DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issue Area—Phase 2 of Low Speed Alerting Task

AGENCY: Federal Aviation Administration (FAA), DOT. **ACTION:** Notice of new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: The FAA assigned the Aviation Rulemaking Advisory Committee (ARAC) a new task to identify and develop recommendations on additional requirements for low speed alerting. Phase 1 of the task addresses new standards for transport category airplanes. Phase 2 of the task addresses possible retrofit standards for existing transport category airplanes. This notice is to inform the public that the ARAC working group has completed activity for Phase 1 of the task and will begin activity for Phase 2.

FOR FURTHER INFORMATION CONTACT: Joe Jacobsen, Airplane & Flight Crew Interface Branch, ANM–111, Transport Airplane Directorate, Federal Aviation Administration, 1601 Lind Ave, SW., Renton, Washington 98057; telephone (425) 227–2011, facsimile (425) 227– 1149; e-mail *joe.jacobsen@faa.gov.*

SUPPLEMENTARY INFORMATION:

Background

The FAA established ARAC to provide advice and recommendations to the FAA Administrator on the FAA's rulemaking activities with respect to aviation-related issues. With respect to low speed alerting, the FAA previously revised regulations in the area of flight guidance (autopilot) and performance and handling qualities in icing conditions to improve transport airplane standards for low speed protection (in the case of icing, stall warning standards were enhanced). However, as a result of several recent loss-of-control accidents and incidents, the FAA has identified a need for additional low speed safeguards, in addition to the regulatory actions that have already been taken. The committee addressed the Phase 1 task—new part 25 standards under the existing Avionics System Harmonization Working Group within the Transport Airplane and Engine Issues Group. (The FAA published a notice of Phase 1 task assignment in the Federal Register (75 FR 16902) on April 2, 2010.) The committee will also address the Phase 2 task-parts 25/121/ 129 retrofit standards under the existing

Avionics Systems Harmonization Working Group within the Transport Airplane and Engine Issues Group.

The Task

ARAC was initially tasked with providing information that will be used to develop standards and guidance material for low speed alerting systems. This information may result in standards that complement existing stall warning requirements. The working group provided a report that addressed several low speed alerting technical questions, relative to new aircraft designs (Phase 1 task—new part 25 standards), and provided the rationale for their responses.

Since the Phase 1 task is complete, ARAC is now tasked with providing information that will be used to develop possible retrofit standards and guidance material for low speed alerting systems. This information may result in standards that complement existing stall warning requirements. The working group will also be expected to provide a report that addresses the following low speed alerting technical questions, relative to existing aircraft designs (Phase 2 task-part 25/121/129 retrofit standards), and provide the rationale for their responses. If the recommendation for retrofit is the same as for new designs, the working group should state the rationale and not repeat the information previously reported. If there is disagreement within the working group, those items should be documented, including the rationale from each party and the reasons for the disagreement.

• How timely is the airplane in alerting the crew of flight below the intended operating speed?

• How timely relative to stall warning?

• Is alerting instantly recognizable, clear, and unambiguous to the flightcrew?

• How are nuisance alerts minimized?

• Does the alerting operate under all operating conditions, configurations, and phases of flight, including icing conditions?

• Does the alerting operate during manual and autoflight?

• After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

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

 If improvements are needed for low speed alerting in the existing fleet, should the FAA adopt a design approval holder (part 26) requirement to mandate development of design changes, or would an operational rule be sufficient? In responding, the working group should address the factors set forth in "FAA Policy Statement: Safety—A Shared Responsibility—New Direction for Addressing Airworthiness Issues for Transport Airplanes" (70 FR 40166, July 12, 2005). The ARAC working group should provide information that could lead to standards for low speed alerting that can be satisfied with practical design approaches.

Schedule

The required completion date for Phase 2 of the task is 15 months after the FAA publishes this notice in the **Federal Register**.

ARAC Acceptance of Task

ARAC accepted the task and assigned it to the existing Avionics Systems Harmonization Working Group in the Transport Airplane and Engine Issue Area. The working group serves as support to ARAC and assists in the analysis of assigned tasks. ARAC must review and approve the working group's recommendations. If ARAC accepts the working group's recommendations, it will forward them to the FAA.

Working Group Activity

The Avionics Systems Harmonization Working Group must comply with the procedures adopted by ARAC. As part of the procedures, the working group must:

1. Prepare a work plan on how to complete the task, including the rationale for this plan. Present the plan for consideration to the Transport Airplane and Engine Issues Group following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations prior to proceeding with the work stated in item 3 below.

3. Draft the appropriate documents and required analyses and/or any other related materials or documents.

4. Provide a status report at each meeting of the ARAC held to consider Transport Airplane and Engine Issues.

Participation in the Working Group

The Avionics Systems Harmonization Working Group is composed of technical experts having an interest in the assigned task. We recommend the existing working group be expanded to include individuals involved in current fleet operations so there is appropriate representation for the Phase 2 task. A working group member need not be a representative or a member of the full committee.

