, and the pilot not flying said that after the visual portion of the approach began he noted that the glide slope raw data indicator pointer was halfway down toward a full scale deflection.

Case 6

A DC-9 was on a night precision approach to Chattanooga Municipal Airport, Chattanooga, Tennessee. The captain was flying the aircraft. The approach minima were 200 ft and 1/2 mile and the reported weather was: Ceiling 400 ft broken, visibility 2 mi with heavy rainshowers. This was an undershoot.

The pilot not flying called the lights in sight about 1,000 ft AGL.

All required altitude callouts were made by the pilot not flying. He also made 2 callouts depicting an increasing descent rate after he had called minimums. There were no callouts made indicating displacements from the ILS glide slope. This was an autocoupled approach and the autopilot was not disconnected until the aircraft reached the DH of 200 ft.

Case 7

A Boeing 707 was on a night precision approach to Los Angeles International Airport, California. The first officer was flying the aircraft. The approach minima were 200 ft and 1/2 mile, and the reported weather was: Clear, visibility -- 4 miles with ground fog and smoke. This was a visual approach using the localizer and glide slope for guidance. The aircraft flew into a rapidly developing fog bank, The flightcrew had not been advised of the fog on the runway. The runway was in sight until the landing flare; a hard landing resulted.

The required visual approach altitude callouts were made at 1,000 ft AGL and 500 ft AGL. The required 100 ft AGL callout was not made. The 100 ft above DH and the DH callouts were instrument procedure altitude callouts and were not made.

The flight engineer noted and called that the aircraft was low on the glide slope during the early portion of the approach. He returned to his instrument panel scan, then turned forward to watch the last part of the approach and was surprised to note that the airport could not be seen. He saw the pilot not flying's glide slope indicator move to the top of the scale, but the aircraft struck the runway before he could say anything.

Case 8

A Boeing 707 was on a night precision approach at Pago Pago, Samoa. The captain was flying the aircraft. The approach minima were 250 ft and 1/2 mile and the reported weather was: Ceiling 1,600 ft broken, visibility 1 mile with heavy rainshowers. This was an undershoot.

The pilot not flying called the runway in sight when the aircraft was 7 nmi from the runway.

The 1,000 ft AGL, 500 ft AGL, and 100 ft above DH and the DH callout was made.

The pilot not flying told the pilot flying that he was high on the glide slope before the aircraft had reached the DH. He called out airspeed deviations before reaching the DH and again after he had called out DH. Except for the first glide slope displacement call and the airspeed deviation calls, there were no further displacement or deviation calls made.

Case 9

A DC-9 was on a night precision approach at Akron, Ohio. The captain was flying the aircraft. The approach minima were 200 ft and 1/2 mile and the reported weather was: Indefinite ceiling 200 ft obscured, visibility 1 1/2 mile with light rainshowers and fog. This was an overshoot. The pilot not flying called the runway in sight at minima.

The pilot not flying called OM passage, but not the 1,000 feet AGL. The 500 ft AGL callout was not made. The DH callout was made.

The pilot not flying called out airspeed deviations before reaching DH, but made no further deviation or displacement callouts after he had called DH or the field in sight. The aircraft was high on the glide slope and the indicated airspeed exceeded the target approach speed by almost 20 knots.

Case 10

A DC-9 was on a night precision approach at Charlotte, North Carolina. The first officer was flying the aircraft. The approach minima were 200 ft and 1/2 nmi, and the reported weather was: Ceiling 2,400 ft broken, visibility 2 nmi. with light rainshowers and fog. The first officer said that the rain could have been classified as moderate. This was an undershoot. Both pilots stated that the runway lights were visible throughout the entire approach.

The 1,000 ft AGL and 500 ft AGL callouts were not made. Since the runway lights were visible, instrument procedure altitude callouts were not made and localizer and glide slope raw data were not monitored. The pull-up command from the pilot not flying was based upon his observation and evaluation of visual cues. The aircraft struck a 30-foot high tree adjacent to the middle marker.

Case 11

A Boeing 707 was on a day nonprecision approach at Ontario, California. The first officer was flying the aircraft. The approach minima were 300 ft and 3/4 mi, and the reported weather was: Ceiling 300 ft overcast, visibility 4 mi with light drizzle, fog, haze and smoke. The transmissometer on the landing runway disclosed that the touchdown visibility was 6,000 ft RVR. This was an undershoot. The pilot not flying called the ground in sight about 50 ft above the MDA. The runway environment was not called in sight.

The air carrier's procedures required callouts every 100 ft from 500 ft AGL to the ground. The evidence did not indicate whether these callouts were made. The pilot not flying stated that he noted that the descent rate was a little higher than normal and told the pilot flying to level off at the MDA.

Case 12

A Boeing 727 was on a night precision approach at Atlanta, Georgia. The captain was flying the aircraft. The CAT II approach was to minima of 1,200 ft RVR, and a DH of 100 ft. The reported weather was: Indefinite ceiling 100 ft sky obscured, visibility 1/8 mi with fog, RVR 1,200 ft on the landing runway. This was an undershoot.

The pilot not flying called the approach lights in sight about 200 ft AGL. Thereafter, he made no further callouts.

