U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: TAKEOFF CONFIGURATION WARNING SYSTEMS
Date: 3/17/93
Initiated by: ANM-110
AC No: 25.703-1
Change:

1. PURPOSE. This advisory circular (AC) provides guidance for the certification of takeoff configuration warning systems installed in transport category airplanes. Like all AC material, this AC is not mandatory and does not constitute a regulation. It is issued to provide guidance and to outline a method of compliance with the rules.

2. RELATED REGULATIONS. Sections 25.703, .1301, .1309, .1357, .1431, and .1529 of the Federal Aviation Regulations (FAR).

3. RELATED READING MATERIAL.

a. Federal Aviation Administration Documents.

(1) Advisory Circular 25.1309-1A, System Design and Analysis. Advisory circulars can be obtained from the U.S. Department of Transportation, M-443.2, Subsequent Distribution Unit, Washington, D.C. 20590.

(2) Report DOT/FAA/RD-81/38,II, Aircraft Alerting Systems Standardization Study, Volume II, Aircraft Alerting Systems Design Guidelines. This document can be obtained from the National Technical Information Service, Springfield, Virginia 22161.

(3) FAA report, Review of Takeoff Configuration Warning Systems on Large Jet Transports, dated April 29, 1988. This document can be obtained from the Federal Aviation Administration, Transport Airplane Directorate, 1601 Lind Avenue, S.W., Renton, Washington, 98055-4056.

b. Industry Documents.

(1) Aerospace Recommended Practice (ARP) 450D, Flight Deck Visual, Audible and Tactile Signals; ARP 4012/4, Flight Deck Alerting Systems (FAS). These documents can be obtained from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

(2) Radio Technical Commission for Aeronautics (RTCA) document DO-160C, Environmental Conditions and Test Procedures for Airborne Equipment; RTCA document DO-178A, Software Considerations in Airborne Systems and Equipment Certification. These documents can be obtained from the RTCA, One McPherson Square, Suite 500, 1425 K Street Northwest, Washington, D.C. 20005.

(3) Aeronautical Radio, Inc. (ARINC) 726, Flight Warning Computer System. This document can be obtained from the ARINC, 2551 Riva Road, Annapolis, Maryland 21401.

4. BACKGROUND. A number of airplane accidents have occurred because the airplane was not properly configured for takeoff and a warning was not provided to the flightcrew by the takeoff configuration warning system. Investigations of these accidents have indicated a need for guidance material for design and approval of takeoff configuration warning systems.

5. DISCUSSION.

a. Regulatory Basis.

(1) Section 25.703 of the FAR, "Takeoff warning system," makes it mandatory for a takeoff configuration warning system to be installed in transport airplanes. This rule was added to Part 25 by Amendment 25-42 effective on March 1, 1978. Section 25.703 requires that a takeoff warning system be installed and provide an aural warning to the flightcrew during the initial portion of the takeoff roll, whenever the airplane is not in a configuration which would allow a safe takeoff. The intent of this rule is to require that the takeoff configuration warning system cover (a) only those configurations of the required systems which would be unsafe, and (b) the effects of system failures resulting in wrong surface or system functions if there is not a separate and adequate warning already provided. According to the preamble of Amendment 25-42, the takeoff warning system should serve as "back-up for the checklist, particularly in unusual situations, e.g., where the checklist is interrupted or the takeoff delayed." Conditions for which warnings are required include wing flaps or leading edge devices not within the approved range of takeoff positions, and wing spoilers (except lateral control spoilers meeting the requirements of § 25.671), speed brakes, or longitudinal trim devices in a position that would not allow a safe takeoff. Consideration should also be given to adding rudder trim and aileron (roll) trim if these devices can be placed in a position that would not allow a safe takeoff.

(2) Prior to Amendment 25-42, there was no requirement for a takeoff configuration warning system to be installed in transport airplanes. Since this amendment is not retroactive, some transport airplane models in service today may not have takeoff configuration warning systems; however, all large turbojet transports currently in service, even those with a certification basis established prior to 1978, include a takeoff configuration warning system in the basic design. These include the majority of jet transport category airplanes.

