March 19, 2021

Mr. Brandon Roberts
Executive Director, Office of Rulemaking
Designated Federal Official, Aviation Rulemaking Advisory Committee
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

RE: Avionics Systems Harmonization Working Group – Recommendation Report; Low Energy Alerting

Dear Mr. Roberts,

On March 18, 2021, the Aviation Rulemaking Advisory Committee ("ARAC") voted unanimously to accept the Final Recommendation Report ("Report"), submitted by the Avionics Systems Harmonization Working Group ("ASHWG") on Low Energy Alerting.

As you know, the work of the ASHWG is an important component to enhance aviation safety. ARAC would like to thank the Chair, Mr. Clark Badie, the AHSWG members and the Transport Aircraft and Engines Subcommittee ("TAE") for its work and commitment to the development of this report. Moreover, we appreciate the submission of such a detailed report, including suggested regulatory and supporting guidance language, especially given the challenges of meeting in a virtual environment.

On behalf of the ARAC members, please accept the ASHWG's Recommendation Report and submit to the relevant program offices for consideration and implementation. Please do not hesitate to contact me with any questions. Thank you very much.

Sincerely yours,

Yvette A. Rose
ARAC Chair
202.293.1032
yrose@cargoair.org

cc: Keith Morgan, TAE Chair
Clark Badie, Working Group Chair
David Oord, ARAC Vice Chair

Avionics Systems Harmonization Working Group (ASHWG)

Low Energy Alerting

Proposed requirements for context-dependent low energy alerting systems for airplanes engaged in commercial operations

Prepared for the Aviation Rulemaking Advisory Committee (ARAC)
1-29-2021

Contents

1. EXECUTIVE SUMMARY

As a result of the July 6, 2013 Asiana Flight 214 accident, the National Transportation Safety Board (NTSB) issued a recommendation to the Federal Aviation Administration (FAA) to "Task a panel of human factors, aviation operations, and aircraft design specialists, such as the Avionics Systems Harmonization Working Group, to develop design requirements for context-dependent low energy alerting systems for airplanes engaged in commercial operations."

The ASHWG recommends the incorporation of changes into the existing §25.1303(c) as well as changes to AC 25-7D paragraph 32.2 associated with this proposed regulation as described in detail in this report. The recommended changes would incorporate new regulatory and guidance material for flightcrew alerting, equipment for use by the flightcrew and crew workload. Additional changes to AC 25-7D paragraphs 4.11, 5.1, 7.3, and 42.4 are proposed to clarify guidance for various compliance demonstrations with the incorporation of the proposed low energy alert.

The recommended changes include the requirement for a low energy flightcrew alert when the airplane is "slow and close to the ground." The ASHWG recommendation also includes accommodation for designs incorporating low energy protections, as these may mitigate a low energy condition.

Performance-based safety regulations, policies, and guidance are preferred in order to provide the flexibility necessary to accommodate a diverse set of users along with the ability to adapt at a faster pace. Their use will promote innovative means of compliance not bound by prescriptive technical requirements in the regulations.

The ASHWG strongly recommends that the FAA examine other contributing factors which could result in inadvertent low energy conditions, including unstable approaches and associated possible mitigation strategies. Standards for these recommendations are not included in the scope of this task but both future considerations are described further in this report.

The ASHWG also recommends that a review by non-U.S. regulatory agencies that were not participants in drafting this report be conducted, with feedback provided and dispositioned by the ASHWG before the report is released to the rulemaking process.

There are no dissenting positions on the findings and the rationale for each position.

2. BACKGROUND

The Federal Aviation Administration (FAA) previously examined low speed alerting requirements and tasked the Aviation Rulemaking Advisory Committee (ARAC) to provide information to develop standards and guidance material for low speed alerting systems. This resulted in two reports previously issued by the Avionics Systems Harmonization Working Group (ASHWG).

- Phase 1 Report: Avionics Systems Harmonization Working Group Report – Low Airspeed Alerting Systems for Part 25 Aircraft (April 2011).
- Phase 2 Report 2: Low Airspeed Alerting For Retrofit Applications (March 2013)

The information from those reports included recommendations for low airspeed alerting, but to date no additional operational requirements have been issued.

However, as a result of the July 6, 2013 Asiana Flight 214 accident, the National Transportation Safety Board (NTSB) issued a recommendation to the FAA to "Task a panel of human factors, aviation operations, and aircraft design specialists, such as the Avionics Systems Harmonization Working Group, to develop design requirements for context-dependent low energy alerting systems for airplanes engaged in commercial operations. (A-14-43)"

3. WHAT IS THE TASK?

The task (ref Federal Register /Vol. 83, No. 12 /Thursday, January 18, 2018) stated that

"The ASHWG will provide advice and recommendations to the ARAC through the TAE Subcommittee in a report that addresses the following questions relative to new airplane designs. The report should include rationale for the responses.

1. Do you (the ASHWG) recommend any changes to the existing low speed alerting requirements to provide additional pilot reaction time in cases where the airplane is both slow and close to the ground?

2. Do you recommend any new or revised guidance material to define an acceptable low energy alert?

3. After reviewing airworthiness, safety, cost, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that the FAA should take into account regarding avoidance of low energy conditions?

4. Is coordination necessary with other harmonization working groups (e.g., Human Factors, Flight Test)? If yes, coordinate with that working group and report on that coordination."

