



U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Airworthiness Approval for Aircraft Weather Radar Systems

Date: 10/1/16

AC No: 20-182A

Initiated By: AIR-130

1 **WHAT IS THE PURPOSE OF THIS ADVISORY CIRCULAR (AC)?**

- 1.1 This advisory circular (AC) provides guidance for the initial and follow-on airworthiness approval of aircraft weather radar systems meeting the latest revision of the Technical Standard Order (TSO)-C63, *Airborne Weather Radar Equipment*. This AC covers aircraft radar systems with weather detection and ground mapping, forward-looking windshear detection, forward looking turbulence detection, and atmospheric threat awareness capability. The guidance is applicable to Title 14 of the Code of Federal Regulations, parts 23, 25, 27, and 29 aircraft. For forward-looking windshear and/or turbulence detection capability, the guidance in this AC applies to parts 25 and 23 fixed-wing airplane installations.
- 1.2 This AC is not mandatory and does not constitute a regulation. This AC describes an acceptable means, but not the only means, of accomplishing airworthiness approval for the installation of airborne weather radar equipment. However, if you use the means described in the AC, you must follow it in all important respects. Appendix A provides additional guidance on the forward-looking windshear system annunciation, alert, and display icons. A list of related documents can be found in Appendix B of this AC.
- 1.3 This AC provides guidance intended for new approvals. This AC is not intended to modify, change, or cancel existing equipment design or airworthiness approvals. Equipment with existing approvals can continue to be installed within the provisions of its original design and airworthiness certification.

2 **WHO DOES THIS AC AFFECT?**

This AC is for applicants seeking airworthiness approval of aircraft weather radar systems. The airworthiness approval can be approved under a type certificate (TC), supplemental type certificate (STC), amended type certificate (ATC), or amended supplemental type certificate (ASTC).

3 **DOES THIS AC CANCEL ANY PRIOR AC?**

This AC cancels AC 20-182, dated June 17, 2014.

4 **BACKGROUND.**

4.1 **Airborne Doppler Weather Radar Systems with Forward-Looking Windshear Detection.**

The forward-looking windshear detection function is incorporated into TSO-C63e. This AC incorporates and clarifies appropriate airworthiness guidance and eliminates errata from System Level Requirements (SLR) 10.2 “Airborne Short and Long Range Windshear Predictive Systems (Forward-Looking Windshear Systems) Interim Certification Requirements, Revision 10.2.” SLR 10.2 is no longer applicable for systems that comply with TSO-C63e or later.

4.2 **Airborne Doppler Weather Radar Systems with Forward-Looking Turbulence Detection.**

Prior to February 2012, the FAA used design standards developed by the Airborne Turbulence Detection Systems (ATDS) Working Group and airworthiness requirements documented in issue papers to certify forward looking turbulence detection radars. The FAA published TSO-C63d in February 2012, incorporating the ATDS Working Group design requirements. With the release of TSO-C63e, the turbulence detection function continues to be included in the TSO. This AC incorporates the remaining airworthiness guidance from issue papers into formally published FAA guidance.

5 **GENERAL.**

5.1 The display of weather radar alerts, graphical depictions of weather or other hazards, and the expected pilot response to information provided by a weather radar system (e.g., display format, colors, labels, data formats, and interaction with other display parameters) should be clear and unambiguous.

5.2 In general, the progression from green to amber/yellow to red represents an increasing degree of threat, potential hazard, or need of flight crew awareness or response. You should ensure the use of color for display of weather radar system information follows the guidance in the latest revisions of the following ACs for parts 23, 25, 27, and 29 aircraft:

