# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

**Date:** July 12, 2006

**In reply refer to:** A-06-44 through -47

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

The National Transportation Safety Board has investigated 11 aircraft accidents[1]—10 involving apparent controlled flight into terrain (CFIT) and one involving a midair collision—that have caused serious concern about the effectiveness of the Federal Aviation Administration's (FAA) methods of ensuring that air traffic controllers detect and properly respond to imminently hazardous situations. The recommendations contained in this letter are intended to improve safety of flight through changes to the minimum safe altitude warning (MSAW) and conflict alert systems used to direct controller attention to CFIT hazards or impending collision and to FAA air traffic control (ATC) training.

**Background**

MSAW and Conflict Alert Systems Functionality

MSAW processing monitors aircraft position, altitude, and direction and uses both current and predicted position to alert controllers when an aircraft is in danger of striking the ground or obstructions, such as tall buildings or radio antennas. En route facilities (that is, air route traffic control centers) perform MSAW processing by comparing current and predicted aircraft position to a digitized chart containing minimum instrument flight rules (IFR) altitudes (MIA)[2] for all airspace under the facility's jurisdiction. When an IFR aircraft descends below the depicted

[1] Six of these accidents, including the midair collision, are discussed in this letter where applicable. Five other accidents were found to share similar characteristics and are as follows: CHI03FA041, occurring at Rockford, Illinois, on December 17, 2002; IAD05CA015, occurring at Binghamton, New York, on November 18, 2004; NYC06LA034, occurring at Burlington, Vermont, on November 22, 2005; NYC06FA040, occurring near Nantucket, Massachusetts, on December 1, 2005; and LAX06FA066, occurring near Livermore, California, on December 23, 2005. All were fatal accidents except for IAD05CA015, which involved only substantial damage to the aircraft. Descriptions for each can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

[2] MSAW and conflict alert services are typically provided to aircraft operating under IFR. In both en route and terminal ATC facilities, aircraft operating under visual flight rules (VFR) are excluded from MSAW processing by default because such aircraft often operate below MIAs and would, therefore, cause spurious alerts even though engaged in normal VFR operations. However, MSAW service is available to VFR aircraft on pilot request.

altitudes or is predicted to be below the depicted altitudes within a variable projected period, the system will alert the controller by inserting the flashing letters “MSAW” in the aircraft’s data block and also displaying the appropriate minimum altitude for the aircraft’s actual or predicted position in bright numbers. Aural alarms are not used in en route facilities.

Terminal facilities (that is, terminal radar approach control [TRACON] or airport traffic control towers) use a more complicated MSAW algorithm that relies on predicted or actual aircraft position compared to a digital terrain map composed of 2-nautical-mile (nm) squares. Each square contains a minimum altitude, and the software provides alerts when an aircraft is presently within 500 feet of the depicted minimum altitude or is predicted to be within 300 feet of the minimum altitude within 30 seconds. Different rules are applied to aircraft known to be executing an instrument approach procedure, recognizing that the flight is intentionally descending to ground level. The MSAW system still attempts to warn controllers if an aircraft significantly deviates below the approach procedure and CFIT may occur. Terminal radar controllers are alerted to MSAW hazards by the flashing letters “LA” (for low altitude), which are displayed above the data blocks of the affected flights (in facilities where color displays are installed, “LA” is displayed in red). The visual alert is supplemented with an aural warning tone that can be heard either locally through a speaker located at the controller positions involved in controlling the aircraft or via a single speaker that is audible to all positions in the operations room. The length of the aural alarm tone is variable but is typically set to sound for 5 seconds, which is the default setting. If the alert continues for more than 5 seconds, “LA” will continue flashing until the MSAW hazard is resolved, but the aural alarm will terminate.

Potential aircraft collision hazards are detected by conflict alert processing, which monitors aircraft speed, altitude, and direction and attempts to detect aircraft that may pass closely enough to warrant a controller-issued warning to the pilots about the other aircraft’s position.[3] In en route facilities, controllers are alerted to conflicts between aircraft by the data blocks of the involved aircraft flashing on and off. As with MSAW alerting in en route facilities, there is no associated aural warning. In terminal ATC facilities, the method for alerting controllers to conflicts between aircraft is identical to that used for MSAW alerts, except that the display shows the letters “CA” (for conflict alert) above the data blocks of the aircraft involved, and the aural alarm tone is modulated slightly differently.