(NOTE) It is important to point out that the NTSB report included several other recommendations and findings, some of which the ASHWG considers to be relevant and will be addressed in the response to question 3.

4. WHO HAS WORKED THE TASK?

This task was worked by the Avionics Systems Harmonization Working Group (ASHWG). The ASHWG consists of individuals from industry, ALPA, NASA and regulatory (FAA, Transport Canada) organizations. Disciplines represented include systems engineering, certification, flight test, and human factors. In addition, members from the Flight Test Harmonization Working Group (FTHWG) are also members of the ASHWG. Coordination from the FTHWG included reviews of relevant reports used in the making of this ASHWG report, along with a review of the ASHWG draft report prior to release.

5. ANY RELATION WITH OTHER TOPICS ?

Yes - The ASHWG recommends that the FTHWG should review and revise, as necessary, their recommended 25.176(c) requirement after consideration of the ASHWG proposal for a new 25.1303(c)(3). For a copy of the FTHWG recommendation please refer to the FTHWG Phase 2 Final Recommendation Report – Rev A, located at the following link.

https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/09%20-%20FTHWG_Final_Report_Phase_2_RevA__Apr_2017.pdf

6. HISTORICAL INFORMATION

Section 25.1329(h) requires that "when the flight guidance system is in use, a means must be provided to avoid excursions beyond an acceptable margin from the speed range of the normal flight envelope. If the airplane experiences an excursion outside this range, a means must be provided to prevent the flight guidance system from providing guidance or control to an unsafe speed." AC 25.1329-1C addresses low airspeed alerting or protection including protection provided by an Auto Flight System and for aircraft equipped with auto flight systems. The ASHWG position is that a low energy alert should be included for both automatic and manual flight.

The FTHWG previously proposed Phase 2 Final Recommendation Report includes a new regulation to require low energy alerting associated with neutral longitudinal stability based on previous FAA Special Conditions used to certify these types of designs. The FAA Special Conditions were applicable for fly-by-wire aircraft for low energy awareness, and linked to the neutral longitudinal stability feature that is considered providing insufficient attention getting cues to the pilot when the aircraft is in all the relevant low energy situations. The Special Condition covers all flight phases.

The ASHWG recommendation also incorporates alignment with new regulatory material that should be integrated where applicable in future revisions of AC 25-7. This include the most recent versions of §25.1322 and AC 25 1322-1, §25.1302 and AC 25.1302-1, Part 25 Appendix D, §25.1329 and AC 25.1329-1.

7. CONSENSUS

This report provides the ASHWG recommendations on the findings and results of the tasks explained above. There are no dissenting positions on the findings and the rationale for each position.

8. RECOMMENDATION

The ASHWG recommends the incorporation of changes into the existing §25.1303(c) as well as changes to AC 25-7D paragraph 32.2 associated with this proposed regulation as described in detail in this report. Additional changes to AC 25-7D paragraphs 4.11, 5.1, 7.3, and 42.4 are proposed to clarify guidance for various compliance demonstrations with the incorporation of the proposed low energy alert.

The ASHWG recommends that the FTHWG revisit the previously proposed Phase 2 Final Recommendation Report related to low energy alerting, with consideration of the ASHWG recommendations.

9. WHO WOULD BE AFFECTED BY THE PROPOSED CHANGE?

The proposed change would be applicable to Applicants for certification of new, or changes to, transport category aircraft to Title 14 CFR Part 25 where:

- The date of application for type certification is after the final rule effectivity date and,
- For a change to a certified product, the change has been evaluated as either significant or substantial pursuant to §§ 21.101 and 21.19 and,
- Low energy alerting is determined by the Administrator to be necessary to establish an adequate and appropriate level of safety.

10. ECONOMICS

The ASHWG's position is (for new airplane designs only) that the estimated cost to develop, integrate, test, evaluate, and certify a context-specific low energy alert be assessed in a detailed cost benefit analysis.

11. DOES THE HWG WANT TO REVIEW THE DRAFT NPRM PRIOR TO PUBLICATION IN THE FEDERAL REGISTER?

Yes.

The remainder of this report provides the ASHWG responses to the specific questions from the tasking statement.

QUESTION 1: DO YOU (THE ASHWG) RECOMMEND ANY CHANGES TO THE EXISTING LOW SPEED ALERTING REQUIREMENTS TO PROVIDE ADDITIONAL PILOT REACTION TIME IN CASES WHERE THE AIRPLANE IS BOTH SLOW AND CLOSE TO THE GROUND?

ASHWG Position: Yes, changes to existing requirements are recommended to provide the flightcrew with adequate time to react in cases where the airplane is slow, close to the ground, and with insufficient thrust for continued safe flight and landing (a 'low energy' condition).

Existing low airspeed alerts or protection may be inadequate for a normal landing configuration, where the flightcrew may benefit from earlier alerting on final approach at low altitudes to avoid the low energy condition and ensure continued safe flight. The existing regulations (§25.1329 Amendment 119) only address low airspeed alerting or protection (e.g. Autothrottle Wakeup) for aircraft equipped with auto flight systems. The ASHWG position is that low energy alerting or protection should include both automatic and manual flight.