5.2.1 AC 25-11, *Electronic Flight Displays, Appendix G Weather Displays.*

5.2.2 AC 25.1302-1, *Installed Systems and Equipment for Use by the Flight Crew.*

5.2.3 AC 25.1322-1, *Flight Crew Alerting.*

5.2.4 AC 23.1311-1, *Installation of Electronic Display in Part 23 Airplanes.*

- 5.2.5 AC 27-1, *Certification of Normal Category Rotorcraft*.
- 5.2.6 AC 29-2, *Certification of Transport Category Rotorcraft*.
- 5.3 The weather radar system may interface with other systems (e.g., ground proximity warning system, and traffic alert and collision avoidance system).
- 5.4 You must ensure the weather radar system does not adversely affect the functioning of, and is not adversely affected by, other aircraft systems.
- 5.5 You should ensure all the aircraft alerts are prioritized. If alerts can be issued simultaneously or issued by separate systems, then you ensure the alerts do not interfere with one another and both are understandable. TSO-C151c, *Terrain Awareness and Warning System*, Appendix 1, Table 4-2 provides an acceptable example of alert prioritization. For part 25 aircraft, AC 25.1322-1, section 8.b provides additional information regarding prioritization of multiple aural alerts.
- 5.6 You should document any areas where radar emissions could be harmful to people or wildlife. The following three standards provide acceptable guidelines for safe radar operation and determining minimum safe distances:
 - 5.6.1 AC 20-68B, Recommended Radiation Safety Precautions for Ground Operation of Airborne Weather Radar.
 - 5.6.2 IEEE standard C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
 - 5.6.3 Federal Communications Commission Office of Engineering & Technology (OET) Bulletin 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*.
- 5.7 If the radar system includes downlink capability, follow the radar manufacturer's recommended procedures to ensure the system is capable of transmitting the radar data as specified by the manufacturer.

6 FORWARD-LOOKING WINDSHEAR DETECTION.

6.1 Forward-Looking Windshear Activation.

- 6.1.1 To allow timely takeoff abort due to windshear condition, you should ensure the forward-looking windshear function is capable of manual activation prior to the start of the takeoff roll.
- 6.1.2 You should ensure the forward-looking windshear function automatically activates for takeoff so that timely takeoff warnings are provided.

- 6.1.3 When the forward-looking windshear function is enabled, you should ensure the system will automatically activate without flight crew intervention during descent to approach at an altitude sufficient to allow visual and aural alerts as specified in paragraph 6.2.2 of this AC.
- 6.1.4 The forward-looking windshear detection system may be reset to the appropriate mode (landing or takeoff) in the event of a go-around or touch and go.
- 6.1.5 Some system configurations utilize the transponder mode to automatically activate the radar to enable forward-looking windshear alerts during takeoff, even if the flight crew has not manually activated the radar. This configuration was established at a time when the transponder was not turned on until an aircraft taxied onto the runway before takeoff and was turned off when the aircraft left the runway after landing. However, with the advent of Airport Surface Detection Equipment-Model X (ASDE-X) radars and Automatic Dependent Surveillance-Broadcast (ADS-B), flight crews now routinely keep the transponder “on” while taxiing. This could create a hazard for ground crews handling the aircraft, as aircraft marshals and tug operators often operate in extremely close proximity to the nose radome. A hazard assessment should be done for the automatic activation feature of the forward-looking windshear function taking this type of operation or any automatic ground activation feature of the windshear function into account.

6.2 Forward-Looking Windshear Alert Requirements.

- 6.2.1 You must ensure the alerts and annunciations follow flight deck alerting philosophy for aircraft and adhere to both the regulation and the guidance in the latest revision of the following ACs for parts 23 and 25 aircraft:
 - 6.2.1.1 14 CFR § 25.1322, *Flight Crew Alerting*.
 - 6.2.1.2 AC 25.1322-1, *Flight Crew Alerting*.
 - 6.2.1.3 AC 23.1311-1, *Installation of Electronic Display in Part 23 Airplanes*.
- 6.2.2 You must ensure the integrated system is capable of making all forward-looking windshear Advisory, Caution, and Warning annunciations and alerts described in Table 1 of Appendix A.
- 6.2.3 You must ensure the visual textual warning alerts are annunciated when any of the following conditions exist:
 - 6.2.3.1 The aural alert is being annunciated;
 - 6.2.3.2 The threat exceeds the alert threshold; or
 - 6.2.3.3 The threat exists within the area defined by the latest revision of the TSO-C63.