If you have expertise in the subject matter and wish to become a member of the working group, write to the person listed under the caption FOR FURTHER **INFORMATION CONTACT** expressing that desire. Describe your interest in the task and state the expertise you would bring to the working group. We must receive all requests by March 17, 2011 for the meeting scheduled to start from March 15 to 17, 2011, located at the Cessna Conference Center, 6711 West 31st Street South, Wichita, Kansas 67215. The assistant chair, the assistant executive director, and the working group co-chairs will review the requests and advise you whether or not your request is approved.

If you are chosen for membership on the working group, you must represent your aviation community segment and actively participate in the working group by attending all meetings and providing written comments when requested to do so. You must devote the resources necessary to support the working group in meeting any assigned deadlines. You must keep your management chain and those you may represent advised of working group activities and decisions to ensure that the proposed technical solutions do not conflict with your sponsoring organization's position when the subject being negotiated is presented to ARAC for approval. Once the working group has begun deliberations, members will not be added or substituted without the approval of the assistant chair, the assistant executive director, and the working group co-chairs.

The Secretary of Transportation determined that the formation and use of the ARAC is necessary and in the public interest in connection with the performance of duties imposed on the FAA by law. Meetings of the ARAC are open to the public. Meetings of the Avionics Systems Harmonization Working Group will not be open to the public, except to the extent individuals with an interest and expertise are selected to participate. The FAA will make no public announcement of working group meetings.

Issued in Washington, DC, on February 28, 2011.

Pamela Hamilton-Powell,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 2011–4761 Filed 3–2–11; 8:45 am] BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[Docket No. FAA-2011-0146]

Notice of Intent To Review Structure of the Aviation Rulemaking Advisory Committee

AGENCY: Federal Aviation Administration (FAA), DOT. **ACTION:** Notice and request for public comment.

SUMMARY: The FAA is considering restructuring the Aviation Rulemaking Advisory Committee (ARAC). This notice is to inform the public of FAA's intent and invites the public to provide any ideas or thoughts it may have on this matter.

DATES: Send your comments on or before April 4, 2011.

ADDRESSES: You may send comments identified by Docket Number FAA–2011–0146 using any of the following methods:

• *Government-wide rulemaking Web site:* Go to *http://www.regulations.gov* and follow the instructions for sending your comments electronically.

• *Mail:* Send comments to the Docket Management Facility; U.S. Department of Transportation, 1200 New Jersey Avenue, SE., West Building Ground Floor, Room W12–140, Washington, DC 20590.

• *Fax:* Fax comments to the Docket Management Facility at 202–493–2251.

• *Hand Delivery:* Bring comments to the Docket Management Facility in Room W12–140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

Privacy: We will post all comments we receive, without change, to *http:// www.regulations.gov*, including any personal information you provide. Using the search function of our docket Web site, anyone can find and read the comments received into any of our dockets, including the name of the individual sending the comment (or signing the comment for an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (65 FR 19477–78).

Docket: To read background documents or comments received, go to http://www.regulations.gov at any time or to the Docket Management Facility in Room W12–140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. SUPPLEMENTARY INFORMATION:

Background

The Aviation Rulemaking Advisory Committee (ARAC) was established in February 1991 to provide FAA's Administrator with industry and public input in the form of information, advice, and recommendations to be considered in the full range of FAA rulemaking activities. These factors are consistent with the dictates of the Administrative Procedures Act (APA). The exchange of ideas that occurs through the ARAC process affords the FAA additional opportunities to obtain firsthand information and insight from those parties who are most affected by existing and proposed regulations.

ARAC consists of approximately 55 member organizations selected by the FAA as most representative of the various viewpoints of those impacted by FAA regulations. The organizations provide a membership fairly balanced in terms of points of view of those represented and the functions to be performed by the committee. The committee is composed of organizations representing air carriers, airports, flight attendants, manufacturers, pilots, public interest and advocacy groups, repair stations, and consumer groups. Members serve in a representative capacity. In addition, an Executive Committee (ExCom) was formed to provide overall administrative oversight for committee activities. The ExCom consists of the ARAC Chair and Vice Chair, who serve as chairperson and vice chairperson, respectively for ExCom; assistant chairpersons representing aeronautical technical subject areas (presently, air carrier operations, maintenance, occupant safety, general aviation certification and operations, noise, aircraft certification, airport certification, transport airplane and engine, rotorcraft, and training and qualifications) with active projects only in transport airplane and engine, and air carrier operations.

The goal of ARAC is to assemble the strongest expertise possible to address particular issues facing the aviation industry and traveling public. The committee conducts its business in open deliberations in the form of public meetings (working groups are exempted). As an advisory body, ARAC has consistently exercised its independence and freedom to provide the FAA recommendations that are not influenced or predetermined by the government. Since 1998, ARAC has submitted more than 110 documented recommendations or products to the March 11, 2013

Federal Aviation Administration 800 Independence Avenue, SW Washington, D.C. 20591

Attention:	Lirio Liu, Director, Office of Rulemaking
Subject:	ARAC Recommendation, Avionics System Harmonization Working Group (ASHWG)
Reference:	Tasking Notice 77 FR 11844 (March 3, 2011)

Dear Lirio,

On behalf of the Aviation Rulemaking Advisory Committee, I am pleased to submit the attached report and presentations as an ARAC recommendation. This report addresses the Phase 2 – Low Airspeed Alerting (Retrofit Applications) and presents the following key findings and recommendations:

- (1) A detailed examination of low airspeed/low energy events (accidents and incidents over a 20 year period), including all contributing factors, not just the lack of a low airspeed alert.
- (2) Examination of operational and safety data to help determine whether a low airspeed alert would have operational benefit.
- (3) Sufficient quantification of the effectiveness of a low airspeed alert (future JSIT report pending).
- (4) A cost-benefit analysis to determine how the system can be "practically" implemented for existing aircraft.