The ASHWG has understood the context of low energy conditions "slow and close to the ground" associated with low thrust as typically occurring in a normal landing configuration. Other flight phases such as Take-Off and Go-Around can also result in conditions which are "slow and close to the ground" but are normally associated with higher thrust settings.

Energy management during the approach to landing phase is a critical flightcrew task, so the Standard Operating Procedures (SOPs) of Part 121/135 operators state that the monitoring pilot shall call out speed deviations in excess of pre-defined limits. Usually, any speed excursion below Vref or, depending on operators´ polices, below the still more conservative speed associated with the normal all-engines-operating procedure Vapproach, shall be called out. The same is applied for speed excursions above Vref or Vapproach, the tolerances again defined by operators´ policies (reference Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices, 2nd Edition, ISBN 978-92-9229-317-8, © 2016 International Air Transport Association - specifically paragraph 3.3). The data included in the NTSB Report on the Asiana 214 accident indicated insufficient flightcrew monitoring of airspeed indications during the approach likely resulted from expectancy, increased workload, fatigue, and automation reliance. Lack of compliance with standard operating procedures and crew resource management were cited as additional factors.

As indicated in the NTSB report, although a subsequent low airspeed alert (notably present but not required for autoflight certification at the time) was effective in drawing the flightcrew's attention to the condition, the probability of a safe recovery may have been increased if the alert had been generated earlier and/or in a more compelling manner, or the airplane's systems provided protection against a low energy condition.

The ASHWG recommends a new requirement for low energy alerting, alone or in combination with low energy protection, for the normal landing configuration. This would be applicable to both manual and automatic flight and all types of transport (Part 25) aircraft. Under the existing regulations, the first required flightcrew alert for a low energy condition could be stall warning (or an envelope limit) which may correspond to a significant amount of energy depreciation. The intent of the low energy alert, alone or in combination

with low energy protection, is to facilitate continued safe flight and/or landing prior to encountering such a low energy state.

The proposed requirement after incorporation into existing §25.1303(c) is as follows (note that all changes are highlighted):

25.1303 Flight and Navigation Instruments, and Low Energy Alerting

.....

(c) The following flight and navigation instruments and alerting functions are required as prescribed in this paragraph:

(1) A speed warning device is required for turbine engine powered airplanes and for airplanes with VMO/MMO greater than 0.8 VDF/MDF or 0.8 VD/MD. The speed warning device must give effective aural warning (differing distinctively from aural warnings used for other purposes) to the pilots, whenever the speed exceeds VMO, plus 6 knots or MMO +0.01. The upper limit of the production tolerance for the warning device may not exceed the prescribed warning speed.

(2) A machmeter is required at each pilot station for airplanes with compressibility limitations not otherwise indicated to the pilot by the airspeed indicating system required under paragraph (b)(1) of this section.

(3) A timely low energy alert, alone or in combination with low energy protection, to assist the flightcrew in continuing safe flight, to the extent practicable, in any normal landing configuration.

QUESTION 2: DO YOU RECOMMEND ANY NEW OR REVISED GUIDANCE MATERIAL TO DEFINE AN ACCEPTABLE LOW ENERGY ALERT?

ASHWG Position: Yes, changes to AC 25-7D paragraphs 32.2, 4.11.2.4, 5.1.1.5, 7.3.1.4.3, and 42.4.4.2.4 are recommended to provide guidance for low energy alerting, alone or in combination with low energy protection. Note that all changes are highlighted.

- A new paragraph 32.2.1.6 provides guidance for the design of a low energy alert and, as applicable, low energy protection.
- The title of existing paragraph 32.2.2 is proposed to clarify applicability associated with Overspeed Alerting to differentiate from low energy.
- A new paragraph 32.2.3 provides guidance for evaluation of a low energy alert and, as applicable, low energy protection.
- Guidance material changes are proposed to paragraphs 4.11.2.4, 5.1.1.5, 7.3.1.4.3 and 42.4.4.2.4 to clarify guidance for various compliance demonstrations with the incorporation of the proposed low energy alert. Modifications to this guidance are generally related to the acceptance of alerting without fundamentally changing the associated performance demonstration; for example, changes to 42.4.4.2.4 would clarify that flightcrew alerting would be permissible during the performance abuse testing associated with approval of steep approach to landing, but would not be used to modify the demonstration currently expected.

AC 25-7D

32.2 **Flight and Navigation Instruments, and Low Energy Alerting—§ 25.1303.**

32.2.1 Explanation.

32.2.1.1 Section 25.1303(b)(1) requires an airspeed indicator to be visible at each pilot station. Additionally, if airspeed limitations vary with altitude, airspeed indicators must have a maximum allowable airspeed indicator showing the variation of V_{MO} with altitude. Presenting this variation in V_{MO} as a marker on the airspeed indicator whose position varies as a function of altitude is an acceptable means of compliance with this requirement.

32.2.1.2 Production tolerances for speed warning devices at V_{MO}/M_{MO} are required to be taken into account in accordance with § 25.1303(c).

32.2.1.3 Section 21.127(b)(2) requires each production flight test to include "An operational check of each part or system operated by the crew while in flight to establish that during flight, instrument readings are within normal range." Nowhere in these requirements is there any inference that the finite performance or quantitative limits, defined during type certification, need to be determined for each production airplane.