MSAW and conflict alerts are routed to specific air traffic facilities and controllers based on a set of eligibility rules that are controlled by software parameters. These parameters have default settings that are typically retained when the software is installed. If these parameters are not carefully managed, however, the alerting eligibility at certain facilities may be inconsistent with local air traffic procedures, which could result in alerts not being directed in a timely manner to the facility that is in the best position to address the safety hazard. This issue is of particular concern in terminal facilities because software parameter settings in TRACONs govern software settings at airport traffic control towers. Tower radar displays generally operate as

[3] Conflict alert processing also includes an enhanced conflict detection capability known as “mode C intruder,” which provides a warning when a conflict is detected between an aircraft receiving ATC services and another radar-observed aircraft that may not be under ATC control. Mode C intruder detection identifies such a conflict as described for conflict alert detection, except that the controller receiving the alert may be in contact with only one of the two aircraft involved. The second pilot may not even be aware that there is another aircraft in the vicinity, and the controller typically has no way of providing a warning to the second aircraft.

remote positions driven by data sent from the parent radar approach control facility. Alert processing occurs at the approach control, and any pertinent alerts are then presented on the appropriate tower radar display along with accompanying aural alarms.

FAA ATC Requirements Regarding the Provision of Safety Alerts

FAA Order 7110.65, "Air Traffic Control," paragraph 2-1-6, "Safety Alerts" directs controllers in how to respond when they become aware of potentially hazardous situations and states, in part, the following:

> Issue a safety alert to an aircraft if you are aware the aircraft is in a position/altitude which, in your judgment, places it in unsafe proximity to terrain, obstructions, or other aircraft. Once the pilot informs you action is being taken to resolve the situation, you may discontinue the issuance of further alerts. Do not assume that because someone else has responsibility for the aircraft that the unsafe situation has been observed and the safety alert issued; inform the appropriate controller.
>
> NOTE-
>
> 1. The issuance of a safety alert is a first priority…once the controller observes and recognizes a situation of unsafe aircraft proximity to terrain, obstacles, or other aircraft. Conditions, such as workload, traffic volume, the quality/limitations of the radar system, and the available lead time to react are factors in determining whether it is reasonable for the controller to observe and recognize such situations. While a controller cannot see immediately the development of every situation where a safety alert must be issued, the controller must remain vigilant for such situations and issue a safety alert when the situation is recognized.
>
> 2. Recognition of situations of unsafe proximity may result from MSAW/E [en route]-MSAW/LAAS [low altitude alert system], automatic altitude readouts, Conflict/Mode C Intruder Alert, observations on a PAR [precision approach radar] scope, or pilot reports.
>
> 3. Once the alert is issued, it is solely the pilot's prerogative to determine what course of action, if any, will be taken.
>
> a. Terrain/Obstruction Alert. Immediately issue/initiate an alert to an aircraft if you are aware the aircraft is at an altitude which, in your judgment, places it in unsafe proximity to terrain/obstructions.
>
> b. Aircraft Conflict/Mode C Intruder Alert. Immediately issue/initiate an alert to an aircraft if you are aware of another aircraft at an altitude which you believe places them in unsafe proximity. If feasible, offer the pilot an alternate course of action.

Although this paragraph specifically addresses MSAW and conflict alert activations as possible reasons for warning a pilot, the Safety Board notes that such occurrences are not a prerequisite for issuance of a safety alert. Controllers are required to remain vigilant for hazardous situations and to apply good judgment in warning pilots of potential danger when necessary. A variety of circumstances may require the application of good judgment (discussed below)—some resulting from activation of a warning system such as MSAW or conflict alerting and others in which, in the absence of an automated alert, controllers may need to evaluate available information and decide whether a safety hazard exists.

**Discussion**

Preliminary and final data obtained during the Safety Board's investigations of a series of accidents that occurred between December 2002 and February 2006 have shown that, in several accidents, MSAW and conflict alert software provided timely warning of hazardous situations but controllers did not provide appropriate safety alerts. In other accidents, MSAW and conflict alert services were not effective in alerting controllers because of software configuration and other issues. Other accidents occurred when, in the absence of automated alerts, controllers did not use available information to identify and warn pilots of hazardous situations. Accidents illustrating each of these safety issues are discussed below.

