# Airworthiness Considerations

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6. AIRWORTHINESS CONSIDERATIONS.

a. Certification Program. This advisory circular provides guidance for the airworthiness approval of both "annunciation only" and "annunciation with guidance" airborne windshear warning systems as many of the system design aspects, functions, and characteristics are common. In either case, the scope of the applicant's program should be directed toward airworthiness approval through the Type Certificate (TC) or Supplemental Type Certificate (STC) process. In the case of systems with flight guidance which will ultimately be used on aircraft in air carrier service, the applicant is encouraged to undertake a certification program which will satisfy both the criteria contained herein, as well as that contained in AC 120-41, Criteria for Operational Approval of Airborne Windshear Alerting and Flight Guidance Systems. Many of the criteria outlined below in paragraph 6(d)(2) can also be satisfied in finding compliance with § 25.1301 of the FAR, if the certification program satisfies both operational and airworthiness criteria. A statement will be placed in the approved Airplane Flight Manual indicating compliance with AC 120-41, thereby providing for a more streamlined operational approval process for an air carrier under Parts 121 or 135 of the FAR.

b. Certification Plan. A comprehensive certification plan should be developed by the applicant. It should include how the applicant plans to comply with the applicable regulations and should provide a listing of the substantiating data and necessary tests. Also, a comprehensive system description and an estimated time schedule should be included. A well developed plan will be of significant value both to the applicant and the FAA.

c. System Criticality. Certain types of failure cases must be addressed in consideration of the potential hazard they may induce during the course of normal system operation. Advisory Circular 25.1309-1, System Design Analysis, provides criteria to correlate the depth of analysis required with the type of function the system performs (nonessential, essential, or critical). Also, failure conditions which result from improper accomplishment or loss of function are addressed. The criticality of certain system failure cases for windshear warning and systems with escape guidance are outlined in paragraphs (1) and (2) below. In the case of systems which provide escape guidance, there may be a number of complex system integrations with existing airplane systems and sensors; and the treatment of all the combinations possible is beyond the scope of this AC. In this case, AC 25.1309-1 states that the flight test pilot should: (1) determine the detectability of a failure condition, (2) determine the required subsequent pilot actions, and (3) make a judgment if satisfactory intervention can be expected of a properly trained crew. In addition, failure of the windshear warning system should not degrade the integrity of other essential or critical systems installed in the airplane. This includes common shared sensors.

(1) Windshear Warning. The system should be designed so that false warnings have a probability of occurrence on the order of $10^{-4}$ or less. This includes the failure of the system to annunciate a windshear warning as a result of a latent failure.

(2) Systems with Escape Guidance. In addition to the criteria of paragraph (1) above, the following system failure cases should be improbable in

accordance with AC 25.1309-1. (Consideration for out-of-production airplanes with early versions of unmonitored flight director computers and mechanical flight instruments is warranted, and those systems may have a probability of failure on the order of $10^{-3}$ or less.)

(i) Unannunciated failure of the system to provide the escape guidance function when commanded. Removal of flight director command bars constitutes adequate annunciation.

(ii) The display of escape guidance other than that evaluated and approved in accordance with § 25.1301 of the FAR (see paragraph d, Intended Function, below).

NOTE: The loss of windshear warning annunciation should not preclude or inhibit the presentation of the escape guidance information, as long as the guidance mode change annunciation remains valid and the annunciation is provided in a clear and unambiguous manner.

(3) Software Based Systems. The software should be developed to a minimum of level 2. An acceptable means for obtaining approval for the development of the software based system is to follow the design methodology contained in RTCA Document DO-178A, Software Considerations in Airborne Systems and Equipment Certification.