32.2.1.4 Section 25.1303(c) requires that turbine-powered airplanes be equipped with a speed warning device that will provide aural warning whenever the speed exceeds V_{MO} plus 6 knots or M_{MO} + 0.01 M. The regulations

specify that the upper limit of the production tolerances permitted for the warning device must be at a speed not greater than the prescribed warning speed.

32.2.1.5 Accuracy requirements specified in §§ 25.1323 and 25.1325 that apply to the airspeed indicator and altimeter required by § 25.1303(b)(1) and (2), respectively, apply equally to all installed airspeed indicators and altimeters, including standby airspeed indicators and altimeters.

32.2.1.6 Section 25.1303(c)(3) requires a timely low energy alert, alone or in combination with low energy protection, to assist the flightcrew in continuing safe flight, to the extent practicable, in any normal landing configuration. The requirement to assist assumes compliance with the intended functions of both the low energy alert described in paragraph 32.2.1.6.6 and, as applicable the low energy protection described in paragraph 32.2.1.6.7.

32.2.1.6.1 The low energy alert must be designed in accordance with the requirements found in § 25.1322 (amendment 131 or later version). This includes considerations such as alert category, timely cueing, message nomenclature, false and nuisance alerts, alert components (e.g. aural, visual, tactile), and prioritization with other alerts, including windshear alerts or stall warning if applicable. (ACs 25.1322-1 and 25-11B)

32.2.1.6.2 The low energy alert should be consistent with other related flight deck indications according to AC 25-11B.

32.2.1.6.3 The applicant must show that the low energy alert, alone or in combination with low energy protection, will meet the requirements in § 25.1302 for installed systems and equipment for use by a qualified flightcrew. This should include the requirements related to accessible and usable information consistent with the urgency of the flightcrew's tasks along with flightcrew awareness of the effects on the airplane or systems resulting from flightcrew actions.

32.2.1.6.4 Design considerations of the low energy alert, alone or in combination with low energy protection, must account for effects on flightcrew workload in accordance with § 25.1523, Appendix D to Part 25 (AC 25.1523-1).

32.2.1.6.5 A low energy condition is an airplane state where the airspeed, in combination with altitude and thrust, is too low (or trending too low) and which, if not corrected, may result in an unsafe condition.

32.2.1.6.6 The intended function of the low energy alert (alone) is to attract attention and inform the flightcrew of a low energy condition with adequate time to elicit intervention with corrective action by a qualified flightcrew to continue safe flight. Appropriate flightcrew corrective actions are normally defined by airplane procedures (for

example, in checklists) and are part of a flightcrew training curriculum or considered basic airmanship (AC 25.1322-1).

32.2.1.6.7 The intended function of low energy protection is to assist the flightcrew in maintaining continued safe flight. If used to show compliance with § 25.1303(c)(3), low energy protection is intended to automatically intervene (e.g., automatic thrust increase) to continue safe flight.

32.2.1.6.8 Section 25.1303(c)(3) requires a timely low energy alert. A timely flightcrew alert is an alert that is presented early enough that a qualified flightcrew can respond appropriately to continue safe flight, to the extent practicable, without requiring exceptional skill, alertness or workload. In determining if a low energy alert is early (timely) enough, attention should be given to whether the design includes allowances for any time delays associated with the flightcrew's recognition time and correct accomplishment of corrective actions that may be reasonably expected in service. (ACs 25.1302-1, 25.1322-1, and 25.1523-1)

32.2.1.6.9 Section 25.1303(c)(3) requires continued safe flight, to the extent practicable. In this context, continued safe flight is defined as the capability for continued controlled flight using appropriate procedures, but without requiring exceptional flightcrew skill, alertness or workload. Appropriate procedures are those associated with continuing the landing or performing a go-around. Low energy conditions, as defined in 32.2.1.6.5, which are foreseeable should be identified and evaluated by the applicant with enough detail to demonstrate performance of the intended function. The intent of requiring continued safe flight "to the extent practicable" is meant to avoid imposing a requirement or expectation to provide complete risk avoidance or mitigation for conditions where such a requirement would not be practicable or feasible.

An example where it may not be practicable to provide complete risk avoidance or mitigation could be a condition where a design solution may be technically feasible but would correspondingly result in an adverse effect such as those identified in 32.2.1.6.10. An example where it may not be feasible could be a low energy condition (e.g., which materializes at a sufficiently low altitude or with an unreasonable rate of onset) that would require exceptional airplane, system, or flightcrew response.

32.2.1.6.10 The low energy alert is not intended to result in a design which increases reference landing speed or increase idle thrust solely for the purpose of addressing § 25.1303(c)(3).

32.2.1.6.11 A low energy alert provided in combination with low energy protection should consider the additional complexities and interactions between

the low energy alert and low energy protection. (§§ 25.1302 and 25.1523, Appendix D of Part 25, ACs 25.1302-1 and 25.1523-1)

32.2.1.6.12 The low energy alert should be available in any normal aircraft landing configuration, and for all possible combinations of manual flight and autoflight (e.g., autopilot, flight director, autothrottle and auto thrust

32.2.1.6.13 The low energy alert, and (if applicable) low energy protection, must meet its intended function under any foreseeable operating conditions in accordance with § 25.1309, including icing conditions.