Ineffectiveness of MSAW and Conflict Alert Warnings in Capturing/Directing Controller Attention

On December 17, 2002, about 0335 Guam standard time, Philippine Airlines flight 110, an Airbus A330, struck power lines at the top of Nimitz Hill while attempting to execute a localizer approach to runway 6L at A. B. Pat Won International Airport the (GUM), Agana, Guam. The flight crew received a warning from the onboard ground proximity warning system (GPWS) and executed a missed approach, averting a collision with houses and terrain by about 30 feet. The aircraft incurred minor damage, but the flight crew was able to complete a second approach and successfully land at GUM. There were no injuries to anyone aboard the 14 *Code of Federal Regulations* (CFR) Part 129 flight or on the ground.

At the time of the incident, flight 110 had been cleared for approach by Guam Combined Center/Radar Approach Control (CERAP) and was in communication with GUM airport traffic control tower. During the approach, the aircraft began descending prematurely and flew the approach much lower than normal.[4] The CERAP MSAW system detected that the aircraft was approaching terrain and generated a visual MSAW alert to the CERAP final approach controller that continued for 1 minute and 15 seconds; the visual alert was accompanied by a 5-second aural alarm. During this time, the aircraft descended about 1,000 feet before the GPWS activated and the flight crew executed a missed approach. Because of the software parameter settings at CERAP, GUM control tower received only a visual alert on the tower radar display until the aircraft was within 5 miles of the airport, at which point an aural alarm sounded. The aural alarm

[4] According to flight data recorder information and the captain's statement, the captain set the autopilot to fly a 3.4º descent angle as the aircraft descended through 3,600 feet. At that point, the aircraft was 12.7 miles from the runway 6L touchdown point, where the calculated glideslope height based on the 3.0º glideslope specified on the instrument landing system 6L approach chart is 4,060 feet. This resulted in a descent path that ended at the top of Nimitz Hill, approximately 4.5 miles from the runway 6L touchdown point.

in the tower occurred about the time that the flight crew reported the missed approach. Neither the CERAP controller nor the GUM tower controller took action to resolve the MSAW alerts.

Even though the CERAP controller was no longer in contact with flight 110 when the incident occurred, she remained responsible for providing radar monitoring of the aircraft's approach until it landed safely because GUM control tower is not an IFR control facility. According to postincident statements, the CERAP controller heard the aural alarm but did not contact GUM control tower or the flight crew because she mistakenly believed a second alarm would sound if the MSAW hazard was not resolved.[5] She also indicated that MSAW alerts "go off all the time." When interviewed after the incident, the GUM tower controller indicated that he did not remember receiving a visual or aural MSAW alert.

On May 10, 2004, about 2051 Pacific daylight time, a Piper Seminole, N304PA, was destroyed and the two pilots aboard were killed after impact with terrain near Julian, California. The flight was being conducted under IFR as a 14 CFR Part 91 training flight from Phoenix Deer Valley Airport (DVT), Deer Valley, Arizona, to McClellan-Palomar Airport (CRQ), Carlsbad, California. N304PA was part of a group of Piper Seminole airplanes with registration numbers ending in "PA" that were all flying a few minutes apart along the same route from DVT to CRQ.

At the time of the accident, N304PA was receiving IFR radar services from Southern California TRACON (SCT), San Diego, California. The flight had been transferred to SCT about 2038 by the sector 9 radar controller at Los Angeles ARTCC (ZLA), Palmdale, California, and was being displayed to two controllers at the receiving sector at SCT and the transferring controller at ZLA. At 2047:55, one of the controllers at the SCT sector handling N304PA instructed "Seminole Four Papa Alpha" to descend to 5,200 feet, intending the instruction for an airplane in the group with registration N434PA. Instead, the pilot of N304PA acknowledged the clearance and read back his full callsign. The two SCT sector controllers failed to notice that the pilot of the wrong aircraft had read back the clearance, and N304PA began to descend to 5,200 feet in an area where the MIA for both SCT and ZLA varied from 7,700 to 8,000 feet.

Seconds after N304PA left 8,000 feet, the ZLA MSAW system noted that the aircraft had descended below the charted MIA and initiated a low altitude alert to the ZLA sector 9 radar controller. According to FAA Order 7110.65, the ZLA sector 9 controller was required to evaluate the situation and determine whether a warning to the pilot was needed even though he was no longer in communication with the aircraft. If he determined a warning was necessary, the controller was then obligated to ensure that the SCT controllers were aware of the low altitude alert. However, the ZLA controller did not contact SCT about the MSAW alert. As N304PA descended through 6,800 feet, the controller dropped the aircraft's data block from his display[6] more than a minute after the alert began.