The ASHWG formally requests that when this data is gathered, the FAA task the ARAC to reconvene and review that data for further recommendations.

If a low airspeed alert is required in the future, the ASHWG recommends that the information from this report be used to develop the rules and associated guidance. There must be an integrated approach that incorporates design changes with flight crew procedures and pilot training. There may be multiple mitigations to improve low airspeed awareness.

To facilitate FAA/EASA harmonization and implementation, any associated rulemaking should be reviewed by the ASHWG to ensure that it is aligned with the findings in this report.

The ARAC approved the report for transmittal to the FAA during its March 5th, 2013 meeting. I want to thank all the members of the RPWG for their hard work on both phases of this report.

Sincerely,

Dan Elwell ARAC Chairman

Copy: Renee Butner – FAA Office of Rulemaking ARAC members Loran Haworth – FAA Representative Joe Jacobsen – FAA, Transport Airplane Directorate

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1 Background

At the agency's request, the Aviation Rulemaking and Advisory Committee (ARAC) provide advice and recommendations to the Federal Aviation Administration (FAA) on aviation-related rulemaking activities.

As a result of several loss-of-control accidents and incidents, the FAA and EASA identified a need for additional low airspeed safeguards, therefore, the agencies issued Amendment 14 CFR Part 25-121, issued Oct 9, 2007 and CS 25 Amendment 3, effective Sept 19, 2007, *Performance and Handling Qualities in Icing Conditions* to address handling and low speed protection requirements in icing conditions. In addition:

- (1) In June 2007 the FAA revised Advisory Circular AC 25-11A and EASA introduced CS-25 amendment 11, AMC 25-11, which includes guidance for low airspeed *awareness*.
- (2) In November 2010 the FAA revised 14 CFR § 25.1322 and EASA issued CS-25 amendment 11 for flightcrew *alerting*.
- (3) Information from AC 25.1329-1B (and the associated AMC) provides information which may be helpful in determining how to address low airspeed conditions. These were released in 2006.

To augment the regulatory actions taken, the Transport Airplane and Engine Issues Group (TAEIG) assigned the Avionics Systems Harmonization Working Group (ASHWG) to provide information for developing standards and guidance on low airspeed alerting systems (LAS), which could complement existing stall warning requirements. The ASHWG activity was broken into two tasks.

1.1 The First Task

The ASHWG addressed the following ten (10) technical questions relative to new aircraft designs in its first report provided to the ARAC and FAA in April 2011:

- (1) How much time is needed to alert the crew in order to avoid stall warning or excessive deviation below the intended operating speed?
- (2) What would make the alerting instantly recognizable, clear, and unambiguous to the flight crew?
- (3) How could nuisance alerts be minimized?
- (4) Could the alerting operate under all operating conditions, configurations, and phases of flight, including icing conditions?
- (5) Could the alerting operate during manual and auto flight?
- (6) Could the system reliability be made consistent with existing regulations and guidance for stall warning systems?
- (7) Are there any regulations or guidance material that might conflict with new standards?
- (8) What recommended guidance material is needed?
- (9) After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?
- (10) Is coordination necessary with other harmonization working groups (e.g., Human Factors, Flight Test)? (If yes, coordinate and report on that coordination.)

1.2 The Second Task

This report provides answers to the following low speed alerting technical questions relative to *existing* aircraft designs), including a recommendation as to whether retrofit requirements should be the same as new designs.

- (1) How timely is the airplane in alerting the crew of flight below the intended operating speed?
- (2) How timely relative to stall warning?
- (3) Is alerting instantly recognizable, clear, and unambiguous to the flightcrew?
- (4) How are nuisance alerts minimized?
- (5) Does the alerting operate under all operating conditions, configurations, and phases of flight, including icing conditions?
- (6) Does the alerting operate during manual and autoflight?
- (7) After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?
- (8) Is coordination necessary with other harmonization working groups (e.g., Human Factors, Flight Test)? (If yes, coordinate and report on that coordination.)
- (9) If improvements are needed for low speed alerting in the existing fleet, should the FAA and EASA adopt a design approval holder (part 26) requirement to mandate development of design changes, or would an operational rule be sufficient?

Note that the terms "low airspeed" and "low energy" are both used in this report. A low airspeed alert is intended to provide awareness to the flight crew that the aircraft's airspeed is reaching a point where the energy level of the aircraft is being compromised.

1.3 Definitions, Acronyms, and Abbreviations

The following are key definitions for this report:

- Alphafloor The point automated low energy protection will engage.
- Low Airspeed Alert Provides visual, aural or tactile awareness that the aircraft's airspeed is reaching a point where the decrease exceeds a pre-determined threshold.
- Low Energy Alert Provides awareness that the Angle of Attack exceeds a pre-determined low energy threshold.