32.2.1.6.14 Section 25.1303(c)(3) is applicable in any normal landing configuration. Though not required in accordance with § 25.1303(c)(3), a low energy alert and/or low energy protection may still be designed to be available for other cases (e.g., non-normal landing configuration or other flight phases).

32.2.2 Procedures: Overspeed Alerting.

The applicant should substantiate, by appropriate ground and/or flight tests, with possible production instrument error corrections, that the system operates within the boundaries established by the **§**25.1303 regulation. Understanding that other procedures may be acceptable, this could be accomplished in accordance with the following:

32.2.3 Procedures: Low Energy Alerting & Protection

The applicant should substantiate that the low energy alert, alone or in combination with low energy protection, meets the safety intent of § 25.1303(c)(3). Understanding that an acceptable evaluation may vary according to design specifics such as novelty, complexity, and degree of integration, substantiation could be accomplished in accordance with the following considerations:

32.2.3.1 AC 25.1322-1 contains guidance on how to evaluate flightcrew alerts. AC 25.1302-1 provides recommendations for the design and evaluation of controls, displays, system behavior, and system integration that are all part of human factors considerations. The material contained within AC 25.1329-1 is available to help develop evaluation of low energy protection features

32.2.3.2 Foreseeable operating and environmental conditions should be evaluated where the low energy alert, alone or in combination with low energy protection, would be expected to be triggered in normal landing configurations, including those listed in paragraphs 32.2.1.6.12 and 32.2.1.6.13. Evaluations should be defined by the applicant, and should consider operating and environmental conditions expected in service that would impact the flightcrew's ability to continue safe flight including:

- all possible combinations of manual flight and autoflight (autopilot, flight director, and auto thrust).

- where low energy protection may not be available or during potential Flight Guidance System (FGS) mode changes which may become critical (e.g., FGS disengage following deceleration below the desired approach speed as a result of FGS maintaining the defined vertical path).

32.2.3.3 The effects of false and nuisance low energy alerts should be minimized in accordance with § 25.1322(d) (AC 25.1322-1).

32.2.3.4 A structured approach for determining compliance with the intended functions for § 25.1303(c)(3) is described in paragraph 32.2.3.6. Analysis and flight test are expected to be appropriate means of compliance supporting timeliness determinations. Flight test is the most realistic testing environment, although it may be limited by the extent to which flight conditions of particular interest can be found or produced and then safely evaluated in flight. In those instances part-task evaluations or full flight simulation may be useful.

Part-Task Evaluations: These types of evaluations use devices that emulate (using flight hardware, simulated systems, or combinations) the crew interfaces for a single system or a related group of systems. Typically, these evaluations are limited by the extent to which acceptability may be affected by other flight deck tasks.

32.2.3.5 An example where the low energy alert and/or protection may be inhibited by design are at very low height above terrain, with the aircraft in take-off or go-around conditions, and during failure cases as defined by the applicant.

32.2.3.6 **Evaluation using Analysis, Simulation and/or Flight Test.**

32.2.3.6.1 A timeline analysis as described in AC 25.1523-1 along with simulation and flight test are recognized means for determining if the applicant's design is timely enough for the flightcrew to continue safe flight in response to the low energy alert. There should be adequate time for the qualified flightcrew to successfully accomplish all corrective actions as described in the alert's intended function alone or with protection (32.2.1.6.6 and 32.2.1.6.7). Successful accomplishment of corrective actions should not require exceptional flightcrew skill, alertness or workload as described in paragraph 32.2.1.6.9.

In determining adequate time for the qualified flightcrew actions, all sources of time delays should be considered. This includes delays associated with the flightcrew's recognition and identification of the alert, their corrective actions (with contribution of the protection if applicable) and the airplane's response delays including systems delays.

Whether or not a separate timeline analysis has been conducted, simulation and flight test are essential to help establish and validate if the qualified flightcrew can adequately perform all tasks resulting from the low energy alert (with contribution of the protection if applicable) and continue safe flight.

32.2.3.6.2 The applicant should describe how relevant human factors elements will be addressed (such as flightcrew response times, workload, corrective actions, and minimizing of flightcrew errors) and other assumptions that must be made about crew behavior as part of the evaluations discussed in this section. These elements should be reviewed to ensure that no assumptions are being made that will require the flightcrew to respond in a manner beyond their expected capabilities.

32.2.3.6.3 Evaluations should consider foreseeable operating and environmental conditions discussed in paragraph 32.2.3.2 including typical deceleration rates that will trigger the low energy alert. For example, representative conditions may include:

- Idle thrust, speedbrakes retracted deceleration, wings level.
- Idle thrust, speedbrakes retracted deceleration, typical max bank angle for approach.
- Idle thrust, speedbrakes deployed deceleration, wings level.
- Idle thrust, speedbrakes deployed deceleration, typical max bank angle for approach.

Other foreseeable operating and environmental conditions may need to be identified and evaluated. It may be warranted to consider increased magnitudes of some parameters (e.g., larger deceleration rate than typical such as 3 kt/sec) as a means to represent other foreseeable environmental conditions (e.g., wind gradient).