Because the MSAW algorithms at SCT (a terminal facility) were different than those at ZLA (an en route facility), the SCT MSAW system did not generate an alert when N304PA descended below 8,000 feet but generated two predicted alerts at 2050:46 and 2050:51 when the

[5] The controller had received MSAW training and was certified to use the system.

[6] Dropping an aircraft's data block is a routine action when an aircraft leaves the transferring controller's area of responsibility.

airplane was at 6,400 feet. These two consecutive predicted alerts caused a 5 second aural alarm to the SCT sector controlling N304PA beginning at 2050:51 and a flashing red "LA" in N304PA's data block from 2050:51 until about 2051:06. After reaching 6,100 feet, the aircraft was below radar coverage, which caused the MSAW alert at SCT to terminate because of loss of radar contact. Shortly afterward, N304PA struck terrain at an elevation of 5,500 feet.

When interviewed after the accident, the ZLA controller stated that, in his judgment, he did not need to call SCT when he received the MSAW alert because he had no reason to suspect that the aircraft's descent was a problem. However, he was unable to articulate any facts or IFR procedures that would support that determination. During their postaccident interviews, the two controllers on duty at the SCT sector stated that they did not notice the aural and visual MSAW alerts. Consequently, no warning was provided to the pilots of N304PA.

On February 8, 2006, about 1642 Pacific standard time, a Cessna 172RG, N9531B, and a Cessna 182Q, N759KE, were destroyed when they collided in flight approximately 3 miles south of Gillespie Field Airport (SEE), El Cajon, California. The certified flight instructor and student pilot in N9531B and the private pilot operating N759KE were all killed. N9531B was operating under 14 CFR Part 91 and departed from runway 27R at SEE about 1637 on an IFR flight plan, destined for Brown Field Municipal Airport (SDM), San Diego, California, about 15 miles south of SEE. N759KE, also operated under Part 91, departed runway 27R at SEE about 1638 on a local visual flight rules (VFR) flight to SDM. Visual meteorological conditions (VMC) prevailed and included high broken cloud cover with visibility of 25 miles. The Safety Board's investigation of this accident is ongoing.

According to a SEE tower controller on duty at the time of the accident, N9531B followed the standard IFR departure procedure for SEE after takeoff, which requires runway 27R departures to complete a right 270º climbing turn and cross over the airport southbound. The pilot was given a frequency change to SCT during the turn and contacted SCT at 1639:41. N759KE, departing from runway 27R a minute after N9531B, was instructed by the tower controller to proceed west for 2 miles before turning southbound. As the pilot of N759KE reached 2 miles west of the airport and turned south, he asked the SEE tower controller for permission to leave the frequency. During postaccident interviews, the controller stated that she looked for traffic in the immediate area around the aircraft and, seeing none, approved the pilot's request.[7]

At 1640:24, one of two controllers at the SCT radar sector handling N9531B instructed the pilot to fly heading 200, and the pilot acknowledged the instruction. At that time, N759KE was about 1.6 miles west of N9531B, and the SCT controller's turn instruction put the two aircraft on converging courses. Radar replay data indicates that the aural conflict alert alarm at SCT activated twice, at 1640:55 and 1641:05, and that a continuous visual alert was displayed to the radar sector handling N9531B, as well as the South Bay sector at SCT from 1640:55 until the airplanes collided about 40 seconds later. An aural alarm is audible in the background of a radio transmission from the SCT radar controller to N9531B at 1640:56. The pilots were not provided with traffic advisories or a safety alert. When interviewed after the accident, the two controllers

[7] Because of damage to the aircraft, investigators were unable to determine the frequency the pilot was monitoring at the time of the collision.

at the radar sector handling N9531B and the controller at the South Bay sector all stated that they did not hear or see a conflict alert at any time before the accident.

Because of the SCT radar system configuration, the SEE tower radar display was not eligible to receive visual or aural MSAW or conflict alerts on departing aircraft. Even if N759KE had remained on the SEE tower frequency, it is unlikely that the tower controller would have been aware of a visual conflict alert because her attention would have been focused on airport operations visible through the windows rather than on the tower radar display, making the need for an aural alarm even more critical. The Safety Board also notes that, because the collision occurred inside class D airspace delegated to SEE tower, the tower controller still had some responsibility for both aircraft and the lack of an aural and visual alert on the tower radar display could increase the likelihood that a conflict between aircraft on tower frequency could go unnoticed.