- 6.2.4 You should ensure the annunciation of the failure of the windshear detection capability is readily visible to the flight crews from their normal seated position on the flight deck.

6.3 **Forward-Looking Windshear Alert Inhibit.**

- 6.3.1 During takeoff, the system should inhibit all new aural and visual alerts at a specified aircraft speed prior to rotation and re-enable the alerting capability after liftoff. You should set the takeoff alert settings per installation manual instructions and ensure the inhibits coincide with aircraft type specific takeoff alert inhibit criteria.
- 6.3.2 During final approach, you should ensure all new system aural and visual caution and warning alerts are inhibited from 50 feet above ground level (AGL) until touchdown.
- 6.3.3 You should ensure all new aural and visual warning and caution alerts are inhibited above 1200 feet AGL.

6.4 **Forward-Looking Windshear Alert Prioritization.**

- 6.4.1 You should follow the guidance of paragraph 5.5 in this AC on aircraft alert prioritization.
- 6.4.2 If you install a forward-looking windshear system on an aircraft that also has a reactive windshear system, you should ensure the reactive windshear system's caution alert is disabled. It is acceptable to issue reactive windshear caution alerts if the forward-looking windshear system is inoperative.

Note: The reactive windshear system warning alert should remain enabled.

6.5 **Display Requirements.**

- 6.5.1 It is permissible to display the windshear icon at any altitude at which the system is armed in the windshear mode.
- 6.5.2 The windshear icon consists of alternating red and black bars. The bars should be oriented such that they are circular arcs centered on the apex. The color red is appropriate in order to provide visual discrimination from the underlying yellow weather display. Figure 1 in Appendix A depicts several forward-looking windshear icon examples.
- 6.5.3 You should ensure the depth of each bar makes the windshear icon conspicuous from other displayed information.
- 6.5.4 If the range selected by the flight crew for the display is greater than 5 nautical miles (nm), and this range selection does not allow the flight crew to differentiate the windshear symbology from other displayed information, then you should ensure amber/yellow radial lines extend from the icon to the upper edge of the display to help differentiate the windshear symbology. To accommodate icons (or groups of icons) with wide azimuth extent, it is permissible to limit the width between the radial lines. As such,

the radial lines may extend along azimuth lines that are inside the left and right radial boundaries of the icon(s).

- 6.5.5 If other windshear symbology is used, then you should demonstrate that this symbology provides a clear and substantial benefit to the flight crew.
- 6.5.6 When a windshear threat is detected, the corresponding display may be automatically presented or selected by flight crew action. If only manual selection is provided, then you should ensure the flight crew workload necessary for manual presentation of the windshear display is minimized and does not take more than one action by the flight crew when the flight deck is configured using normal operating procedures.

7 FORWARD-LOOKING TURBULENCE DETECTION.

- 7.1 Paragraph 2.2.4.1 of RTCA/DO-220A, *Minimum Operational Performance Standards for Airborne Weather Radar*, defines three aircraft classes. The aircraft classes are solely differentiated by wing loading. You should ensure the radar is appropriate for the wing loading of the aircraft.
- 7.2 Some applicants may wish to provide detection and display of multiple levels of turbulence. You should ensure the displays of those levels are sufficiently distinct from each other.

8 ATMOSPHERIC THREAT AWARENESS FUNCTIONS.

- 8.1 You should ensure the symbology or other display indications used to depict the potential threat is understandable and not misleading, distracting, or confusing.
- 8.2 You should ensure the atmospheric threat awareness feature's symbology and display indications do not adversely impact the ability to view, read, and interpret the weather, ground mapping, turbulence, and/or forward-looking windshear display. Automatic decluttering, such as during specific phases of flight or during certain alerts, may be appropriate.
- 8.3 If an atmospheric threat awareness function could lead to an alert, then you should ensure any alerts and annunciations follow the flight deck alerting philosophy for the aircraft and adhere to the guidance in the latest revision of the following ACs for parts 23, 25, 27, and 29 aircraft:
 - 8.3.1 AC 25.1322-1, *Flight Crew Alerting*.
 - 8.3.2 AC 23.1311-1, *Installation of Electronic Display in Part 23 Airplanes*.