32.2.3.6.4 When conducting the evaluation for conditions identified in 32.2.3.6.3:

- Determine if the low energy alert and low energy protection, if applicable, meet their intended function(s).
- Determine if the low energy alert is presented early enough that a qualified flightcrew has time to recognize and respond completely and correctly and then continue safe flight without requiring exceptional skill, alertness or workload.
- Determine if the low energy alert meets the requirements listed in § 25.1302 that includes clear and unambiguous alerting information, and accessible alerting information consistent with the urgency and the limited duration of the flightcrew corrective actions.
- Determine appropriate integration of the low energy alert with other systems such as Reactive Windshear alerting function and escape guidance (ref AC 25-23).
- Determine proper integration of the low energy alert with other systems, including labeling.
- Determine compatibility of the low energy alert with other displays and controls, including multiple alerts.

- Refer to the additional evaluation guidance for flightcrew alerting in AC 25.1322-1, Chapter 13.

32.2.3.7.3 The low energy flightcrew alert should be evaluated to ensure that the effects of false and nuisance low energy alerts are minimized at normal approach speeds consistent with the procedures for the following nominal operating and environmental conditions by following the guidance in AC 25.1322-1 paragraphc 12 and 13. Examples of such conditions from AC 25.1329-1C include:
1. Light to moderate winds
2. Light to moderate wind gradients
3. Light to moderate gusts
4. Light to moderate turbulence
5. Typical localizer capture bank angle in calm conditions

4.11 **Landing—§ 25.125.**

(…)

4.11.2.4 Whichever method is chosen to establish airborne distances, satisfactory flight characteristics should be demonstrated in the flare maneuver when a final approach speed of V_{REF}-5 knots is maintained down to 50 feet. Flightcrew alerting in accordance with §25.1322(b) (e.g., low energy alerting as required by § 25.1303(c)(3)) may be permissible when demonstrating a final approach speed of V_{REF}-5 knots.

(…)

5.1 **General—§ 25.143.**

5.1.1 Explanation.

(…)

5.1.1.5 Modern wing designs can exhibit a significant reduction in maximum lift capability with increasing Mach number. The magnitude of this Mach number effect depends on the design characteristics of the particular wing. For wing designs with a large Mach number effect, the maximum bank angle that can be achieved while retaining an acceptable stall margin can be significantly reduced. Because the effect of Mach number can be significant, and because it can also vary greatly for different wing designs, the multiplying factors applied to VSR may be insufficient to ensure that adequate maneuvering capability exists at the minimum operating speeds. To address this issue, §25.143(h) was added by amendment 25-108 to require a minimum bank angle capability in a coordinated turn without encountering stall warning or any other characteristic (including the envelope protection features of fly-by-wire flight control systems or automatic power or thrust increases) that might interfere with normal maneuvering. The maneuvering requirements consist of

the minimum bank angle capability the FAA deems adequate for the specified regimes of flight combined with additional bank angle capability to provide a safety margin for various operational factors. These operational factors include both potential environmental conditions (e.g., turbulence, wind gusts) and an allowance for piloting imprecision (e.g., inadvertent overshoots). The FAA considers the automatic application of power or thrust by an envelope protection feature to be a feature that might interfere with normal maneuvering because it will result in a speed increase and flight path deviation, as well as potentially increasing crew workload due to the unexpected power or thrust increase. Caution and/or Advisory flightcrew alerting in accordance with §25.1322(b) (e.g., low energy alerting as required by § 25.1303(c)(3)) may be permissible while demonstrating compliance with § 25.143(h) subject to and in accordance with § 25.1322(d)(1) (amendment 131 or later version). Other systems intended to enhance flightcrew awareness, for example through appropriate automated callouts to assist or maintain situation awareness, may be permissible while demonstrating compliance with § 25.143(h).

7.3 **Static Directional and Lateral Stability—§ 25.177.**

(…)

7.3.1.4.3 Section 25.177(d) states that the criteria listed in paragraph 7.3.1.4.1 above must be met at all approved landing gear and flap positions for the range of operating speeds and power conditions appropriate to each landing gear and flap position with all engines operating. The range of operating speeds and power conditions appropriate to each landing gear and flap position with all engines operating should be consistent with the following:

(…)

4. For landing configurations, speeds from V_{REF}-5 knots to V_{FE} or V_{LE}, as appropriate, with power from idle to go-around power/thrust at speeds from V_{REF} to V_{FE}/V_{LE}, and idle power at V_{REF}-5 knots (to cover the landing flare). Flightcrew alerting in accordance with §25.1322(b) (e.g., low energy alerting as required by § 25.1303(c)(3)) may be permissible subject to and in accordance with § 25.1322(d)(1) (amendment 131 or later version).

42.4 **Criteria for Approval of Steep Approach to Landing.**

(…)

42.4.4 Test Conditions for Reasonably Expected Variations in Approach Speed and Path Angle.

The following additional criteria should be applied to show that the airplane is safely controllable and maneuverable during landing (§ 25.143(a)(5)):

(…)

42.4.4.1.2 The steepest approach path angle for which approval is sought at a speed 5 knots lower than the V_{REF} established for a steep approach.

42.4.4.2 For both conditions in paragraphs 42.4.4.1.1 and 42.4.4.1.2 above:

(…)

42.4.4.2.4 Below a height of 200 feet, no action should be taken by the pilot to increase power or thrust, apart from those small changes needed to maintain an accurate approach. This includes no flightcrew action in response to flightcrew alerting in accordance with section 25.1322(b) (e.g., low energy alerting as required by § 25.1303(c)(3)) which may be permissible during this demonstration, subject to and in accordance with § 25.1322(d)(1) (amendment 131 or later version);

42.4.4.2.7 To ensure adequate capability for a go-around or down path adjustment, the engines should remain above flight idle power or thrust when stabilized on the approach path.