In each of the above accidents, the MSAW and conflict alert software performed as designed and attempted to alert controllers about the detected hazards. However, none of the warnings resulted in timely ATC intervention because controllers were either aware of the alert but failed to take action or they remained unaware of the hazardous situation despite the activation of the alerting systems. When Safety Board investigators reviewed recorded audio and radar data surrounding the events, the same controllers appeared to be conscientiously and attentively engaged in performing their duties. The Board is concerned about the lack of effectiveness of these alerting systems, which failed to reliably capture the attention of otherwise apparently conscientious and attentive controllers.

When asked during postaccident interviews to explain the factors they believed might have contributed to missing the warnings presented to them, controllers repeatedly cited the number of unwarranted "nuisance alarms" that they are exposed to on a routine basis. Controllers described situations in which routine and repetitive VFR operations in terminal areas caused frequent conflict alerts or in which certain approach procedures coupled with topographical features triggered MSAW alerts even when aircraft were in compliance with the track and altitudes shown on the procedure. This can lead to controllers assuming that alerts are invalid or tuning them out from overexposure. Supervisors, who are normally expected to monitor several dispersed control positions, noted that the source of an aural alarm is often difficult to identify, which makes it harder for them to investigate and provide assistance if needed to resolve a hazardous situation.

These observations are consistent with a 2003 study[8] about ATC aural alarms published by the Research Development and Human Factors Laboratory of the FAA's William J. Hughes Technical Center. Researchers conducted structured interviews with terminal controllers to identify their concerns about aural alarm systems in use at terminal ATC facilities and found that the five most commonly discussed issues were alarms that can be easily confused because they sound alike; alarms that go off too frequently, especially false alarms; alarms that are annoying (examples cited were alarms that continued to sound after the problem was acknowledged and alarms that did not give pertinent information); alarm sources that are difficult to localize; and

[8] V. Ahlstrom, *An Initial Survey of National Airspace System Auditory Alarm Issues in Air Traffic Control*, DOT/FAA/CT-TN03/10, (Atlantic City, New Jersey: FAA, 2003).

too many simultaneous alarms. MSAW alarms attracted a particularly large number of negative comments because of the quantity of alarms and the large number of them that are perceived as unwarranted. Controllers in the study noted that MSAW and conflict alert aural alarms are frequently difficult to distinguish and, on some FAA automation systems, are effectively identical. They also noted that MSAW frequently and unnecessarily alarmed for aircraft flying visual approaches because the software is configured to protect aircraft flying within the limits of a standard IFR approach. The study recommended that the FAA act to reduce the number of "nuisance alarms" and that aural alarms be redesigned to account for humans' ability to distinguish alarm sounds in the working environment. It also recommended the use of alarm sounds that are easily identified and localized.

The Safety Board agrees with these findings and notes that presenting MSAW and conflict alert warnings using both visual and aural methods is beneficial because the ATC task environment often requires controllers to be responsible for multiple subtasks that do not involve constantly looking at their displays. However, the current design of MSAW and conflict alert warning systems does not provide effective redundant cuing of the alarm condition because the aural component of the warning automatically silences after a few seconds. The current design of these systems also does not provide any assurance that a controller has recognized and acknowledged the warning. A possible modification to address these concerns would be to require that controllers acknowledge alarms by clicking on the data block of the aircraft involved, for example, before the aural alarm terminates. Because MSAW and conflict alert warnings are critical in directing controller attention to an unsafe condition and current methods for alerting controllers have been shown to be ineffective, the Safety Board believes that the FAA should redesign the MSAW and conflict alert systems and alerting methods such that they reliably capture and direct controller attention to potentially hazardous situations detected by the systems. Implement software changes at all ATC facilities providing MSAW and conflict alert services.

The Safety Board notes that unless the issue of false MSAW alarms is addressed through systematic review and evaluation of the eliciting criteria, any changes intended to increase the salience of the actual alarm will not be effective. During the investigation of this safety issue, discussions of "nuisance alarms" with FAA technical personnel responsible for MSAW software management revealed known areas for improvement in system performance. These include increased resolution and accuracy of the digital maps used to model terrain and obstructions, terminal software changes that will allow MSAW processing to take into account charted minimum vectoring altitudes in addition to the digital terrain model presently used, and modifications to reduce the frequency of alarms attributable to visual approach operations. Regarding this last area for improvement, FAA automation staff reported that, in an effort to limit "nuisance alarms," MSAW parameters are presently set not to trigger an alarm for aircraft that routinely fly visual approaches lower than any precision instrument approach. Because the present MSAW design does not provide any way to alter system performance to treat aircraft flying visual approaches differently from aircraft flying instrument approaches, aircraft that deviate from instrument approach limits during instrument meteorological conditions (IMC) may not generate an MSAW alert until they are well below the expected instrument approach altitude.

