U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

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	Initiated by: ATP-120	Change:

MINIMUM SAFE ALTITUDE WARNING (MSAW) EN ROUTE MINIMUM SAFE ALTITUDE WARNING (E-MSAW)

1. PURPOSE. This advisory circular (AC) describes the capabilities and limitations of MSAW and E-MSAW and contains only information which does not impose requirements on the public or on the FAA.

2. CANCELLATION. AC 90-72A dated 1/31/78 is cancelled.

3. DISCUSSION.

a. The FAA has furnished Air Route Traffic Control Centers (ARTCC), En Route Automated Radar Tracking Systems (E-ARTS) and Automated Radar Terminal System (ARTS IIA/III/IIIA/IIIE) facilities with a computer function called E-MSAW and MSAW to assist air traffic controllers in detecting aircraft that are within or are approaching unsafe proximity to terrain/obstacles. The function generates an alert when a participating aircraft is or is predicted to be below a predetermined minimum safe altitude. All instrument flight rules (IFR) aircraft and those visual flight rules (VFR) aircraft requesting MSAW, which have been radar identified and are equipped with an operating altitude encoding transponder, automatically participate in the E-MSAW/MSAW program. The controller will evaluate any observed alerts and, when appropriate, issue a radar safety alert.

b. Federal Aviation Regulations place responsibility for safe altitude management on the pilot. E-MSAW/MSAW provides the controller with information which, when judged to be significant, can be relayed to assist the pilot with that responsibility. Participation in E-MSAW/MSAW does not relieve the pilot of responsibility for safe altitude management.

4. FUNCTIONAL DESCRIPTION.

a. ARTCC E-MSAW

(1) E-MSAW airspace is defined as polygons of airspace within an ARTCC. The geometry of the polygons is variable, often being determined by the topography of an area. Separate algorithms perform the calculations required to determine E-MSAW violations, due to the variable geometries. Each algorithm performs operations on a particular geometry of the polygon within a particular radar sort box (RSB). Convex-angled polygons within an RSB; concave-angled polygons within an RSB; and mixed-concave, convex-angled polygons within an RSB each have separate algorithms.

(2) E-MSAW calculates which tracks are candidates for E-MSAW violation by eligibility tests which occur on a cyclic basis, on high gross filter frequency tracking cycles, or every 12 seconds. The track's current altitude is used for filtering if a track has valid altitude data. Aircraft will not be subjected to the E-MSAW test at this cycle if the aircraft's altitude is at or above high gross filter altitude (HGFA), 25,000 feet, or if the aircraft is level or climbing at or above the middle gross filter altitude (MGFA), 14,000 feet. Aircraft between the HGFA and the MGFA, (adaptable center parameters) and descending aircraft below the MGFA will be considered candidates for eligibility tests.

(3) Tracks are considered eligible for detailed violation detection if they pass the gross altitude filter tests mentioned above and the eligibility tests. Aircraft which pass the eligibility criteria include tracks that are not in "NONE," "DROP," or unchained status; tracks not in "HOLD" status; a valid velocity which is not zero; an outbound track with expiration of the drop data block interval of its full data block (FDB); a track in "COAST" while in E-MSAW alert status; or a track having a flight plan VFR aircraft will be considered upon controller-requested action.

(4) Detailed violation detection that determines candidates for E-MSAW alerts occurs as a frequency of candidate retest filter frequency which is two tracking subcycles (every 12 seconds). A violation occurs if any portion of the projected track vector, projected 2 minutes ahead, penetrates an E-MSAW area within the confines of the RSB being examined and the minimum track altitude is below the maximum warning altitude adapted for the E-MSAW polygon.

(5) Time-to-violation is calculated based on the difference between the aircraft's entry-point altitude and the E-MSAW altitude, divided by the transition rate of the aircraft if climbing or descending. This value is zero and time-to-violation is immediate if the aircraft is level.

(6)The alert is validated if violations are detected at a consistency of a mask known as alert redetection validation mask which is two out of three detections.

