

AIRBORNE WINDSHEAR SYSTEMS

1. SCOPE:

This document recommends criteria for Airborne Windshear Systems, including operational objectives, characteristics, and functional requirements.

The recommendations of this document apply to transport aircraft, and describe the operational objectives of windshear alerting systems, situational displays, guidance systems, and detection/avoidance systems.

2. REFERENCES:

- 2.1 Applicable Documents: This document should be used in conjunction with the ARP4102 Core Document. The following documents may also be applicable:

- SAE S-7 ARP4102/4 - Flight Deck Alerting System
- SAE S-7 ARP4102/7 - Electronic Displays

2.2 Definitions:

- 2.2.1 Airborne Windshear Alerting System: A system which senses and identifies the presence of windshear after the phenomenon is encountered. Does not provide flight guidance information.

- 2.2.2 Airborne Windshear Detection and Avoidance System: System(s) which sense and identify windshear before the phenomenon is encountered.

- 2.2.2.1 Airborne Windshear (Forward Looking) Detection System: A system which senses and identifies windshear shortly before an encounter.

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- 2.2.2.2 Airborne Windshear (Forward Looking) Avoidance System: A system which senses and identifies windshear far enough in advance of a possible encounter to allow the crew to consider maneuvering away from the hazard. Such a system shall include display(s) to assist the crew with identification of the hazardous area.
- 2.2.3 Airborne Windshear Flight Guidance System: A system which provides the crew with flight guidance to improve recovery probability in a windshear encounter.
- 2.2.4 Airborne Windshear Auto Recovery System: A system which integrates or couples autopilot and the autothrottle systems of the aircraft with an Airborne Windshear Flight Guidance System.
- 2.2.5 Airborne Windshear Situational Display: A display which presents pertinent windshear information such as flight path angle and stall margins. May be available in conjunction with alerting, guidance and/or detection/avoidance system. Windshear severity information may be supplied to the crew on a continuous basis. Does not provide flight guidance information.
- 2.2.6 False Alert: An alert which occurs when the design windshear threshold conditions do not exist.
- 2.2.7 Windshear Advisory Alert: An alert which is set at a windshear level requiring crew awareness and may require crew action. (Advisory Condition, Level One, ARP4102/4)
- 2.2.8 Windshear Caution Alert: An alert which is set at a windshear level requiring immediate crew awareness and subsequent corrective action. (Abnormal Condition, Level Two, ARP4102/4)
- 2.2.9 Windshear Warning Alert: An alert which is set at a windshear level requiring immediate corrective action by the crew. (Emergency Condition, Level Three, ARP4102/4)

3. OPERATIONAL REQUIREMENTS:

3.1 General:

- 3.1.1 Systems may be designed to interface with other required systems.
- 3.1.2 Systems shall not adversely affect the functioning of other aircraft systems.
- 3.1.3 Systems shall be designed with suitable self-monitoring capability and monitoring capability of sensor inputs to the system. Automatic and continuous monitoring should be implemented. As a minimum, a self test feature with pass/fail criteria and suitable failure annunciations shall be required.

3.1.4 Systems shall have no emissions harmful to people or wildlife.

3.1.5 Windshear alert threshold (in the energy loss sense) should be the lesser of:

- a) a windshear of 2.86 knots/s (0.15 "g") increasing tailwind component (or decreasing headwind), or
- b) the equivalent energy loss rate due to vertical downdraft (0.15 x airspeed), or
- c) any combination of the a) and b) such that

$$0.15 = (1/\text{airspeed})W_v + (1/g)W_h$$

where: W_v = vertical wind speed

W_h = horizontal wind acceleration

g = gravitational acceleration

filtered for normal turbulence and maneuvering flight, or,

- d) upon critical degradation of performance capability (less than level flight) for existing atmospheric conditions and aircraft configuration.

When aircraft systems allow, filtering as stated above should consider any wind correction factor input.

3.2 Airborne Windshear Alerting System:

3.2.1 The system shall function in initial climb, landing approach and go-around after landing approach, and its use is desirable in takeoff roll and rotation.

3.2.2 The system shall function below approximately 1000 ft AGL, and should function below 2500 ft AGL.

3.2.3 The computed severity of a windshear encounter should include the rate of energy change from the horizontal and/or vertical winds of a shear, in whatever combination they appear.

3.2.4 The probability of a false alert shall be 10^{-5} per flight hour or less.

3.2.5 The probability of an unannounced failure shall be 10^{-5} per flight hour or less.

3.2.6 The system should function independently of Windshear Guidance System or Windshear Auto Recovery System.

3.2.7 Windshear Warning Alert:

- 3.2.7.1 A Windshear Warning Alert shall activate for measured shear exceeding the threshold defined by 3.1.5.
- 3.2.7.2 Windshear Warning Alerts shall cease when adverse conditions no longer exist. Adverse conditions include, but are not limited to, the conditions which initiate the alert. Additional criteria, such as attainment of a minimum altitude or a finite timespan (e.g., 30 s), may be applicable to the cessation of alerts. See Section 6 for aural, visual, and voice alerts.

3.2.8 Windshear Caution Alert:

- 3.2.8.1 A Windshear Caution Alert shall provide an alert of increasing performance shear exceeding the same threshold magnitudes as those defined by 3.1.5 a) through c) (opposite sign for increasing performance).
- 3.2.8.2 Windshear Caution Alerts shall continue for a finite time unless superseded by a Warning Alert, then cease if the conditions which initiated the alert no longer exist.

