Key 1688

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: August 13, 1984

Forwarded to:

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-84-82 through -84

Between 4 p.m. and 5 p.m. on March 8, 1984, the National Transportation Safety Board received several telephone calls from witnesses who had observed aircraft flying close to tall buildings located in the Rosslyn, Virginia, area. These aircraft were conducting approaches to land at Washington National Airport, Washington, D.C. The witnesses were located on the ground and in the building at 1000 Wilson Boulevard. As a result of the reports and because of previous similar incidents investigated by the Safety Board, the Safety Board conducted a comprehensive investigation of the incidents. Ground witnesses, flightcrews, and air traffic controllers were interviewed, flight data recorders (FDR) from involved aircraft were read out, and recorded radar data were plotted. An analysis of this information has uncovered several safety hazards which warrant corrective action by the FAA. These involve the interpretation of descent profile altitude restrictions on instrument approach procedure charts, effectiveness of the minimum safe altitude warning system (MSAW), 1/ and air traffic controller procedures for issuing safety advisories to aircraft.

The official weather observation at Washington National Airport at 4 p.m. on March 8, 1984, was reported as ceiling measured 1,000 feet variable and broken, 2,000 feet overcast, visibility 6 miles with light rain and light snow; the wind was from 100° at 12 knots. The weather remained generally as reported at 4 p.m. until about 5:30 p.m. when, as the result of a frontal passage, ceilings lowered to indefinite, 200 feet, the sky was obscured, and visibility was one-quarter mile with thunderstorms and heavy snowshowers.

1/ MSAW is designed to monitor aircraft with altitude transmitting equipment (Mode-C) for terrain clearance and to generate aural and visual alarms to controllers when an aircraft is at or predicted to be at an unsafe altitude.

The arriving flights were executing the very high frequency omni-directional range station (VOR)/distance measuring equipment (DME) standard instrument approach to runway 18 at Washington National Airport. The VOR/DME runway 18 approach is a nonprecision approach with a series of step-down descents beginning at an altitude of 3,000 feet at the 10-mile DME fix down to 900 feet at the 3-mile DME fix. After passing the 3-mile DME fix, an aircraft may descend to the minimum descent altitude (MDA) of 720 feet. The MDA must be maintained until the required visual references for the intended runway are identifiable to the pilot and the aircraft is in a position from which a descent to landing can be made at a normal rate of descent. The missed approach point is located at the 0.5 DME fix.

The Safety Board's laboratory analyzed the recorded radar data from the FAA's Automated Radar Terminal System III (ARTS III) to determine whether any of the flights deviated from the VOR/DME runway 18 approach procedures. The flightpaths of 21 approaches to National Airport between 4 p.m. and 5 p.m. were plotted using the aircraft course and altitudes to examine their relation to the standard approach procedure and the tall building located at 1000 Wilson Boulevard. Nine of the resultant flight profiles showed that the aircraft were descended below the 900-foot-altitude specified for the approach before reaching the 3-mile DME fix. Six of these flights were 200 feet low, one flight was 300 feet low, one was 400 feet low, and one was 500 feet low. An examination of the latter flight's flight data recorder showed that it had descended to 365 feet just after passing the 3-mile DME fix and before passing the tall building at 1000 Wilson Boulevard. The height of this building is 396 feet. At least two of these flight profiles indicated that the aircraft were flown dangerously close, either directly over or near abeam, to the tall building with no more than 100 feet vertical clearance. The Safety Board's investigation also revealed that nine MSAW alerts were activated at Washington National Approach Control and Tower, and that a controller took action on only two, to warn pilots of their low altitude.

Human Performance Aspects of Approach Charts

The Safety Board's investigation has focused on why the pilots of these nine flights deviated from the altitudes depicted on their approach charts. The crew of one of these flights stated that their interpretation of the 3-mile DME fix altitude of 900 feet was that it was only a recommended, and not a minimum, altitude. They further stated their belief that unless the word mandatory was depicted over the altitude, the flight was allowed to descend to the MDA altitude of 720 feet after it had passed the final approach fix (5 DME). Through discussions with other airline pilots, Safety Board investigators determined that many of them also had differing interpretations of what the 3-mile DME fix, 900-foot altitude meant on this VOR/DME runway 18 approach procedure. Some pilots viewed the altitude as recommended, some as minimum, and others as mandatory. This confusion suggests the need to clarify approach plates so that pilots understand the exact procedure to be followed.