(7) The track is tagged "not eligible" for E-MSAW alert and any existing displays are removed if violations are not detected at a consistency of two consecutive misses.

b. E-ARTS MSAW

(1) The general terrain monitor (GTM) observes all nonapproach aircraft in the terminal and en route areas for possible terrain/obstruction hazards and generates a timely determination of potential conflicts. The GTM accomplishes this by monitoring the track's reported and predicted altitude along a projected path making altitude comparisons for each polygon and grid box the path traverses. The path begins with the current track position and ends with a projected track position. An MSAW violation occurs when the track altitude is less than the polygon altitude or grid box altitude at any point along the path.

(2) The general terrain map is modeled by convex polygons, each with an associated altitude, overlaying the controlled airspace area of interest. One polygon may partially or totally overlap another, in which case the higher of the two associated altitudes prevails in the common region.

(3) The current track position and the projected track position is used to identify the polygons to be used for altitude comparison. The projected track position is based on the current track position, current track velocity, and look-ahead time which is parameterized for terminal and en route areas. System parameter pads are added to the terrain altitude for the current and predicted checks.

(4) All MSAW-eligible aircraft within the vicinity of an airport are monitored by the approach path monitor algorithm. Eligibility is based on the aircraft's position relative to a runway threshold and final approach course centerline. The track must be within the limits of the approach capture box and must be in arrival status. An aircraft which fails to qualify for approach-path monitoring is considered for general terrain monitoring. The approach capture box is defined as an area designated for approach monitoring. The approach capture box includes the approach monitor area. The lateral limits of the approach capture box are defined as a box 2 nautical miles (NM)

site parameter (SP) wide, 1 NM either side of the final approach course centerline, extending from the defined runway end point out to the final approach fix (FAF). The vertical limit of the capture box is defined by adaptation for the particular runway. The approach monitor inhibit area portion of the capture box is from the runway end point to the monitor cutoff point. The approach monitor area is from the monitor cutoff point to the FAF.

(5) An aircraft is eligible for approach path monitor violations only when it is within the approach capture box and qualified for approach monitoring. Approach path aircraft are monitored based on their current established altitude as compared to the lowest minimum descent altitude (MDA) for the published nonprecision approaches defined for the particular runway. The approach violation count is incremented by two if the aircraft's current established altitude is equal to or less than the MDA. The aircraft is predicted 15 SP seconds ahead if it has not violated the approach altitude boundary. The approach violation count is incremented by two if the aircraft's predicted altitude is equal to or less than the MDA, minus an SP pad. The purpose of the pad during prediction is to minimize the probability of a nuisance alarm due to changes in aircraft descent rate during an approach. The approach violation count shall be decremented by one to a minimum of zero if no violation is detected or if the aircraft becomes ineligible for monitoring. Approach monitoring will continue until the approach monitor cutoff point which is defined by an SP distance from runway threshold (approximately 2 NM). The approach monitor inhibit area is designed to minimize nuisance alerts for aircraft operating in the vicinity of the airport or making circling approaches to a different runway at the airport.

(6) The final approach course closest to the aircraft's heading will determine the appropriate capture box. Special logic is employed where final approach courses intersect to resolve any ambiguity caused by overlapping capture boxes.

(7) The MSAW data base is site adaptable in the same manner as the operational data base. Various site and system parameters are combined either at assembly or program preset time to generate or initialize the MSAW data base for a particular site. The MSAW data base outlines the definition of the polygons and the associated altitude.

c. ARTS IIA/III/IIIA/IIIE MSAW.

(1) MSAW maintains a computerized grid map comprised of 2-mile squares for general terrain altitude monitoring. The highest known obstacle in each grid or bin determines the minimum safe altitude for that location. The minimum safe altitude is 500 feet above the highest terrain/obstacle in each bin.

The computer compares the current Mode C altitude of an aircraft against the minimum safe altitude. It then looks ahead 30 seconds to determine if the aircraft will enter a bin below the minimum safe altitude on the present heading, altitude, or rate of climb/descent. The program then assumes a 5-degree climb and computes if the aircraft will remain above the minimum safe altitude with an immediate climb.

(2) A buffer of 300 feet instead of 500 feet above the highest obstacle is used for the "look ahead." MSAW monitors the final approach course from the final approach fix to a point approximately 2 miles from the landing threshold. MSAW first checks 100 feet below the MDA/stepdown fix altitude. MSAW then looks ahead down the final approach course using the computer-established descent rate to determine if the aircraft will be 200 feet below the MDA/stepdown fix altitude in 15 seconds.