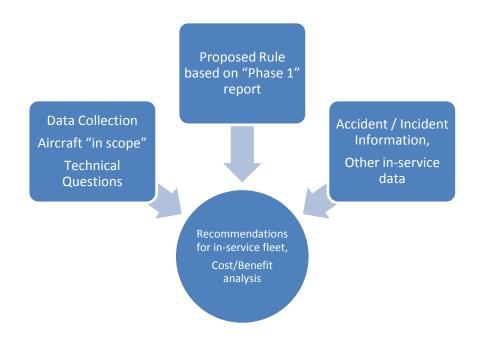
The following are acronyms and abbreviations used in this report:

- AC/AMC Advisory Circular/Acceptable Means of Compliance
- AoA Angle of Attack
- ARAC Aviation Rulemaking Advisory Committee
- ASHWG Avionics Systems Harmonization Working Group
- EASA European Aviation Safety Agency
- EICAS Engine Instrument and Crew Alerting System
- FAA Federal Aviation Administration

- FBW Fly-by-Wire
- JSIT Joint Safety Implementation Team
- LAS Low Airspeed Alerting System
- PFD Primary Flight Display
- TAEIG Transport Airplane and Engine Issues Group
- TAWS Terrain Awareness and Warning System

2 Process Followed

In order to perform this task, the ASHWG prepared a work plan, and presented a summary of that plan to the TAEIG.



Following approval of the work plan, information was collected from aircraft manufacturers to identify existing designs' capability to provide low airspeed awareness and alert functionality.

The ASHWG were provided with a review of relevant accident information to understand whether a low airspeed alerting function could have played a role in reducing loss of control. Specifically, a briefing was provided of a summary of six events occurring from 1999 – 2009, where failure to maintain proper airspeed resulted in a loss of control.

Three key factors were discussed in creating the findings for this report:

- (1) Distractions in the flight deck.
- (2) The effectiveness of the alerting in aircraft; and
- (3) Lack of flight crew system knowledge resulting from current training.

As a result of this data collection and group discussion, the ASHWG were able to generate this report.

3 Scope

Aircraft certificated under 14CFR/CS 25 and operated under 14CFR/CS 121, 129 and 135 (and the international equivalent) manufactured in the Americas and Europe. Representing the global air transport fleet of approximately 24,000; approximately 85% of the total current air transport fleet of 28,000.

All of the aircraft in this analysis were certificated prior the update 14CFR/CS 25.1322, 25.1329, and their associated advisory material. The flight deck capability of the aircraft was categorized into major groups:

- (1) Representing 21% of the fleet studied, aircraft with no low airspeed alert before stick shaker, no PFD (i.e., glass display), and minimal alerting (i.e., no crew alerting "system" or EICAS.
- (2) Aircraft with no low airspeed alert before stick shaker, but with PFD and centralized alert capability (but no low airspeed alert); approximately 15% of aircraft studied.
- (3) Aircraft with PFD and visual low airspeed alert; approximately 10% of the aircraft studied.
- (4) Aircraft with PFD and both visual and aural low airspeed alert. Boeing and Airbus aircraft representing approximately 45% of the fleet.

NOTE: Approximately 8-9 % of the 24,000 aircraft covered by this report did not have manufacturer data available, so are excluded from the analysis.

Appendix A and B provide the survey used to help generate this information and the survey results.

4 Key Findings and Recommendations

Imposing a rule on existing aircraft to incorporate a <u>practical</u> method for implementing low airspeed alerts can only be substantiated by:

- (1) A detailed examination of low airspeed/low energy events (accidents and incidents over a 20 year period), including all contributing factors, not just the lack of a low airspeed alert.
- (2) Examination of operational and safety data to help determine whether a low airspeed alert would have operational benefit.
- (3) Sufficient quantification of the effectiveness of a low airspeed alert (future JSIT report pending).
- (4) A cost-benefit analysis to determine how the system can be "practically" implemented for existing aircraft.

The ASHWG formally requests that when this data is gathered, the FAA task the ARAC to reconvene and review that data for further recommendations.

If a low airspeed alert is required in the future, the ASHWG recommends that the information from this report be used to develop the rules and associated guidance. There must be an integrated approach that incorporates design changes with flight crew procedures and pilot training. There may be multiple mitigations to improve low airspeed awareness.

To facilitate FAA/EASA harmonization and implementation, any associated rulemaking should be reviewed by the ASHWG to ensure that it is aligned with the findings in this report.

5 Technical Questions

The answers to technical questions 5.1 through 5.6 are limited to aircraft designs that incorporate a low airspeed alert system; i.e., approximately 45% of the in-service aircraft.

The terms "low airspeed" and "low energy" are used in this report; both are intended to provide awareness that airspeed is reaching a point where the aircraft may be compromised.

- (1) Example of Low Airspeed Alert: The alert is primarily a function of airspeed, configuration and minimum maneuver speed. It is set when the airspeed decreases 30 percent into the lower amber band. It is reset when airspeed increases above the amber band.
- (2) Example of Low Energy Alert: The alert is a function of configuration, deceleration rate and flight path angle; it is presented when the AoA exceeds an alpha low energy threshold; The AoA corresponds to when it is impossible to recover a long term positive flight path by only increasing lift. The crew's attention is drawn to the speed scale and indicates the need to adjust thrust.