The Safety Board compared the symbology used to depict altitude requirements on both the Jeppesen and the National Oceanic and Atmospheric Administration (NOAA)/Defense Mapping Agency (DMA) profile views of instrument approach charts, and found the two to be significantly different. The NOAA/DMA charts use the numerical altitude alone, or in conjunction with underscoring and overscoring lines, to depict different altitude requirements; for example, an altitude of 900 means "recommended altitude"; an altitude with an overscore, $\overline{900}$, means "maximum altitude"; an altitude with an underscore, $\underline{900}$, means "minimum altitude"; and an altitude with both an underscore and an overscore, $\underline{\overline{900}}$, means "mandatory altitude." On the other hand, the Jeppesen charts use the numerical notation in conjunction with words to depict the various meanings. The altitude alone, 900', means "minimum altitude"; if other than "minimum altitude" is intended, the numerical notation is used in conjunction with the appropriate word above the altitude — mandatory, maximum, recommended.

900' 900' 900'

Many air carrier pilots were trained in the U.S. military service, which uses the NOAA/DMA approach charts. Also, many airline pilots are active in U.S. military reserve and national guard units, flying military aircraft on weekends and summer duty assignments. These same pilots, when flying for the airlines, generally use Jeppesen approach charts. Thus, these pilots use NOAA/MDA charts while flying for the military and Jeppesen charts while flying commercially.

The Safety Board believes that the lack of standardization of altitude legends on NOAA/DMA and Jeppesen charts could, in part, be responsible for the different interpretations of altitude requirements on approach charts. The Safety Board believes, therefore, that the same symbology or legend for depicting altitude restrictions should be used on both NOAA/DMA and Jeppesen charts to avoid misinterpretation by flightcrews.

This lack of standardization of chart legends is part of a bigger issue of serious concern to the Safety Board — that insufficient attention is given to human performance criteria in the review of approach procedure depiction on approach charts. These considerations go much farther than certain display requirements (e.g. width/height of letters) to include such items as amount of information displayed, and ease of identification and usability of that information. Pilots have been criticized for misinterpreting approach charts, but little consideration has been given to the operating environment in which the charts are used and the degree to which the charts themselves may be conducive to mistakes.

The Safety Board has investigated several accidents involving approach chart issues. In addition, testimony at public hearings has revealed that the FAA does not formally review approach charts designed by either the government or the private sector for human performance considerations. Further documentation of this concern is to be found in the NASA Aviation Safety Reporting System (ASRS) and the 1981 President's Task Force on Aircraft-Crew Complement. NASA has identified numerous ASRS incident reports in which approach chart issues played a significant role in the occurrence of the incident; and the President's Task Force emphasized that "the design and content of these charts should be improved."

In August 1982, the Safety Board issued a safety recommendation on this topic. In its November 1982 response, the FAA stated that it had undertaken a review of the subject area and expected this review to be completed in May 1983. The Board has not received the results of this review. Therefore, the Safety Board reiterates its previous recommendation that the FAA:

> Establish formal human performance criteria for the development and evaluation of instrument approach procedures and instrument approach charts. (Class II, Priority Action)(A-82-91)

MSAW System

The second safety hazard of concern to the Safety Board as a result of its investigation of the March 8 incidents involves the MSAW system and its use by controllers.

Of the nine MSAW alerts activated at Washington Approach Control and Tower on the afternoon of March 8, 1984, a tower controller took action on only two to warn pilots of their low altitude. The Safety Board investigation focused on the reasons action was not taken on the other seven alerts. In order to verify that all nine MSAW alerts were properly transmitted to controllers, Safety Board investigators took the recorded air traffic control radar data to the FAA Technical Center in Atlantic City and ran the data on a "retrack program." Investigators witnessed the same radar and audio information that was presented to the controllers on March 8. The recorded radar data revealed that, in fact, all nine MSAW alerts were properly processed by the system to provide an aural alarm and video presentation in the tower.

When an aircraft descends below the minimum safe altitude a buzzer sounds over speakers in the tower control cab and in the radar room for about 5 seconds. The volume can be adjusted by controls located in both the tower and the radar room. The lowest possible volume setting is audible throughout the facility, but the system can be selectively inhibited or turned off completely. At Washington National Airport, MSAW alerts are heard simultaneously in both the approach control radar room and the tower cab.