9 TEST AND EVALUATION.

This section provides guidance for testing radar systems on aircraft. Follow the guidance in section 9.1 for weather and ground mapping radar. Follow the guidance in section 9.2 if your radar system includes a forward-looking windshear detection function. Follow the guidance in section 9.3 if your radar system includes turbulence detection or atmospheric threat awareness functions. Testing of all radar systems should ensure:

- The radar antenna and radome combination function correctly;
- The radar display and alert prioritization functions correctly and the alerts, alert inhibits, annunciations, and controls function correctly;
- The fault detection functionality works properly;
- The human factors interface is acceptable;
- The radar does not adversely interfere with other systems; and
- Other systems do not adversely interfere with the radar.

9.1 Weather Radar.

Accomplish flight test of the weather and ground mapping pulsed radar functions in accordance with the latest revision of the following ACs for parts 23, 25, 27, and 29 aircraft:

- 9.1.1 AC 23-8, *Flight Test Guide for Certification of Part 23 Airplanes*, Chapter 5, paragraph 1.b (10).
- 9.1.2 AC 25-7, *Flight Test Guide for Certification of Transport Category Airplanes*, Chapter 6, section 1, paragraph 170.c(8).
- 9.1.3 AC 27-1, Change 3, *Certification of Normal Category Rotorcraft* Chapter 3, AC 27 MG 1, paragraph b (10).
- 9.1.4 AC 29-2, Change 3, *Certification of Transport Category Rotorcraft* Chapter 3, AC 29 MG 1, paragraph b (10).

9.2 Forward-Looking Windshear Detection.

Follow the TSO instructions to verify performance of the forward-looking windshear function. Installation testing of the forward-looking windshear function often relies on general weather radar functional testing as described in paragraphs 9.1.1 and 9.1.2 of this AC and integration testing versus dedicated forward-looking windshear flight testing.

9.2.1 Penetration Flight Evaluation.

Penetration flights will typically be accomplished by the radar manufacturer as part of the TSO authorization. If penetration data and analysis are available and you determine they are applicable, then you do not need to conduct penetration flight tests. Previously

approved test data generated during the TSO authorization or previous certification effort is acceptable. If forward-looking windshear capability was not previously demonstrated, then verify the detection capability of the forward-looking windshear system by flying in areas of convective activity that can be verified by in-situ measurements, appropriate ground-based radar systems, or the equivalent.

Note: Flying in or near storm cells can be extremely hazardous. Flight crews should exercise good judgment for safe flight based on knowledge of their own abilities and of the capability of the aircraft when considering approaching or penetrating any storm cell or turbulent area.

9.2.2 Clutter Suppression Flight Test.

Evaluate the system's ability to reject spurious conditions (e.g., clutter suppression, bi/multi-static signal interference, range ambiguous returns, and radome effects). The flight tests may be conducted under visual meteorological conditions. Conduct this evaluation at one or more airports with the following characteristics:

- 9.2.2.1 Expressways and high-volume surface streets within approximately 1 nm of the runway.
- 9.2.2.2 Nearby taxiing aircraft.
- 9.2.2.3 Concentrated urban clutter. The clutter should occupy a minimum area of approximately 1 nm surrounding the airport.

9.3 Turbulence Detection or Atmospheric Threat Awareness.

Follow the TSO installation instructions to verify performance of turbulence detection or atmospheric threat awareness functions. Atmospheric threat awareness functions could include, but are not limited to, hail and lightning indication. Installation testing of these functions often relies on general weather radar functional testing as described in paragraphs 9.1.1 and 9.1.2 of this AC and integration testing versus dedicated flight testing. You should attempt to evaluate the performance of these functions against operationally significant weather when weather is reasonably available and you can do so without placing the aircraft in the hazardous weather. This performance evaluation should ensure the depiction of turbulence or weather hazard is consistent with actual weather phenomenon. Data from the radar manufacturer may be used to supplement or replace additional flight testing if the data is determined to be applicable.