3.2.9 Windshear Advisory Alert:

- 3.2.9.1 A Windshear Advisory Alert shall provide an alert of detected shear ahead of the aircraft exceeding the same threshold magnitudes as those defined by 3.1.5 a) through c).
- 3.2.9.2 Windshear Advisory Alerts shall continue for a finite time unless superseded by a Warning or Caution Alert, then cease if the conditions which initiated the alert no longer exist.

3.3 Airborne Windshear Flight Guidance System and Auto Recovery System:

- 3.3.1 Systems should utilize the available kinetic and potential energy of the aircraft. If terrain contact is a consideration, recovery guidance should provide commands to take advantage of all usable aircraft energy.
- 3.3.2 Systems should take account of such things as height above the ground, vertical speed, shear severity, general aircraft aerodynamic characteristics, rate of performance degradation, and aircraft limitations.
- 3.3.3 For each aircraft type in which these systems are installed, adequate controllability shall be demonstrated within the envelope of the system commands.
- 3.3.4 Systems should only provide guidance commands which are found to be reasonable in piloted evaluations. Such commands should be compatible with manual techniques trained in the event of system failure.
- 3.3.5 The probability of misleading guidance commands shall be 10^{-5} per flight hour or less.

- 3.3.6 A Windshear Warning Alert shall precede any automatic presentation of Windshear Flight Guidance or any automatic activation of Windshear Auto Recovery permitted under 3.3.9 or 3.3.10. Suitable mode annunciation shall be provided and any conflicting mode annunciations shall be withdrawn.
- 3.3.7 Manual selection of Windshear Flight Guidance and/or Windshear Auto Recovery shall only be via the TOGA switches or similar switches in an equivalent location.
- 3.3.8 Manual de-selection of Windshear Flight Guidance and Windshear Auto Recovery mode shall be possible by means other than the TOGA switches.
- 3.3.9 Flight Director Presentations of Windshear Flight Guidance:
- 3.3.9.1 During takeoff (after liftoff) and climb phases, or during go-around, Windshear Flight Guidance shall be automatically presented, regardless of the previous status or mode of the guidance display (autopilot OFF).
- 3.3.9.2 During approach, the availability of automatic presentation of Windshear Flight Guidance is optional.
- 3.3.9.3 Windshear Flight Guidance shall be displayed on the PFD/ADI flight director, and Head Up Display if the aircraft is so equipped.
- 3.3.9.4 Flight director commands should guide the pilot to fly the profile determined to be as close to optimum as possible for the situation.
- 3.3.9.5 Systems should, if applicable, inhibit or override flight director pitch limits without exceeding aircraft handling limitations.
- 3.3.9.6 Failure of the Windshear Flight Guidance System should remove any Windshear Flight Guidance information from the flight director, and disengage the Windshear Auto Recovery System.
- 3.3.9.7 In the absence of a Windshear Auto Recovery System, manual autopilot disconnection should precede presentation of Windshear Flight Guidance (if the autopilot is engaged).
- 3.3.10 Automatic Flight System Modes:
- 3.3.10.1 AFS modes should execute the profile determined to be as close to optimum as possible for the situation.
- 3.3.10.2 Any Windshear Auto Recovery System shall interface with both the autopilot and autothrottle systems when activated.
- 3.3.10.3 The autopilot and autothrottle should both be engaged prior to a Windshear Warning Alert for a Windshear Auto Recovery System to operate.
- 3.3.10.4 When the autopilot is engaged following takeoff, or in the autopilot go-around mode, Windshear Auto Recovery should activate without further pilot action.

- 3.3.10.5 In the autopilot approach mode, activation of Windshear Flight Guidance should require pilot action.
- 3.3.10.6 Failure of the Windshear Auto Recovery System should disengage any automatic systems associated with the failed system or failed portion of the system.
- 3.3.10.7 Failure of either the autopilot or the autothrottle should preclude selection of Windshear Auto Recovery, or should deselect Windshear Auto Recovery if already active.
- 3.3.10.8 When active, the Windshear Auto Recovery System shall command maximum thrust until subsequent pilot action is taken.

3.4 Airborne Windshear Detection and Avoidance System (Forward Looking):

3.4.1 General:

- 3.4.1.1 The system shall be able to detect windshear in both dry and wet meteorological conditions.
- 3.4.1.2 Probabilities of false alerts and unannounced failures shall be the same as those for Windshear Alerting System (see 3.2).
- 3.4.1.3 Airborne Windshear Detection and Avoidance System(s) should complement the functions of Airborne Windshear Alerting System.

3.4.2 Airborne Windshear Forward Looking Detection System:

- 3.4.2.1 The system shall function below approximately 1500 ft AGL, and should function below 2500 ft AGL.
- 3.4.2.2 The system should detect hazardous areas up to 1.5 nautical miles ahead even in heavy rain, up to 2.0 inches per hour (red radar return, 50 dBZ), and within five degrees of the track and flight path angle (ten degree cone), even with worst case drift angles.
- 3.4.2.3 The system shall issue a Windshear Warning Alert which conforms to 3.1.5 and 3.2.7 for threshold and cessation.
- 3.4.2.4 The system should interface with Airborne Windshear Flight Guidance and/or Airborne Windshear Auto Recovery systems, although automatic mode switching is not recommended.

3.4.3 Airborne Windshear Forward Looking Avoidance System:

- 3.4.3.1 The system shall function below approximately 2500 ft AGL.