The autopilot was disconnected about 200 ft AGL, and the captain looked up and flew the remainder of the approach visually. The evidence did not indicate if the 1,000 ft, and 500 ft AGL callouts were made by the pilot flying.

Case 13

A Boeing 727 was on a night nonprecision approach to Houston, Texas. The first officer was flying the aircraft. The approach minima were 350 ft and 1/2 nmi, and the reported weather was: Ceiling 1,700 ft broken, visibility 7 mi with heavy rainshowers and thunderstorms. This was an undershoot.

The runway was sighted at 4 nmi, and then called "in sight" at the 3 nmi radar fix.

The captain's rain removal and windshield wiper systems were inoperative, and he was trying to restore them to use with the flight engineer's help.

The evidence did not indicate if the 1,000 ft, and 500 ft AGL callouts were made. The MDA callout was not made, but the pilot not flying recalled the warning light illuminating at the MDA. The pilot flying leveled off at the MDA, and the sighting call was made. No further callouts were made. The pilot flying stated that the runway became a blur in heavy rain. The pilot not flying had no forward or side visibility. The aircraft descended into trees, the tops of which were about 300 to 340 ft below the MDA.

Case 14

A DC-10 was on a day precision approach to Logan Airport, Boston, Massachusetts. The captain was flying the aircraft. The approach minima were 200 ft and 1/2 mi, and the reported weather was: Ceiling 300 ft sky obscured, visibility 3/4 mi with rain and fog. This was an undershoot.

The approach lights were called in sight by the pilot not flying at 100 ft above DH. The runway was in sight at DH.

This was an autocoupled approach and the autothrottle system was used for airspeed control. The autopilot was disengaged shortly after the aircraft descended below the DH.

The flightcrew made all required altitude callouts including the 50 ft to touchdown callouts which are required to be made in 10 ft increments. The pilot not flying and flight engineer told the pilot flying that the aircraft was "low" shortly after the DH callout, and again shortly thereafter. According to the pilot not flying both these callouts were based on the glide slope raw data presentation; however, he could not recall the exact amount of the displacement. The aircraft had just traversed a severe wind shear, and the corrective measures taken by the pilot flying were not of sufficient magnitude to counteract the affects of the shear on the aircraft's flightpath.

Case 15

A Boeing 727 was on a day precision approach to J. F. Kennedy International Airport, Jamaica, New York. The first officer was flying the aircraft. The approach minima were 200 ft and 1/2 mile, and the reported weather was: Scattered clouds at 3,000 ft, ceiling 5,000 ft broken, visibility 2 miles, and there was a thunderstorm overhead. This was an undershoot.

The 1,000 ft and 500 ft AGL callouts were made by the flight engineer. The pilot not flying called the approach lights in sight about 400 ft AGL. The required 100 ft above DH, and DH callouts were not made. The pilot not flying called the runway in sight as the aircraft descended through 150 ft AGL.

Company procedures required that any significant deviations from desired performance be called to the attention of the pilot flying the aircraft. After passing through 400 ft AGL the aircraft's descent rate increased from about 675 fpm to 1,500 fpm; the airspeed decreased to Vref minus 7 KIAS; and the aircraft descended below the ILS glide slope. None of these departures from the desired performance were called out.

The Safety Board also found that the flight traversed a severe wind shear area which began about 500 ft AGL.

Case 16

A Boeing 727 was on a night precision approach to Raleigh/Durham Airport, North Carolina. The captain was flying the aircraft. The approach minima were 200 ft and 1/2 mile, and the reported weather was: Partial obscuration, 1,500 ft overcast, broken clouds at 500 ft, visibility 3/4 mile, heavy rain and fog. This was an undershoot.

The 1,000 ft and 500 ft AGL callouts were made by the pilot not flying. The 100 ft above DH and DH callouts were not made. The pilot not flying called out "ground contact" about 500 ft AGL, "flashers" in sight about 400 ft AGL, and the runway in sight about 300 to 350 ft AGL. Thereafter, the pilot not flying called out that they looked a little low on the VASI, and that the rate of descent was "too high." The descent rate callout did not specify the numerical rate as required by company procedures.

The captain added engine power at 200 ft AGL when he noted the aircraft was low on the glide slope. At 100 ft all forward visibility was lost in heavy rain. The captain added engine power but did not execute a missed approach.

Case 17

A Boeing 737 was on a day nonprecision approach to Natrona County International Airport, Casper, Wyoming. The captain was flying the aircraft. The approach minima were 330 ft and 3/4 mile, and the reported weather was: Indefinite ceiling 800 ft, sky obscured, visibility 1 1/2 miles varying to 3/4 mile in light snow, wind from 30 degrees at 8 knots. The landing was made on runway 25 with a tailwind component. This was a long landing and subsequent overshoot.

The 1,000 ft AGL, 100 above MDA, MDA, and runway sighting callouts were made by the pilot not flying. Company procedures required callouts be made at 100 ft intervals from 500 ft AGL to touchdown. These callouts were not made. Airspeed callouts were required whenever the indicated airspeed exceeded Vref plus 10 KIAS. Though the indicated airspeed exceeded Vref plus 10 KIAS during the approach these callouts were not made until just prior to touchdown and this callout was made using nonstandard terminology.