10 AIRCRAFT FLIGHT MANUAL/SUPPLEMENT (AFM/S).

Follow AC 23-8, Chapter 6, Section 3 for small airplane flight manual/supplement. Follow AC 25.1581-1, *Airplane Flight Manual*, for transport category airplane flight manual/supplement. Follow AC 27-1 and 29-2 as appropriate for rotorcraft flight manual/supplement. You should incorporate the following radar specific information in the AFM/S:

- 10.1 Describe the weather and ground mapping, windshear, turbulence detection, and/or atmospheric threat awareness capabilities of the system.
- 10.2 Provide limitations that are necessary for the safe operation of the weather radar system.
- 10.3 Describe the appropriate actions and recovery procedures for annunciations and alerts.
- 10.4 Describe the conditions necessary for automatic activation of the system, if applicable.
- 10.5 Describe when alerts are provided and when they are inhibited.
- 10.6 Outline hazard areas associated with radar operation on the ground.
- 10.7 Provide normal and abnormal operating procedures.

11 INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (ICA).

11.1 You should incorporate the following information into the ICA:

- 11.1.1 Maintenance instructions for the radar system and radome.
 - 11.1.2 Description of the interface between the radar and the aircraft.
 - 11.1.3 Calibration instructions to maintain the radome and antenna performance to a level equal to or better than that demonstrated for the basic system certification.
 - 11.1.4 Inspection intervals for the radar system and radome.
 - 11.1.5 Hazard areas associated with radar operation.
- 11.2 High performance radar radomes are precisely constructed. Small changes in their physical characteristics can adversely affect radar system performance. All repairs to radomes, no matter how minor, should return the radome to the minimum performances required for aircraft weather radar system operation. If you are repairing or replacing the radome in conjunction with radar installation, refer to the latest revision of AC 43-14, *Maintenance of Weather Radar Radomes*, and RTCA/DO-213A, *Minimum Operational Performance Standards for Nose-Mounted Radomes*, for additional information.

If you have any suggestions for improvements or changes, you may use the template provided at the end of this AC.



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Appendix A. Forward-Looking Windshear System Annunciation, Alert, and Display