5. OPERATIONAL DESCRIPTION.

a. E-ARTS

(1) A violation count should be maintained by the MSAW program. The count should be incremented by two when the track qualifies for a violation declaration. The count should be decremented by 1 SP when a track is either not eligible for monitoring or does not receive a violation declaration. The alert should be terminated when the value is less than 2 SP. MSAW alerts should be activated for the track at any time the violation count is equal to or greater than 2 SP for current altitude checks or 3 SP for predicted altitude checks. This alert should be declared after each scan to generate the display of the appropriate FDB warning message. The track's position should be compared with the aural alarm areas to determine which alarm(s) should be sounded when an alert is declared.

(2) The controller alerts declared by MSAW should be presented both aurally and visually. An alert warning should consist of an aural alarm for 5 SP seconds, the word "LA" displayed above the aircraft identification in field zero of the remote display FDB, the word "MSAW" displayed below the ACID in field seven of the plan view display FDB, and an entry in the "LA/CA ALERT" tabular list on the active controller's display. In addition, for general terrain monitoring, a vector should be drawn from the track position to the violation area. The violation altitude should be depicted and blinking at the violation location. Tracks inhibited from MSAW by alphanumeric keyboard entry or special beacon code should continuously display the appropriate characters as specified in NAS-MD-679.

b. ARTS IIA/III/IIIA/IIIE

(1) The computer alerts the controller by displaying "LA" in the aircraft's data tag, if an aircraft is or is predicted to be below a minimum safe altitude. An aural alarm is also sounded to attract the controller's attention. The controller will evaluate the situation and, if appropriate, issue a radar safety alert, i.e., "LOW ALTITUDE ALERT, CHECK YOUR ALTITUDE IMMEDIATELY. THE (as appropriate) MEA/MVA/MOCA/MIA IN YOUR AREA IS (altitude)"; or if past the final approach fix (nonprecision approach), the outer marker, or the fix used in lieu of the outer marker (precision approach), "THE (as appropriate) MDA/DH (if known) IS (altitude)."

(2) It is the pilot's responsibility to evaluate the situation and determine what action may be necessary when an advisory is received. The pilot is expected to inform controllers immediately should any action be taken after receiving a radar safety alert.

6. LIMITATIONS.

(1) There are situations when controllers will not receive an E-MSAW/MSAW generated low-altitude alert. The situations include:

(a) - Not all sites are operational.

(b) - Air traffic control radar beacon interrogator is not operating.

(c) - The computer with the E-MSAW/MSAW program is not operating.

(d) - The aircraft is not being tracked by the computer.

(e) - The aircraft's Mode A or C transponder is sending garbled, weak, or erroneous signals. Both Mode A and Mode C signals are required for MSAW processing.

(f) - The aircraft is not within radar coverage because it is below line-of-sight or too far away from the radar site.

(g) - A departing aircraft is within 3 NM of the airport, or an arrival is on final approach to an instrument runway and within 2 NM of the airport or between the stepdown fix and the airport. It is not currently practical to continue E-MSAW/MSAW processing within these areas because of the various types of activity in an airport traffic area.

(h) - The aircraft has been inhibited from computer processing for low-altitude alerts. Aircraft are sometimes purposely operated at low altitudes.

(i) - E-MSAW/MSAW processing of these flights could be inhibited because the controller could receive continuous false alarms causing the intentionally low-flying VFR pilot to be unnecessarily advised to check altitude.

(j) - The ARTS IIA/III/IIIA/IIIE computer receiver requires approximately 10 seconds to establish a definite course and/or altitude change due to radar antenna rotation time; consequently, there are two conditions which may result in low-altitude alerts being issued too late to permit the pilot to take corrective action. They are as follows:

(1) An aircraft's projected track is clear of any known obstacle and an abrupt turn is made toward an obstacle.

(2) An aircraft operating at an altitude just above the programmed MSAW altitude makes an abrupt descent.

7. VFR PILOT PARTICIPATION.

VFR pilots of aircraft equipped with an operating altitude encoding transponder may participate in the MSAW/E-MSAW program by requesting the service from the controller. Participating aircraft are requested to fly at least 500 feet (1,000 feet where applicable) above the highest obstacle within 2 NM of their route. E-MSAW facilities require flight 1,000/2,000 feet above the highest obstacle within 3 to 5 miles either side of their route.

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