(3) Other general rules such as §§ 25.1301, 25.1309, 25.1357 and 25.1431 for electronic system installations also apply to takeoff configuration warning systems.

b. System Criticality.

(1) It has been Federal Aviation Administration policy to categorize systems designed to alert the flightcrew of potentially hazardous operating conditions as being at a level of criticality associated with a probable failure condition. (For a definition of this terminology together with discussions and guidelines on the classification of failure conditions and the probability of failures, see AC 25.1309-1A.) This is because failures of these systems, in themselves, are not considered to create an unsafe condition, reduce the capability of the airplane, or reduce the ability of the crew to cope with adverse operating conditions. Other systems which fall into this category include stall warning systems, overspeed warning systems, ground proximity warning systems, and windshear warning systems.

(2) Even though AC 25.1309-1A does not define an upper probability limit for probable failure conditions, generally, it can be shown by analysis that such systems have a probability of failure (of the ability to adequately give a warning) which is approximately 1.0 x 10E-3 or less per flight hour. This probability does not take into account the likelihood that a warning will be needed. Systems which are designed to meet this requirement are usually single channel systems with limited built-in monitoring. Maintenance or preflight checks are relied on to limit the exposure time to undetected failures which would prevent the system from operating adequately.

(3) Applying the practice given in Paragraphs b(1) and b(2) above to takeoff configuration warning systems is not considered to result in an adequate level of safety when the consequence of the combination of failure of the system and a potentially unsafe takeoff configuration could result in a major/catastrophic failure condition. Therefore, these systems should be shown to meet the criteria of AC 25.1309-1A pertaining to a major failure condition, including design criteria and in-service maintenance at specified intervals. This will ensure that the risk of the takeoff configuration warning system being unavailable when required to give a warning, if a particular unsafe configuration occurs, will be minimized.

(4) If such systems use digital electronic technology, a software level should be used, in accordance with RTCA document DO-178A, which is compatible with the system integrity determined by the AC 25.1309-1A analysis.

(5) Since a false warning during the takeoff run at speeds near V_1 may result in an unnecessary rejected takeoff (RTO), which could lead to a mishap, the occurrence of a false warning during the takeoff should be improbable in accordance with AC 25.1309-1A.

(6) If the takeoff configuration warning system is integrated with other systems that provide crew alerting functions, the level of criticality of common elements should be commensurate with that of the takeoff configuration warning system unless a higher level is dictated by one or more of the other systems.

c. Design Considerations.

(1) A review of existing takeoff configuration warning systems has shown a trend towards increased sophistication of design, partly due to the transition towards digital electronic technology which is amenable to self-monitoring and simple testing. The net result has been an improvement in reliability, fewer unwanted warnings and enhanced safety.

(2) With the objective of continuing this trend, new systems should be designed using the objectives and criteria of AC 25.1309-1A. Analysis should include all the remote sensors, transducers and the elements they depend on, as well as any takeoff configuration warning system line replaceable unit (LRU) and the actual visual and aural warning output devices.

(3) Unwanted warnings may be reduced by suppressing the takeoff configuration warning system where it is safe to do so, e.g., between V_1 and V_R, so that a rejected takeoff is not attempted if, for example, a sensor fails due to vibration during the takeoff run. Suppression of the takeoff configuration warning system at high speeds will also avoid any confusion from the occurrence of a warning during a touch-and-go landing. This is because the basic message of an alert is to stop because it is unsafe to take off. It does not tell the flightcrew which surface or system is wrong. A warning may be more hazardous than depending on the flightcrew's skill and training to cope with the situation.

(4) Even though § 25.703 specifies those inputs common to most transport category airplanes that must be included in the design, each airplane model should be carefully reviewed to ascertain that any configuration or trim setting that could jeopardize a safe takeoff has an input to the takeoff warning system unless a separate and adequate warning is already provided by another system. There may be airplane configurations or electronically positioned lateral or longitudinal trim unique to a particular model that constitute this hazard. In the event that it is necessary to suppress the warning from a particular system during the entire takeoff roll, an equivalent level of safety finding would be required.

(5) Automatic volume adjustment should be provided to maintain the aural warning volume at an appropriate level relative to cockpit ambient sound. According to Report No. DOT/FAA/RD-81/38,II entitled "Aircraft Alerting Systems Standardization Study, Volume II - Aircraft Alerting System Design Guidelines," aural signals should exceed masked threshold by 8 $\pm$ 3 dB.