Note: The 2° steeper approach path angle demonstration is to account for tailwinds on the approach and to take into account necessary corrections back to the desired approach path after inadvertent excursions. The purpose of the test at VREF minus 5 knots is to account for an unnoticed speed decrease during the approach, hence the requirement in paragraph 42.4.4.2.4 for no power or thrust increase to account for the slower speed.

QUESTON 3: AFTER REVIEWING AIRWORTHINESS, SAFETY, COST, AND OTHER RELEVANT FACTORS, INCLUDING RECENT CERTIFICATION AND FLEET EXPERIENCE, ARE THERE ANY ADDITIONAL CONSIDERATIONS THAT THE FAA SHOULD TAKE INTO ACCOUNT REGARDING AVOIDANCE OF LOW ENERGY CONDITIONS?

Yes. Additional considerations include recommendations to reduce unstable approaches, and recommendations for low airspeed/low energy alerting in all phases of flight.

3.1 Unstable Approaches

The ASHWG strongly recommends that the FAA examine other contributing factors which could result in inadvertent low energy conditions, including Unstable Approaches and associated possible mitigation strategies.

The rationale for considering Unstable Approaches is that proactive crew or system response when an unstable approach condition is recognized could mitigate or avoid the low energy condition in the first place. The issue of Unstable Approaches is multifaceted and has a strong

operational component (reference Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices, 2nd Edition, ISBN 978-92-9229-317-8, © 2016 International Air Transport Association). There is no industry standard defining an unstable approach in all cases, given different aircraft types, environmental conditions, margins, etc. - though typical considerations include airspeed, descent rate, attitude, configuration, thrust and altitude. Operators define stable approach criteria and enforce them via SOPs, training and monitoring based on safety management guidelines. Despite this, crews still display reluctance to conduct a go-around even when conditions would so dictate. This reluctance stems from multiple factors – unfamiliarity/ lack of practice/ perceived risk of the go-around maneuver, self or management pressure to land, culture, weather – that cannot necessarily be mitigated by technology. However, unstable approach monitoring and automated responses or alerting by technology enhancement could provide an objective indication to the flightcrew of the destabilized flight condition and remove some of the decision making (i.e.. continue approach vs go-around) workload, freeing more focus for corrective action.

The five basic steps to mitigate an unstable approach are (from IATA report):

- Recognize the approach is unstable
- Communicate with fellow crew members
- Take immediate action to rectify the situation
- Monitor the corrective action
- Continue corrective actions until the airplane is recovered to safe flight

The "Recognize" and "Monitor" steps are areas where technological enhancements could assist with the mitigation. Various manufacturers have already developed systems which can provide stable approach monitoring and alerting, and which could assist with precluding the low energy conditions being addressed by the ASHWG proposed new regulation. The practicality/economic feasibility to mandate stable approach monitoring/alerting functions would need to be evaluated by estimating the cost to implement such a function vs the likelihood of reaching a low energy situation due to an unstable approach, that results in an accident or incident. These functions could also potentially serve as a component of the functionality that will be required by the proposed new Low Energy alerting requirement. Additionally, where an aircraft does incorporate unstable approach alerting, consideration will need to be given to ensuring integration and consistency with the low energy alerting system to avoid confusion, misinterpretation and crew errors.

The ASHWG recommends that a follow-on task be considered which identifies guidelines to reduce the likelihood of unstable approaches. This could be through a combination of airworthiness and operational changes. Data or existing studies that show correlations between unstable approaches and flight safety would be helpful to substantiate this position.

The ASHWG agreed that the technology readily available in current Transport Category Airplane designs somewhat limits the sophistication of energy management systems. In addition, regulations and guidance have been mainly directed at airspeed based designs. Systems that include advanced, predictive energy alerting and/or energy protection are envisioned and likely will be considered in future designs. The ASHWG recommends that industry and the authorities continue to discuss and work towards the development and certification of such improved and advanced systems.

3.2 Alerting in all phases of flight

One of the questions raised during this activity was to determine whether a proposed rule should or should not be considered / expanded for other phases of flight (beyond the approach to landing phase). In the initial "Phase 1" related task, the ASHWG concluded that any new rule should consider "*relevant accidents/incidents,*" and those should be evaluated with all of the relevant facts and data relating to the contribution of that accident/incident.

While 25.1329 (h) addresses low airspeed alerting and protections for autoflight equipped aircraft, a report by NASA * is helpful in providing the "*relevant accident/incident*" information to substantiate the need for low airspeed/energy alerting in other phases of flight (e.g. for applicability in manual flight).