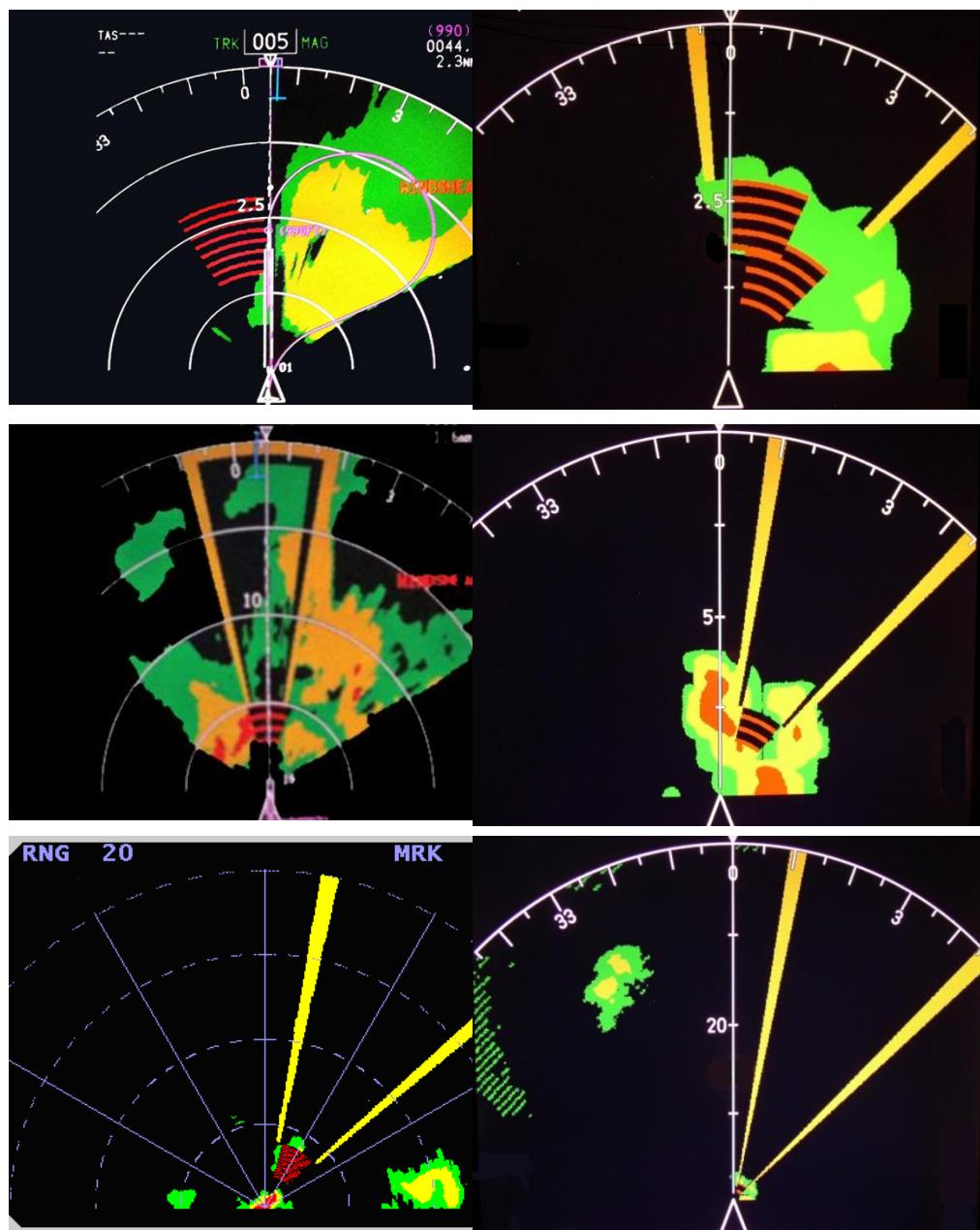
Table 1. Forward-Looking Windshear System Annunciation, Alert, and Display

Alert Level	Advisory	Caution	Warning
Visual Textual Alert	None	Amber/Yellow Visual Textual Annunciation (or lamp): “Windshear” or “Windshear Ahead” or “W/S Ahead”	Red Visual Textual Annunciation (or lamp): “Windshear” or “Windshear Ahead” or “W/S Ahead”
Aural Alert	None	Distinctive Aural Alert: Chime or message; not containing the word windshear. Example: Tone “Whoop” or “Monitor Radar Display”	Voice Alert: Takeoff: “Windshear Ahead, Windshear Ahead” Approach or Go-around: “Go Around, Windshear Ahead”
Icon	Icon symbology as defined in Section 6.5.	Icon symbology as defined in Section 6.5.	Icon symbology as defined in Section 6.5.

Note 1: The forward-looking windshear icon is provided as a weather hazard position indication and not an alert. Its color is not in conflict with the latest revision of AC 25.1322-1, Section 11, or AC 25-11.

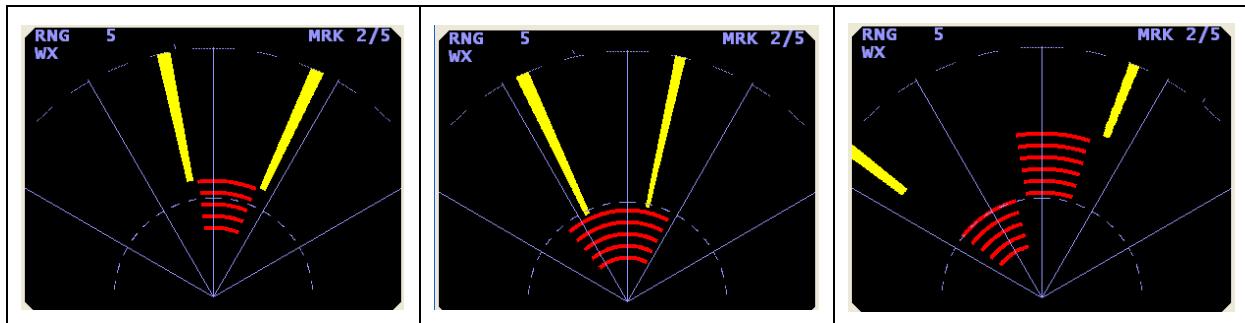
Note 2: The forward-looking windshear caution alert may progress to a time-critical windshear warning alert depending on the location of the windshear hazard.