(6) Of particular importance in the design of takeoff configuration warning systems is the elimination of nuisance warnings. These are warnings generated by a system which is functioning as designed but which are inappropriate or unnecessary for the particular phase of operation. Attempting to eliminate nuisance warnings cannot be overemphasized because any indication which could cause the flightcrew to perform a high speed refused takeoff, or which distracts or adversely affects the flightcrew's performance of the takeoff

maneuver, creates a hazard which could lead to an accident. In addition, any time there are nuisance warnings generated, there is a possibility that the flightcrew will be tempted to eliminate them through system deactivation, and by continually doing this, the flightcrew may be conditioned to ignore a valid warning.

(7) There are a number of operations that could produce nuisance warnings. Specifically, single engine taxi for twin engine airplanes, or in the case of 3 and 4 engine airplanes, taxi with fewer than all engines operating is a procedure used by some operators for the purpose of saving fuel. Nuisance warnings have also been caused by trim changes and speed brake handle adjustments.

(8) Each airplane model has a different means of arming the takeoff configuration warning system, therefore the potential for nuisance warnings varies accordingly. Some existing systems use only a single throttle position, some use position from multiple throttles, some use EPR or N1, and some use a combination of these. When logic from a single operating engine was used, nuisance warnings were common during less than all engine taxi operations because of the higher power settings required to move the airplane. These systems were not designed for that type of operation. Because this procedure is used, inputs that arm the system should be judiciously selected taking into account any likely combination of operating and shut-down engines so that nuisance warnings will not occur if the airplane is not in takeoff configuration.

(9) The FAA approved Master Minimum Equipment List (MMEL) includes those items of equipment related to airworthiness and operating regulations and other items of equipment which the Administrator finds may be inoperative and yet maintain an acceptable level of safety by appropriate conditions and limitations. No MMEL relief is provided for an inoperative takeoff configuration warning system. Therefore, design of these systems should include proper system monitoring including immediate annunciation to the flightcrew should a failure be identified or if power to the system is interrupted.

d. System Tests and Test Intervals.

(1) When manual tests or checks are required to show compliance with § 25.1309(b) and (d), by detecting the presence of and limiting the exposure time to a latent failure that would render the warning inoperative, they should be adequate, simple and straight forward in function and interval to allow a quick and proper check by the flightcrew and maintenance personnel. Flightcrew

checks may be specified in the approved Airplane Flight Manual (AFM) and, depending on the complexity of the takeoff configuration warning system and the airplane, maintenance tasks may be conventional Maintenance Review Board (MRB) designed tasks or listed as Certification Check Requirements (CCR) where appropriate, as defined in AC 25.1309-1A, and determined as part of the approval process between the manufacturer and the certification office.

(2) The specified tests/checks established in accordance with Paragraph 5d(1) above should be demonstrated as part of the approval process and should show that each input sensor as well as the control and logic system and its emitters, including the indication system, are individually verified as required to meet Paragraph 5b(3). It should also be demonstrated that the warning self cancels when required to do so, by retarding the throttles or correcting the wrong configuration.

e. Flight Test Considerations.

(1) During the flight testing it should be shown that the takeoff configuration warning system does not issue nuisance alerts or interfere with other systems. Specific testing, including airplane tests, should be conducted to ensure that the takeoff configuration warning system works satisfactorily in all modes of operation.

(2) It should be shown by test or analysis that for all feasible weights, taxiway slopes, temperatures and altitudes, there will be no nuisance warnings, or failure to give a warning when necessary (e.g., cold conditions, derated takeoff), for any reasonable configuration of engines operating or shut down. This is to test or simulate all expected operational configurations. Reasonable pilot technique for applying power should be presumed.

(3) It should be demonstrated that the takeoff configuration warning system aural warning can be silenced by closing the throttles, bringing the airplane into the proper takeoff configuration, or by pulling the system circuit breaker.

Ronald T. Wojnar

RONALD T. WOJNAR
Manager, Transport Airplane Directorate,
Aircraft Certification Service, ANM-100