* *The Role of Alerting System Failures in Loss of Control Accidents CAST SE-210 Output 2 Report 3 of 6 Randall J. Mumaw San Jose State University Foundation Loran A. Haworth San Jose State University Foundation Michael S. Feary NASA Ames Research Center, March 2019.*

3.3 Review of Other Airworthiness Considerations

The ASHWG conducted a review of current regulations, as well as review of related Advisory Circulars that may be either directly or indirectly related to low energy alerting, applicable to Part 25 aircraft. The notable regulations reviewed included:

- 25.771(a)(c)
- 25.777(a)(c)
- 25.1301(a)(1)
- 25.1302(a)(b)(c)(d)
- 25.1309(a)(1)(c)
- 25.1321(a)(b)(c)
- 25.1322
- 25.1329
- 25.1523(a)(b)(c) and Appendix D
- 25.1545
- 25.1583

PS-ANM-25-16 was also reviewed, as well as AC 25-11B for low airspeed awareness. No conflicts between the reviewed rules/AC and the proposed rule/AC were noted.

During the working group assessment, the working group noted that the existing 25.1303 and AC 25-7D frequently use the term 'warning device.' As referenced in AC 25.1322.4.b future updates to AC 25-7D should consider the term 'alerting' in place of 'warning device.'

- Section 25.1322-requirements and advisory material provide references to an alert, such as a warning, caution or advisory to provide awareness of a non-normal condition that is relevant to the applied rule. Many early FAA rules were written

without recognition of a consistent flight deck alerting philosophy and the three alerting levels and may use the term "warning" in a generic sense to indicate any alerting level. The proposed update to AC 25-7D contained within this report does not intend to conflict with or replace the intent of those rules. If there is a conflict with a rule, the rule takes precedence over the guidance material provided in the proposed update to AC 25-7D. The intent is to standardize flightcrew-alerting terminology used in affected rules and guidance material and provide a means for applicants to show compliance with those rules.

- Section 25.1303 and AC 25-7D should be updated to include the correct title for §25.1322 and also reference the requirements of §25.1322 and guidance in AC 25.1322-1. AC 25-7D should also include references to the latest AC 25-1322.

During the working group assessment, the working group noted that the existing FAA requirements (human factor requirements) 25.1302, 25.1322, 25.1523 and their ACs along with Appendix D of Part 25 were not included in AC 25-7D. These new references, which are now included in the proposed AC changes contained in this report, should be further integrated in other applicable paragraphs of the AC 25-7 in future AC 25-7 revisions.

- Section 25.1302 requirements and advisory material provides new references requiring that an applicant must show that flightcrew alerting systems, individually and in combination with other such systems and equipment, are designed so that qualified flightcrew members trained in their use can safely perform all of the corrective actions associated with the system's intended functions for continued safe flight. In addition it provides requirements on flight deck controls, flight deck information, flightcrew awareness, ability to intervene and flightcrew error management.

- Section 25.1523 and Part 25 Appendix D requirements and advisory material provides new references to flightcrew workload not included in AC 25-7D. These requirements help to ensure that the flightcrew can be expected to complete their allocated tasks successfully in both normal and non-normal operational conditions, within the bounds of acceptable workload and without requiring undue concentration, exceptional skill or strength, or causing undue fatigue. Also to ensure that performance of correction actions is not adversely impacted and the flightcrew's detection and interpretation of information does not lead to unacceptable response times. Special attention should be paid to part 25 Appendix D and, specifically, compliance for items that the appendix lists as (b), workload factors. These include "accessibility, ease, and simplicity of operation of all necessary flight, power, and equipment controls."

3.4 Cost/Benefit Analysis

The ASHWG's position is (for new airplane designs only) that the estimated cost to develop, integrate, test, evaluate, and certify a context-specific low energy alert be assessed in a detailed cost benefit analysis.

QUESTION 4: IS COORDINATION NECESSARY WITH OTHER HARMONIZATION WORKING GROUPS (E.G., HUMAN FACTORS, FLIGHT TEST)? IF YES, COORDINATE WITH THAT WORKING GROUP AND REPORT ON THAT COORDINATION.

The ASHWG consists of individuals from both industry and regulatory background. Disciplines represented include general systems engineering, certification, flight test, and human factors. In addition, members from the Flight Test Harmonization Working Group (FTHWG) are also members of the ASHWG. Coordination from the FTHWG included reviews of relevant reports used in the making of this ASHWG report, along with a review of the ASHWG draft report prior to release.

The ASHWG acknowledges overlap in the proposed 25.1303(c)(3) requirement compared to the recent FTHWG Phase 2 recommendation for a new 25.176(c) to require low energy alerting in the absence of conventional speed stability. It should be noted that the FTHWG recommendation addresses the entire flight envelope only for aircraft that do not meet conventional speed stability requirements whereas the ASHWG recommendation is isolated to the approach to landing at low altitude and is applicable for all types of aircraft. Therefore, the ASHWG recommendation does not replace the FTHWG recommendation.

The ASHWG recommends that the FTHWG should review and revise, as necessary, their recommended 25.176(c) requirements after consideration of the ASHWG proposal for a new 25.1303(c)(3).

There is a pending ARAC recommendation established by the FTHWG 25.144 Envelope Protection Functions—General – which should be considered in future application of the proposed recommendations by the ASHWG contained within this report. For a copy of the FTHWG recommendation please refer to the FTHWG Phase 2 Final Recommendation Report – Rev A, located at the following link.

https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/09%20-%20FTHWG_Final_Report_Phase_2_RevA__Apr_2017.pdf

The ASHWG recommends that a review by non-U.S. regulatory agencies (specifically EASA and ANAC) be conducted, with feedback provided and dispositioned by the ASHWG before the report is released to the rulemaking process. EASA and ANAC were not participants in the drafting of this report.