An alert message also is visually displayed on the radarscope for the duration of the alert condition. The symbol "LA" appears above the alphanumeric identification tag associated with the affected aircraft. A separate area on the scope displays the abbreviation "LOW ALT" and a list identifying the aircraft which are causing the system to issue the low altitude alert. The system can list a maximum of five aircraft simultaneously which may be causing an alarm.

Aural and visual warnings also are used to alert controllers when aircraft come hazardously close to each other. This conflict alert system (CA) aural alarm is the same tone as that of the MSAW alert and the sound emanates from the same speaker. All controllers in the radar room and tower are able to hear the alarm when it activates. When a controller hears an alarm, he must examine his radarscope in order to distinguish between a low altitude alert and a conflict alert (which is displayed as "CA" above the aircraft data tag).

Safety Board investigators interviewed the two supervisors and four controllers who were controlling aircraft on the VOR/DME runway 18 approach during the period 4 p.m. - 5 p.m. on March 8. One tower controller remembered hearing two altitude alerts during this timeframe, and he issued the appropriate warning to the pilots of the affected aircraft. He did not recall hearing the other seven low altitude alerts. The other tower controller recalled hearing only one alert, but the two radar controllers and the two supervisors did not recall how many, if any, aural alerts were sounded.

The supervisor who was on duty in the radar room at the time explained that the conflict alert activates frequently when aircraft are on converging courses, even though they normally will be controlled so as to maintain prescribed separation criteria. According to the supervisor, "a great majority of the time you associate the aural tone with a conflict alert" and "over a period of years the thing goes off (CA) and you really don't pay attention to it 98 percent of the time." Unfortunately, when a controller ignores the aural alarm, he may be ignoring a warning from the MSAW system, rather than a conflict alert. It is a basic precept of psychology and human engineering that the ability of a stimulus to elicit a response (in this case, the ability of a warning tone to get the controller's attention) is reduced when the stimulus is habitually presented without a reinforcement. 2/ Reinforcement for a controller would be the acquisition of useful information from an aural alarm. In other words, when a controller is continually subjected to "nuisance alarms," i.e., those that are perceived as useless or distracting, he/she will pay progressively less attention to alarms. 3/

The Safety Board found during its investigation of aircraft separation incidents at the Hartsfield-Atlanta International Airport on October 7, 1980, that the practice of ignoring alarms was prevalent. In its report, the Safety Board questioned the effectiveness of the CA and MSAW systems:

> The frequency of conflict and low altitude alerts should be considered. This situation and the others mentioned above [common tone and source for LA and CA, and alarms which have their origin in another controller's airspace] results in repetitive alerts which, in turn, condition the controller to dismiss the alarms or alerts (i.e. the "cry wolf" syndrome). The Safety Board believes that improvements are needed in both the audio and visual cues for the low altitude and conflict alert systems. 4/

2/ Psychology and Human Performance, Robert M. Gagne and Edwin A. Fleishman, Holt, Reinhart and Winston, Inc., 1959, page 151.

3/ Flight-Deck Automation: Promises and Problems, Earl L. Weiner and Renwich E. Curry, NASA TM 81206, June 1980, page 12.

4/ Special Investigation Report: Aircraft Separation Incidents at Hartsfield-Atlanta International Airport, Atlanta, Georgia, October 7, 1980, (NTSB-SIR-81-6).

As a result of the investigation, the Board recommended that the Federal Aviation Administration:

> Redesign the low altitude/conflict alert at ARTS III facilities so that the audio signal associated with the low altitude alert is readily distinguishable from that associated with the conflict alert and heard only by controllers immediately concerned with the involved aircraft. (Safety Recommendation A-81-134.)

In a letter dated December 21, 1981, in response to the Safety Board's recommendation, the FAA did not agree that separate aural alarms were needed, and stated, "we believe that the audio alarms represent a general warning or attention getter. The blinking alphanumerics represent the specific warning. It identifies the aircraft involved and the nature of the problem. The controller does not take control action based on the audio alarm; consequently, no benefit can be determined for the second audio alarm. The alarm or alarms mean the same thing, scan the display."