(4) Probability Analysis. The applicant should provide a quantitative probability analysis to support an engineering evaluation of the system failure cases listed above. For this purpose, an exposure time of 0.1 hour has been found acceptable by the FAA in the past. This criteria assumes that internal system tests verify proper system status immediately prior to the system being enabled. The probabiliy of the airplane encountering a severe windshear should be 1 (one) and the computed probabilities of occurrence should be expressed in failures per flight hour.

d. Intended Function. The major emphasis for showing compliance with § 25.1301 is centered around the aspects of establishing a windshear warning threshold that considers remaining airplane performance. For systems that include escape guidance provisions, a subjective evaluation of airplane performance is made to determine that the algorithms manage the available energy in such a manner as to enhance flight path control beyond that which would be normally expected without the use of the system. In addition, applicable system integration aspects are evaluated in order to determine that there are no adverse functional effects with the existing airplane systems and sensors that are integrated to the windshear warning system.

(1) Airborne Warning System. The applicant must demonstrate by analysis and simulation that the system warning threshold is appropriate for a given airplane/engine combination. Once this aspect has been demonstrated and approved by the FAA for a given windshear warning system, it need not be repeated for other airplane models if the applicant can show that the technology employed for this purpose is suitable. If applicable, system integration and the use of external airplane sensors on the same or new model types must be taken into account.

number of severe windshear encounters and conducted studies to determine the criticality of flight variables like airspeed, altitude, thrust-to-weight ratio, etc. This effort has resulted in the identification of a number of items that should be considered when establishing alert threshold, flight procedures, and training requirements.

(2) Warning Only System. The procedure added to the AFMS should contain the following basic elements:

(i) Aggressively apply maximum rated thrust, disengaging autothrottle if necessary.

(ii) Rotate smoothly at a normal rate to the go-around/takeoff pitch attitude and allow the airspeed to decrease, if necessary.

(iii) If the airplane is descending, increase pitch attitude smoothly and in small increments, bleeding airspeed as necessary to stop the descent.

(iv) Use stall warning onset as the upper limit of pitch attitude.

(v) Engine overboost should be avoided unless the airplane continues to descend and airplane safety is in doubt. When airplane safety has been assured, adjust thrust to maintain engine parameters within approved limits.

NOTE: Overboosting engines while at angles of attack near airplane stall warning may cause engine stall, surge, or flameout.

(vi) Do not retract flaps or landing gear until safe climb-out is assured.

(3) Warning with Escape Guidance System. In addition to providing the information and procedures peculiar to the new system, a statement should be made in the AFMS that in all cases of windshear warning, the escape guidance should be followed until the maneuver has been safely completed.

BOB IRELAND (United Airlines) - Ray, I've got one quick question for you. Could you bring up page 13 again that you had on the board before? There seems to have been an effort made on this page, and I applaud it, to recommend a manual recovery technique which is similar to that which comes out in the FAA training aid. The question I'm left with here is "(2)(ii)": "Rotates smoothly at normal rate to the normal go around take off pitch attitude." As you are well aware, the training aid does specify other target pitch attitudes, they are just fixed target pitch attitudes regardless of your gross weight or whatever else might affect takeoff pitch attitude. And I'm wondering why you chose to put something else there, when there is a warning on this airplane, as opposed to when there is not a warning? The FAA recommends just a fixed pitch attitude.

RAY STOER (FAA) - Because Bob, we are not trying to write the flight manual or get down to the details of a particular airplane type. What we are trying to do is say, "you should consider these basic elements." As we went through this with Herb and some of his people in our judgement, we felt that this was not inconsistent with the training aid. If you are trying to identify, perhaps, a specific airplane type then you might say--well that doesn't fit as well. Our intention here was to make some generic considerations which hopefully will bring to the attention of somebody writing the flight manual, the kinds of things that we would like to have considered. That was our intent.

BOB IRELAND (United Airlines) - I understand the intent. Would it, perhaps, be better to have said: "rotate to an appropriately determined pitch attitude," rather than a specific situation like that?

RAY STOER (FAA) - It may have been a better thing to do Bob.

BOB IRELAND (United Airlines) - Okay, I just wanted to understand your intent. I appreciate that.