5.1 How timely is the airplane in alerting the crew of flight below the intended operating speed?

The aircraft alerts the crew to airspeed that may result in negative operational situations. Manufacturers provide different protections based upon other alerting capabilities. Both design approval holders that have low airspeed alerting systems complied with the standard established by the authorities.

Existing designs with low airspeed alerting systems are dependent on stall warning information or to other implemented protections.

The designs are not intended to alert for a deviation <u>from</u> the intended operating speed. Rather there are alerts that a stall warning is approaching or of a low energy situation. Both systems are timely in that they indicate a potentially adverse airspeed situation.

5.2 How timely relative to stall warning (alphafloor)?

Design approval holders ensured no spurious activation of the alert occurred over a variety of flight conditions and airplane configurations. Evaluations were also performed to ensure that the alert reset properly. These testing and analyses established compliance with the standards established by the authorities.

The alert was tested in wings level and in turn at different slat/flap configurations, different acceleration rates, and with & without airbrakes. Operational scenarios (for example approach, cruise, and climb) were evaluated to validate minimal nuisance alerts and subjectively validate acceptable alerting prior to stick shaker. One of the worst-case scenarios for evaluating nuisance alerting was during go-around, with one engine inoperative.

The setting of the low energy alert aims at providing enough time to the pilot to manually recover an adequate level of energy through thrust adjustment, before engagement of any protection mechanism if applicable, for low deceleration rates. The approach cases were considered the most significant, so a one second response time was considered to evaluate the effectiveness of a timely thrust increase before stick shaker was activated.

For nominal deceleration rates (1-2 kts per second), the low airspeed alert is intended to provide the pilot sufficient time to increase thrust and minimize the possibility of decelerating to stick shaker activation.

5.3 Is alerting instantly recognizable, clear, and unambiguous to the flightcrew?

The low airspeed alert systems which provide two senses of attention-getting characteristics are considered to be instantly recognizable by the FAA/EASA, however exceptions have been previously approved (for example, an aural "SPEED SPEED SPEED" voice with a visual indication on the display, coincident with an amber/red band directly on the speed tape, with no written messages. In each case the specific content of the alert makes it clear and unambiguous.

Alerts which provide a visual only sense may not be instantly recognizable under all operating conditions; these represent a small subset of the population.

5.4 How are nuisance alerts minimized?

Existing designs input filtering and large margins from normal operating speeds as techniques to minimize nuisance alerts. Some designs filter airspeed inputs while other designs filter Angle of Attack (AoA). Designs also reduce the likelihood where there are large and sudden fluctuations in airspeed or AoA (e.g., in turbulence).

Nuisance alerts have also been minimized by other conditions such as a fixed number excursion below a pre-determined low airspeed value or accounting for failure of a suitable speed protection mechanism (e.g. autopilot/autothrottle).

A reset of the low airspeed alert (from on to off) typically occurs after the aircraft has recovered to a point when the actual airspeed rises by a fixed value (e.g. 5 kts) above the top of the amber low speed band.

5.5 Does the alerting operate under all operating conditions, configurations, and phases of flight, including icing conditions?

Low airspeed alerting operates in most (but not all) operating conditions; there are phases of flight where low airspeed alerting may not be warranted; for example, during take-off, prior to flap retraction, or above 2500 feet. While the alert is helpful in approach and landing conditions when low energy situation is more likely to occur; there may be other protections from airspeed deviations for take-off, climb, in cruise and en-route. There are also certain abnormal system conditions (e.g., air data failure, alpha data failure) where the alert will be inoperative. The designs include operations during icing conditions.

With respect to configuration, in certain FBW aircraft load factor is used in setting the alert parameter, whereas all alert systems account for the effects of normal weight and center of gravity variations.

5.6 Does the alerting operate during manual and autoflight?

Yes.

5.7 After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

- (1) Aircraft with a history of low airspeed awareness issues be clearly identified.
 - (a) Any relevant accident/incident information and the specific reasons why low airspeed contributed to those events.
 - (b) Detailed information on the effectiveness of any installed low airspeed alert must be clearly identified.
 - (c) Precursor information from operational databases by aircraft type for low airspeed conditions that did not result in a reportable incident/accident. from:
 - Line Operations Safety Audit (LOSA)
 - Flight Operations Quality Assurance (FOQA)
 - Aviation Safety Action Program (ASAP)
 - Aviation Safety Reporting System (ASRS)
- (2) A comprehensive solution to address the need for low-airspeed alerting in existing fleets should be considered, based on the recommendations contained within section 5.10 of this report.

The range of necessary changes to implement low airspeed alert system is variable; the cost and benefit are also variable. This report provides representative examples of a potential integrated and functional solution. One or more technical solutions may be the most practical to incorporate in existing aircraft types. Several example "functional solutions" are described in Appendix C.

Any change will require updated flight crew procedures and pilot training to ensure proper management of the aircraft energy state when presented with a low airspeed alert.