In a September 1, 1982, letter in further response to the Safety Board's urging that it adopt the recommended action, the FAA replied that it had "not changed our position" regarding A-81-134; therefore, the recommendation was classified as "Closed--Unacceptable Action" by the Board. In view of the information obtained during interviews with Washington National controllers during the investigation, the Safety Board believes that the FAA should reconsider its position on this matter and should implement action such as that called for in Safety Recommendation A-81-134 as soon as possible.

In a further attempt to determine why the local controller failed to issue low altitude alerts to seven of the nine flights which had caused the MSAW system to activate, the Safety Board examined the procedures for issuing safety advisories to airplanes. The FAA's Air Traffic Control Handbook, 7110.65C, paragraph 33, provides guidance to air traffic controllers to: "issue a safety advisory to an aircraft if you are aware the aircraft is at an altitude which, in your judgment, places it in unsafe proximity to terrain, obstruction, or other aircraft." Note 2 in paragraph 33 states in part, "recognition of situations of unsafe proximity may result from MSAW...." However, the Safety Board was given to understand that the phrase, "in your judgment," gives the controller the option, once the airplane has been identified on the BRITE display, to look at the airplane from the tower cab and form a judgment concerning the airplane's safety. If, in the controller's judgment, the airplane is a safe distance from obstructions and terrain, the controller may elect not to issue a low altitude alert.

During the investigation, Safety Board investigators discussed the provisions of paragraph 33 with senior FAA air traffic control management at Washington National Airport. Senior ATC management confirmed that a controller could decide not to issue a low altitude alert if, in his judgment, the airplane was at a safe altitude. They suggested further that this option may explain why the local controller may not have issued low altitude alerts to the pilots of at least some of the airplanes which had activated the MSAW system because of the option in paragraph 33.

In interviews with other controllers at Washington National Airport, the Safety Board received varied interpretations of the procedures contained in Paragraph 33. Some controllers stated that, in marginal weather conditions (ceilings close to the MDA), they would always issue a low altitude alert, while other controllers indicated that if they can see the airplane and it is not close to the buildings in Rosslyn, they do not issue the alert. The local controller on duty stated that he "didn't recall hearing the other seven MSAW alerts." The supervisor on duty in the tower, when asked how he judged whether an airplane was in unsafe proximity to the tall buildings, stated, "I can't tell what relation he is to that building when using the VOR DME approach.... I'm assuming he's flying the radial the way he's suppose to be."

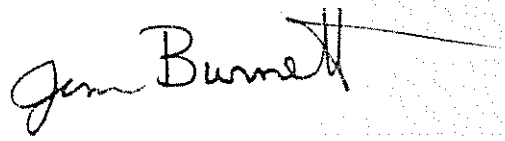
The Safety Board is concerned that the provisions of paragraph 33 can lead a controller to nullifying the intent and objective of the MSAW system which is to alert a pilot when his airplane is at an unsafe altitude. The MSAW system software for approach path monitoring is programmed to activate if the airplane is 100 feet below the MDA, or if it is predicted that the airplane will be 200 feet below the MDA within 15 seconds. The Safety Board believes these activation parameters are definitive indications of unsafe proximity to terrain, and that the controller should not be called upon to make a judgment with regard to an airplane's safety. The controller should immediately inform a flightcrew of the activation of a low altitude alert, and any decisions concerning the airplane's safety should be made in the cockpit. The Safety Board thus concludes that the FAA should amend its procedures in paragraph 33 to eliminate the option apparently available to controllers to not issue a low altitude alert to an aircraft which has activated the MSAW system based on a visual judgment that the airplane is at a safe altitude and to require that a controller issue an alert to the flightcrew of all such aircraft.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Prescribe standardized altitude symbology to be used in the profile view of approach procedure charts. (Class II, Priority Action) (A-84-82)
>
> Redesign the low altitude/conflict alert at ARTS III/III-A facilities so that the audio signal associated with a low altitude alert is readily distinguishable from that associated with a conflict alert and so that it is heard only by controllers immediately concerned with the involved aircraft. (Class II, Priority Action) (A-84-83)

Amend the Air Traffic Control Handbook, 7110.65C, paragraph 33, to require a controller to issue immediately a low altitude alert to any airplane under his control which has activated the Minimum Safe Altitude Warning System. (Class II, Priority Action) (A-84-84)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY and GROSE, Members, concurred in these recommendations.



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