This aspect of MSAW system performance was identified as an issue in the Safety Board's ongoing investigation of a November 22, 2004, accident involving a Gulfstream

G-1159A, which struck a light pole adjacent to a roadway and crashed in IMC while on an instrument landing system (ILS) approach to runway 4 at Houston Hobby Airport, Houston, Texas. Although Safety Board investigators noted that the MSAW system performed as designed and the controller responded in a timely manner to the alert, an analysis of MSAW performance found that the system provided only 11.5 seconds of warning before the aircraft struck the pole, which was not sufficient time for the controller handling the airplane to recognize the alert and warn the crew to prevent the accident.

Configuring the single set of MSAW parameters is a balancing act between minimizing "nuisance alarms" and providing sufficient warning time. Modifying MSAW software to apply different alerting parameters to aircraft flying visual and instrument approaches will likely decrease the number of false alarms when aircraft are in visual approach conditions and increase warning times when aircraft are instrument dependent. More generally, modifying MSAW software to reduce the frequency of false alarms will increase the credibility and overall effectiveness of MSAW warnings, which, in turn, is likely to improve controllers' ability to detect hazards and potentially prevent CFIT accidents. A technical review of en route and terminal MSAW system performance will be useful in determining any necessary changes to the software. Therefore, the Safety Board believes that the FAA should implement any software and adaptation modifications needed to minimize or eliminate unwarranted MSAW alerts.

Effect of Software Configuration on MSAW Performance

On August 4, 2005, about 0206 mountain daylight time, a Mitsubishi MU-2B-60 airplane, N454MA, operating as Americheck flight 700 struck terrain near Parker, Colorado, during an ILS approach to runway 35 at Centennial Airport (APA). The solo commercial pilot was killed and the airplane was destroyed. The aircraft departed from Salt Lake City, Utah, on a 14 CFR Part 135 nonscheduled cargo flight to APA. The Safety Board's investigation of this accident is ongoing.

The pilot contacted the radar controller at Denver TRACON after entering the Denver area from the northwest. The aircraft was vectored to the runway 35 final approach course and cleared for the approach about 0203. About a minute later, when the airplane was about 10 miles from the airport, the pilot was instructed to contact the tower at APA. As N454MA continued inbound on the ILS, the aircraft went below the glideslope. Denver TRACON MSAW visual and aural alerts activated at 0205:37 for about 5 seconds and again from 0206:00 until terrain impact about 42 seconds later. The aircraft was about 7.2 and 6.3 miles from the airport, respectively, when the MSAW alerts at Denver TRACON activated. Because of the MSAW software configuration at Denver TRACON, APA tower was not eligible to receive aural MSAW alarms for any aircraft more than 5 miles from the airport.[9] As a result, APA tower received only visual alerts[10] when the MSAW alerts activated at Denver TRACON. The aircraft reached a point

[9] The Safety Board notes that the software configuration at Denver TRACON was inconsistent with local air traffic procedures because APA tower was routinely in communication with aircraft on approach at least 8 miles from the airport.

[10] At the time of this accident, FAA procedures did not require that TRACON controllers take any action when presented with an MSAW alert for an aircraft in contact with tower controllers. The FAA corrected this deficiency in early 2006, and under current procedures, the Denver TRACON controllers would have been required to advise APA that they were receiving an alert as soon as it occurred.

5 miles from APA at 0206:35, and the ongoing MSAW alert then caused an aural alarm in the tower. The tower controller immediately transmitted a safety alert, but the aircraft struck the ground within seconds.

Interviews with controllers involved in this and other accidents revealed widespread lack of familiarity with MSAW configuration and associated MSAW performance issues. For example, approach controllers were not aware that certain parameter settings inhibit tower alerting until an airplane is within a certain number of miles of the airport. In addition, FAA procedures do not impose any limitations on the point at which aircraft communications are transferred between approach controllers and tower controllers. This deficiency in the regulations leaves a possible gap in full MSAW protection between the point a pilot is instructed to contact the tower controller and the time that the tower controller begins to receive both aural and visual alarms. Aural alarms are particularly important in tower facilities because controller attention must mainly be focused on aircraft visible through the windows, rather than on the radar display, and the aural alarm is the primary method used to draw attention to the radar display in the event of a conflict alert or MSAW alert. Therefore, because it is important that timely and effective MSAW and conflict alert warnings are delivered to all controllers who are in a position to react, the Safety Board believes that the FAA should perform a technical and procedural review at all air traffic facilities with MSAW or conflict alert capability to verify that software configuration and parameters are consistent with local air traffic procedures. Ensure that MSAW and conflict alert warnings are provided to the relevant controllers.