(3) If a low airspeed alert system retrofit is mandated, a cost-benefit analysis must be performed to establish whether the implementation would be economically feasible.

The analysis must be done on a certification-basis. Aircraft variability is vital to understanding the feasibility of implementing the alert system vs. its expected effectiveness. Focus on those aircraft with known concerns of low-airspeed control, as opposed to a broad analysis, to support a specific aircraft safety finding. Expected longevity of the aircraft type being analyzed must be taken into account. For example, there may be plans to make a specific aircraft type obsolete (retire) as a result of future airspace requirements.

- (a) Costs should consider:
 - The proposed rule and advisory information for existing aircraft
 - The proposed technical solution
 - An estimate to develop and certificate the proposed technical solution (non-recurring per aircraft type)

- An estimate to retrofit the proposed technical solution (recurring per aircraft type)
- Operational manual changes
- Training
- (b) Benefits should consider the following:
 - Current accident/incident rate by aircraft type that would be prevented by implementation of a low airspeed alert
 - Average cost per accident/incident

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

Yes, coordination with other harmonization working groups has already occurred.

An advisory circular developed by the FAA-Industry Stall/Stickpusher Working Group in 2010 was published by the FAA in August 2012 (reference: AC 120-109, Stall and Stick Pusher Training) and provided training procedures for stall and stick pusher recovery. The preventions in this AC should be updated to include low airspeed alerting awareness and recovery procedures.

An aviation rulemaking committee (208ARC) addressing stall and loss of control avoidance and recovery training used the information from this AC and additional inputs from industry on Loss of Control to address the pilot training aspects in their final report submitted to the FAA in December 2012. AFS-210 should be made aware of the contents of our report to ensure that low airspeed alerting awareness and recovery procedures are included in the subsequent Upset Recovery and Loss of Control NPRM that should be published for comment in late Spring, 2013.

Coordination is required with the Airplane State Awareness Joint Safety Implementation Team (JSIT), who will be generating a cost-benefit analysis. Reports from JSIT will provide the detailed data required to substantiate the effectiveness of low-airspeed alerting into existing aircraft. The report is to provide other means of mitigation that could help reduce loss of control, for those aircraft which were examined (those with specifically known loss of control accidents/incidents).

5.9 If improvements are needed for low speed alerting in the existing fleet, should the FAA/EASA adopt a design approval holder (part 26) requirement to mandate development of design changes, or would an operational rule be sufficient?

A Part 26 requirement is not necessary. If a broad requirement is deemed necessary an operational rule (e.g., part 121) would be sufficient. The operational rule would have to be specific to low airspeed alerting, regardless of the existing aircraft systems on board, and would be based on the information provided in this report.

5.10 In responding, the working group should address the factors set forth in "FAA Policy Statement: Safety—A Shared Responsibility—New Direction for Addressing Airworthiness Issues for Transport Airplanes" (70 FR 40166, July 12, 2005). The

ARAC working group should provide information that could lead to standards for low speed alerting that can be satisfied with practical design approaches.

If the FAA can justify that a rule is deemed necessary, the ASHWG recommends rulemaking and guidance that existing fleets may be able to utilize based on the information already contained within AC 25.1329-1B and AC 25.1322-1. This does not directly reference AC 25.1329-1B (and EASA Amendment CS-25/4) but instead incorporates the appropriate wording from this AC. AC 25.1329-1B was written for flight guidance systems for forward fit applications.

The following material from the referenced guidance information may be helpful in understanding the aspects of existing material relevant to low airspeed alerting:

Low Airspeed Alerting should be developed in accordance with AC 25.1322-1. A low airspeed alert should be considered as a caution level alert which precedes a warning condition (such as a stall warning), to provide immediate flight crew awareness and subsequent flight crew response.

Caution alerts should be developed in accordance with AC/AMC 25.1322-1, Paragraph 6.d:

d. Caution Alerts.

(1) The alert elements used for caution are typically identical to those used for warnings, as both require immediate flightcrew awareness.

(2) Some caution alerts are related to conditions that are precursors to potential time-critical warning conditions. In these cases, the alerting system elements associated with the caution should be consistent with the elements for related time-critical warnings (described in paragraph 6b of this AC). For example, reactive windshear warnings, ground-proximity warnings, and caution alerts can develop into time-critical warning alerts.

Two senses for attention getting should be provided. The low airspeed alert should be sufficiently specific to direct the attention of the flight crew as to the energy state of the airplane.

Under conditions where multiple alerts are occurring, or during certain failure conditions, the flight crew's workload may be significantly challenged, and any one specific alert may be missed.

Certain failure conditions may reduce the confidence of the flight crew to believe that one or more alerts are valid. For example, if the airspeed information presented to the flight crew were unreliable, the crew may not believe that the logic to set the low airspeed alert is working correctly.

Note that these considerations are not necessarily specific to low airspeed alerting - that is, alerts from legacy aircraft designs which are not in compliance with the recently updated 14 CFR/CS §25.1322, and specifically those where a suitable attention-getting means is necessary, may exhibit similar behaviors.