RAY STOER (FAA) - Even with the change we made here [pointing to viewgraph] and I should point this out, that when we got into the overboost concern here and we made this new number 5 here [pointing to viewgraph], we coordinated this immediately with Herb, in fact we had a national telecom within the FAA on this power plant subject. We had Herb on because we wanted to be sure that whatever we did come up with was not going to be inconsistent with the wind shear training document. Or at least, if we were going to be inconsistent we wanted to understand that, right up front. That doesn't mean that if we don't find something is wrong we can't say it because we're inconsistent, but we wanted to identify that immediately. In our judgement, we are, from a generic standpoint, consistent with the wind shear

training aid.

BOB IRELAND (United Airlines) - That's great. Just a comment on the engine section right there. I think that Ralph and I could tell you that many, many days and hours were expended in talking about engines in the training document as well. It was a very very difficult subject and I really like what you put there. I think it is a very good way to go.

RAY STOER (FAA) - Thank you. Our very first certification with the wind shear system was about 7 or 8 years ago and I had the pleasure of being on that with the United Airlines at the San Francisco Engineering Base on a 747. It was a "one-only" installation. It modified an existing Safe Flight SCAT (Speed Control and Autothrottle) system in the pitch axis computer to accommodate the wind shear escape guidance algorithms. United took the leadership in this field at that time when we hardly knew how to spell wind shear. And Safe Flight had so much patience with us in sitting down and almost training us to what they had. Again it relates back to the aspect that we have no resources but people. We don't have any facilities to go out and research things. We have to develop criteria concurrent with an existing program and depend upon the manufacturer of that equipment to teach and train us what he has. Our wind shear AC (advisory circular) over the past 4 years--formally when we had a team--and going back 7 and 8 years, has been a dynamic document. It started as a one-page of what we think we ought to be doing and has become a living document. And the reason that we are going ahead and printing it now--at last--is because we have a requirement within the government that if we have a rule-making project in process we have to have a means of complying.

DAN LABRIOLA (Tech AirServices) - For those of us on the training side - this is really a good point about the engine overboost and it seems it has really been a tough one because, we started out saying that you should never overboost the engine and you know max EPR's is what it was and we've been coming about on that. But if we are going to start differentiating airplanes; are you, or is someone, going to solicit and publish those aircraft for which we can't recommend pushing the throttle to the firewall.

RAY STOER (FAA) - Dan, I don't know the answer to that. Our power plant group have an idea, but they don't specifically know how many of the manufacturers and on what model types. The individual manufacturers have independently looked at this region outside the envelope. And we never see that on the certification program. Manufacturers don't like to show us anything they don't need to. And that's okay, that is a defense mechanism on their part and that's acceptable. They show us the operation of the airplane in the envelope they seek to have approved. We have no data, and many times we have no knowledge of how far the airplane

is taken out of the envelope and explored by the manufacturer. We know that goes on and it's okay, but we don't have data or knowledge of just what that is. I think what we hope is that this kind of a "hey caution fellows, let's take a look at this," is going to stimulate the equipment manufacturers' interest in contacting the manufacturer and perhaps on getting some data from the manufacturer on this. This may also stimulate new model types that are being certified into, perhaps, taking a look at this region now that it is identified, that we will be operating in this region more often because of the wind shear guidance algorithms.

DAN LABRIOLA (Tech AirServices) - I would suggest to you that if the FAA doesn't solicit this kind of information it might be a little tough for any of the rest of us to find that out.

RAY STOER (FAA) - I can agree with that Dan, and that is a good thought. We didn't want to hold this [advisory circular] up, and we tried to work a way out that we could put something in here that perhaps was defendable (and we think it is defendable outside this document). But we really didn't have the time to do that. And what I would like to take an action item to you, if I may, is discussing this with the manager of our power plant section to see, in more detail, if there could be some interest generated within the FAA to look into this region outside the envelope and how we can control that. If we say we have an approved envelope, do we have the right to ask the manufacturer to show us data? I don't know that, but I think we need to explore that a little bit. It is a good point.