Importance of Good ATC Judgment in the Absence of Automated Warnings

On October 24, 2004, about 2325 Pacific standard time, a Learjet 35A, N30DK, registered to and operated by Med Flight Air Ambulance, Inc., collided with mountainous terrain shortly after takeoff from SDM near San Diego, California. The captain, the copilot, and the three medical crewmembers were killed, and the airplane was destroyed. The repositioning flight was operated under the provisions of 14 CFR Part 91, and an IFR flight plan had been filed. Night VMC, including a broken-to-overcast ceiling at 2,100 feet, prevailed for the flight, which departed runway 8L at SDM about 2323.

The published procedure for IFR aircraft departing from runway 8L called for a climbing left turn to a heading of 280º, which was a nearly complete course reversal intended to avoid high terrain east and northeast of the airport. However, review of recorded radar data showed that the airplane climbed straight-out to the east. After departure, the pilot contacted SCT and requested an IFR clearance, which the pilot was required to obtain before entering clouds in accordance with Federal regulations. The SCT controller transmitted to the pilot that the airplane had been radar-identified and instructed him to turn to a heading of 020º, maintain VFR, and expect the IFR clearance after reaching 5,000 feet. The pilot acknowledged. No further radio communication was received from the flight.

Review of radar data showed that, during this exchange, N30DK was about 3.5 nm west of the mountains at an altitude of 2,300 feet above sea level and that the heading issued by the controller resulted in a flight track that continued toward the mountains. The minimum vectoring altitude ahead of the aircraft was 5,000 feet. According to recorded radar data from SCT, an MSAW alert occurred within 5 seconds after the controller radar-identified the airplane. It struck mountainous terrain east of the airport at an elevation of 2,300 feet about 35 seconds after it was radar-identified and the controller instructed the pilot to fly the 020º heading.

The SCT radar controller had previously worked as a tower controller at SDM and was familiar with the high terrain in the area around the airport. The controller was also aware of the ceiling because he had obtained the weather report when N30DK arrived at SDM about 60 minutes before the accident. Because the controller declined to issue the pilot an IFR clearance until the aircraft reached 5,000 feet (the minimum vectoring altitude in the area), the pilot was effectively unable to climb legally, and the aircraft was caught between the ceiling and the ground in an area of rapidly rising terrain. The controller failed to use available information to recognize that he had left the pilot with no viable options.

On November 10, 2004, about 2200 Pacific standard time, N803ZG, a Piper Saratoga, struck terrain while on a VFR flight from Bakersfield, California, to Santa Barbara, California. The pilot and two passengers were killed, and the airplane was destroyed. The flight was operating in night visual conditions over a remote mountainous area north of Santa Barbara at a cruise altitude of 6,500 feet and was receiving VFR radar flight-following service from ZLA.

The pilot contacted ZLA about 2149 and reported that his altitude was 8,300 feet. Over the next 5 minutes, the aircraft descended to 6,400 feet then continued at 6,400 to 6,500 feet for the remainder of the flight. About 2200, the aircraft disappeared from radar. The controller attempted to contact the pilot about 2202 but was unable to do so. The aircraft collided with trees and terrain extending to approximately 6,700 feet above sea level. Although no MSAW alert was displayed to the controller because N803ZG was operating under VFR and the pilot had not requested MSAW services, the controller did not provide the pilot with a safety alert or other terrain warning, as required by FAA Order 7110.65.

The Safety Board is concerned that all the information needed to prevent the accidents involving N803ZG and N30DK was available to both the controllers and pilots involved, but the accidents still occurred. Both aircraft were radar-identified, altitude information from both aircraft was being displayed to controllers, MIA information was readily available, and a sectional chart showing detailed terrain elevations was posted above each of the involved control positions. Although aircraft operating under VFR are not required to adhere to MIAs, a comparison of observed or reported aircraft altitude against known MIA information provides a rough indication that an aircraft may be operating in close proximity to terrain and, therefore, in need of additional monitoring (especially aircraft operating in remote areas at night).