It is also important to note that none of the aircraft for which low airspeed "incidents" were evaluated by the JSAT had a low airspeed alerting function which would be in compliance. Prioritization of low airspeed alerts should be developed in accordance with AC/AMC 25.1322-1, paragraph 8.a:

a. Rules and General Guidelines.

(1) All flight deck alerts must be prioritized into warning, caution, and advisory categories (§ 25.1322(b)).

(2) To meet their intended function(s), alerts must be prioritized based upon urgency of flightcrew awareness and urgency of flightcrew response (§ 25.1301(a)). Normally, this means time-critical warnings are first, other warnings are second, cautions are third, and advisories are last (§ 25.1322(b)).

(3) Depending on the phase of flight, there may be a need to re-categorize certain alerts from a lower urgency level to a higher urgency level. Furthermore, prioritization within alert categories may be necessary. For example, when near threatening terrain, time-critical aural warnings must be prioritized before other warnings within the warning-alert category

(25.1322(c)(1)). AC 25-23, Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System (TAWS) for Part 25 Airplanes, also identifies situations where prioritization within alert categories is necessary.

(4) The prioritization scheme within each alert category, as well as the rationale, should be documented and evaluated, by following the guidance in paragraph 13, *Showing Compliance for Approval of a Flightcrew-Alerting System*, of this AC.

(5) Documentation should include the results of analyses and tests that show that any delayed or inhibited alerts do not adversely impact safety.

The intended function of the low airspeed alert should be documented, and the alert design should be incorporated according to its intended function.

A low airspeed alert may still be needed for systems that provide a speed protection function. Factors which should be considered include the reliability of the speed protection, the availability of the speed protection function in other than normal flight control laws and in particular flight phases, and speed protection failure conditions where a low airspeed alert may still be needed. Alternatively, aircraft fitted with a high incidence protection system that can demonstrate the loss of AOA protection is improbable (remote) may constitute an Equivalent Level of Safety (Ref 14 CFR §25.1309(b)(2); CS 25.1309(b)(3)).

Standard stall warning and high-speed alerts are not always timely enough for the flight crew to intervene to prevent unacceptable speed excursions. Low Airspeed Alerting should be shown to be appropriate and timely to ensure flightcrew awareness and enable the pilot to keep the airplane within an acceptable margin from the low speed range of the normal flight envelope.

Data regarding crew recognition and response from the Human Engineering Compendium by Boff/Lincoln may be helpful to develop a more "complete" timeline, from condition to expected recovery.

For practical reasons, on existing airplanes where integration of new alerts into the flight deck would be very challenging, incorporating low airspeed alerts into existing designs should consider the guidance contained in AC/AMC 25.1322-1, paragraph 14:

14. Integrating Flightcrew-Alerting System Elements into the Existing Fleet.

a. General.

(1) This material provides recommendations to applicants on how to retrofit existing airplanes so they comply with § 25.1322 without major modifications to the current flightcrew alerting system.

(2) System upgrades to existing airplanes should be compatible with the original airplane's flightcrew-alerting philosophy. The existing alerting system might not be able to facilitate the integration of additional systems and associated alerts due to limitations in the system inputs, incompatible technologies between the airplane and the system being added, or economic considerations.

(a) We discourage incorporating a new additional master visual function into the flightcrewalerting system. If it is not feasible to include additional systems and associated alerts in the existing master visual function, an additional master visual function may be installed, provided that it does not delay the flightcrew's response time for recognizing and responding to an alert.

(b) Where possible, new alerts should be integrated into the existing flightcrew alerting system. If these alerts cannot be integrated, individual annunciators or an additional alerting display system may be added.

(c) Not all alerts associated with failure flags need to be integrated into the central alerting system. However, for those alerts requiring immediate flightcrew awareness, the alert needs to meet the attention-getting requirements of § 25.1322(c)(2) as well as the other requirements in § 25.1322. Thus, a master visual or master aural alert may not be initiated, but an attention-getting aural or tactile indication must still accompany an attention-getting visual failure flag to meet the attention-getting requirement of § 25.1322(a)(1), which requires attention-getting cues through at least two different senses for warning and caution alerts.

b. Visual Alerts. Following the guidance in paragraphs 5 and 6 of this AC, determine whether or not the added system features will require activation of an airplane master visual alert.

c. Aural Alerts.

(1) Using the guidance in this AC, determine if an added system will require activating an aural alert.

(2) The new aural alert should be integrated into the existing aural alerting system and functions. If this is not possible, a separate aural alerting system may be installed, provided that a prioritization scheme between existing aural alerts and the new aural alerts is developed so that each alert is recognized and can be acted upon in the time frame appropriate for the alerting situation. This may require a demonstration of any likely combination of simultaneous alerts.

After the new and existing alerts have been merged, follow the guidance in this AC for determining how to prioritize the alerts.

d. Tactile Alerts.

(1) Using the guidance in this AC, determine if an added system will require activating a tactile alert.

(2) If possible, incorporate the new tactile alert into the existing aural alerting system. If this is not possible, a separate tactile alerting system may be installed, provided that the following elements are included:

(a) A prioritization scheme between existing tactile alerts and the new tactile alerts should be developed so that each alert is recognized and can be acted upon in the time frame appropriate for the alerting situation. After the new and existing alerts have been merged, follow the guidance in this AC for determining how to prioritize the alerts.