Figure 1. Forward-Looking Windshear System Icon Examples



Note: These images are provided only as examples of possible icon implementations. Other implementations may be used. Refer to the manufacturer installation and operations manual for icon implementation.

Figure 2. Examples of Windshear Icon Radial Lines



Appendix B. Related Documents

Note 1: The ACs and TSOs referenced in this document refer to the current revisions.

Note 2: The industry documents referenced in this AC refer to current revisions and amendments or regulatory authority-accepted revisions and amendments.

B.1 FAA DOCUMENTS.

- B.1.1 AC 20-68, *Recommended Radiation Safety Precautions For Ground Operation of Airborne Weather Radar.*
- B.1.2 AC 23-8, *Flight Test Guide for Certification of Part 23 Airplanes.*
- B.1.3 AC 23.1311-1, *Installation of Electronic Display in Part 23 Airplanes.*
- B.1.4 AC 25-7, *Flight Test Guide for Certification of Transport Category Airplanes.*
- B.1.5 AC 25-11, *Electronic Flight Displays.*
- B.1.6 AC 25.1302-1, *Installed Systems and Equipment for Use by the Flight Crew.*
- B.1.7 AC 25.1322-1, *Flight Crew Alerting.*
- B.1.8 AC 25.1581-1, *Airplane Flight Manual.*
- B.1.9 AC 27-1, *Certification of Normal Category Rotorcraft.*
- B.1.10 AC 29-2, *Certification of Transport Category Rotorcraft.*
- B.1.11 AC 43-14, *Maintenance of Weather Radar Radomes.*
- B.1.12 TSO-C63, *Airborne Weather Radar Equipment.*
- B.1.13 TSO-C151, *Terrain Awareness and Warning System.*

B.2 RTCA, INC. DOCUMENTS (RTCA DO).

- B.2.1 RTCA/DO-220A, Minimum Operational Performance Standards (MOPS) for Airborne Weather Radar.
- B.2.2 RTCA/DO-213A, Minimum Operational Performance Standards (MOPS) for Nose-Mounted Radomes.

B.3 HOW TO GET RELATED DOCUMENTS.

- B.3.1 Order copies of 14 CFR parts from the Superintendent of Documents, Government Printing Office (GPO), P.O. Box 979050, St. Louis, MO 63197. For general information, call (202) 512-1800 or fax (202) 512-2250. You can also get copies at <http://www.gpoaccess.gov/cfr>.
- B.3.2 You can get copies of ACs and TSOs at http://www.faa.gov/regulations_policies/advisory_circulars or www.airweb.faa.gov/rgl.
- B.3.3 Order copies of RTCA documents from RTCA Inc., 1150 18th St. NW, Suite 910, Washington, D.C. 20036. For general information, call (202) 833-9339 or fax (202) 833-9434. You can also order copies at <http://www.rtca.org>.

Appendix C. Advisory Circular Feedback Information

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) complete the form online at <https://ksn2.faa.gov/avs/dfs/Pages/Home.aspx> or (2) emailing this form to 9-AWA-AVS-AIR-DMO@faa.gov

Subject: AC 20-182A

Date: [Click here to enter text]

Please check all appropriate line items:

- An error (procedural or typographical) has been noted in paragraph [Click here to enter text] on page [Click here to enter text].
- Recommend paragraph [Click here to enter text] on page [Click here to enter text] be changed as follows:
[Click here to enter text]
- In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)
[Click here to enter text]
- Other comments:
[Click here to enter text]
- I would like to discuss the below. Please contact me.

Submitted by: _____

Date: _____