In the case of N803ZG, the MIA in the area of the accident was 9,000 feet and was displayed on a chart at the sector responsible for radar control of the airplane. When interviewed, the controller handling N803ZG stated that she believed MIAs were established 1,000 feet above terrain and obstructions, which is an incorrect understanding of the MIA regulations for mountainous areas.[11] Her misunderstanding, however, should have caused her even more concern about the accident airplane's altitude because her misinterpretation would mean that the underlying terrain elevation was nearer to 8,000 feet, rather than 7,000 feet, and that, flying at 6,500 feet, the airplane would have been that much further below maximum terrain elevation for the area. The controller also stated that she did not refer to the sectional chart depicting specific terrain elevations while handling N803ZG.

In discussing the circumstances of these accidents with the controllers involved, both stated that terrain avoidance under VFR operations was solely a pilot responsibility. The controller handling N803ZG stated that she had little knowledge of the terrain in her area of responsibility[12] because she was only required to be familiar with the MIA chart and minimum altitudes for the airway structure. The controller handling N30DK stated that he had no obligation to be concerned about the aircraft's altitude, even though he was providing radar vectors in an area of high terrain, because the aircraft was not yet on an IFR clearance. Neither controller perceived that the aircraft they were handling were in danger, even though an IFR aircraft in the same position would have needed to be at least 2,000 feet or more higher to be considered safe. Although the Safety Board recognizes that altitude selection for VFR operations is primarily up to the pilot, aircraft altitude should still be of concern to controllers when they are providing radar services to VFR aircraft. FAA Order 7110.65 makes no distinction between VFR and IFR operations regarding the issuance of safety alerts when hazards to flight are observed. Controllers are required to use their judgment, remain vigilant for situations in which aircraft are endangered, and issue, as a first-priority duty, a safety alert when such situations are recognized.

FAA Order 3120.4L, "Air Traffic Technical Training," requires that terminal controller training include study of minimum vectoring altitudes, as well as significant terrain and obstructions in the area covered by the facility radar map; however, en route controllers are not specifically required to be familiar with the topography in their areas of responsibility by studying sectional or other similar charts. It is not reasonable for the FAA to expect controllers to be able to apply good judgment in recognizing and evaluating potential CFIT situations if they lack the training and knowledge needed to do so. Therefore, the Safety Board believes that the FAA should amend FAA Order 3120.4L, "Air Traffic Technical Training," to require that all controllers study and demonstrate an understanding of the relationship between charted MIAs and the underlying topography for their areas. Emphasize that controllers should maintain awareness of aircraft altitudes to detect and effectively react to situations in which a safety alert may prevent an accident (especially aircraft operating in remote areas at night).

---

[11] Section 91.177, "Minimum Altitudes for IFR Operations," states, in part, "Except when necessary for takeoff or landing, no person may operate an aircraft under IFR below (1) The applicable minimum altitudes prescribed in Parts 95 and 97 of this chapter; or…(i) In the case of operations over an area designated as a mountainous area in [P]art 95, an altitude of 2,000 feet above the highest obstacle within a horizontal distance of 4 nautical miles from the course to be flown." Therefore, an MIA of 9,000 feet in the area of the accident involving N803ZG implies that the underlying topography is in the vicinity of 7,000 feet, and an aircraft operating VFR at 6,500 feet is likely to be at or well below maximum terrain elevation for the area.

[12] Radar controllers are also responsible for knowing MIA information for their area of responsibility.

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

> Redesign the minimum safe altitude warning (MSAW) and conflict alert systems and alerting methods such that they reliably capture and direct controller attention to potentially hazardous situations detected by the systems. Implement software changes at all air traffic control facilities providing MSAW and conflict alert services. (A-06-44)
>
> Implement any software and adaptation modifications needed to minimize or eliminate unwarranted minimum safe altitude warning alerts. (A-06-45)
>
> Perform a technical and procedural review at all air traffic facilities with minimum safe altitude warning (MSAW) or conflict alert capability to verify that software configuration and parameters are consistent with local air traffic procedures. Ensure that MSAW and conflict alert warnings are provided to the relevant controllers. (A-06-46)
>
> Amend FAA Order 3120.4L, "Air Traffic Technical Training," to require that all controllers study and demonstrate an understanding of the relationship between charted minimum instrument flight rules altitudes and the underlying topography for their areas. Emphasize that controllers should maintain awareness of aircraft altitudes to detect and effectively react to situations in which a safety alert may prevent an accident (especially aircraft operating in remote areas at night). (A-06-47)

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS, HERSMAN, and HIGGINS concurred with these recommendations.

*[original signed]*

By: Mark V. Rosenker
Acting Chairman