(b) A means to ensure that an individual alert can be understood and acted upon. This may require a demonstration of any likely combination of simultaneous alerts.

In addition to design, appropriate flight crew procedures and training for proper reaction in response to the alert must be provided.

Flight crew procedures to facilitate corrective action from the low airspeed condition:

- (1) The need to continue flying the airplane
- (2) The recognition of the low airspeed condition
- (3) An assessment of the aircraft's energy state, and other conditions which may be a factor in determining appropriate corrective action
- (4) Roles and responsibilities between flight crew members
- (5) The corrective action necessary to avoid a stall condition, and recover to safe flight

Pilots need to be trained in crew procedures, CRM measures, stall recovery and airspeed management to provide the knowledge and skills to avoid negative aircraft situations that result from low airspeed, and to respond correctly and consistently to the alerts.

Appendix A – Aircraft Survey

The following survey was administered to aircraft manufacturers, and the attached data in Appendix B was collected through the survey to identify where and how low airspeed alerting has been implemented in existing fleets.

Survey - Low Airspeed Indications, Alerting & Protection/Limiting

As a result of several recent accidents and incidents, the FAA has identified a possible need for additional low airspeed safeguards and tasked the Aviation Rulemaking Advisory Committee (ARAC) to answer technical questions on this subject. The ARAC assigned this task to the Avionics Systems Harmonization Working Group (ASHWG). To accomplish this task, the ASHWG is collecting information on the low airspeed indications, alerting and protection/limit functions available on current commercial airplanes. The ASHWG will provide information to help develop recommendations on whether there should be regulatory requirements and guidance material for retrofit of low airspeed alerting on existing aircraft.

Any rulemaking that the FAA might undertake based on the ARAC recommendations would be subject to a cost-benefit analysis. Detailed information for the FAA tasking to ARAC can be found at 76 FR 11844. The survey requests information on low airspeed flight deck indications, alerting and protection/limiting functions as well as technical information on input parameters to these functions. The following are brief definitions of terms to help in understanding the survey.

- "Indications" for low airspeed conditions information presented full time on a display or indicator.
- "Alerting" for low airspeed conditions additional information presented to the flight crew (visual and/or aural) only under specific predefined conditions.
- "Protection/limiting" for low airspeed or approach to stall conditions functions that automatically provide assistance to the flight crew (e.g., throttle advance, increase in stick forces), but only under specific predefined conditions.

The ASHWG strictly adheres to ethical standards, public law, and federal policies for safeguarding the confidentiality of all participants in this survey. Completion of this survey is voluntary and all responses to the survey that are released will not contain survey participant information.

The survey should take approximately 20-30 minutes to complete per airplane model. Please complete the survey within 30 days of receipt. It is recommended that you review the attached survey file and gather all the necessary information before completing the online survey.

Thank you for participating in this survey.

1) Select your airplane model:

• □Airbus A300-600 or A310 All

- · DAirbus A318/319/320/321/330/340/380 All
- · □ATR ATR42 All
- · □ATR ATR72 All
- □BaE J31 All
- ■Boeing 717 All
- □Boeing 727 All
- · □Boeing 737 -300, -400, -500 Conv
- · □Boeing 737 -300, -400, -500 EADI F/S
- · □Boeing 737 -300, -400, -500 EADI Spd Tape
- □Boeing 737 -600, -700, -800, -900
- □Boeing 747 -200
- · □Boeing 747 -400
- · □Boeing 757 -200 EADI F/S
- · □Boeing 757 -200, -300 EADI Spd Tape
- □Boeing 767 -200, -300 EADI F/S
- · □Boeing 767 -200, -300 EADI Spd Tape
- □Boeing 767 -400
- · □Boeing 777 All
- · □Boeing DC9 All
- □Boeing MD 80 All
- □Boeing MD 90 All
- □Boeing MD10 All
- □Boeing MD11 All
- Bombardier CRJ -100, -200, -400, -440
- · □Bombardier CRJ -700, -701, -702
- · □Bombardier CRJ -705, -900
- □Bombardier DHC8 -100, -200, -300
- · □Bombardier DHC8 -400
- □Embraer 120 All
- □Embraer 135 All
- · □Embraer 140 All
- · □Embraer 145 All
- · □Embraer 170 All
- · □Embraer 175 All
- · □Embraer 190 All
- · □Saab 340 All

Section 1 - General System Capabilities

2) 1-1. What general system capabilities does the airplane have to support new flight deck indications and alerting? (Check all that apply)

- · □Primary Flight Display (with speed tape)
- · □Alert message system (visual message list)
- · □Master caution/warning light
- · □Aural tone and/or voice capability
- · □Enhanced Ground Proximity Warning System
- □Angle of attack data
- □Flap data
- · □Anti-ice active data
- · □Other (please specify)

If you selected other, please specify

Section 2 - INDICATIONS for Low Airspeed Awareness

3) 2-1.What low airspeed awareness indications or cues (other than alerts) are presented on the airspeed indicator or airspeed tape? (Check all that apply)

[Reference AC 25-11A Appendix 1, Paragraph 2.3 provides information for low airspeed awareness]

- · \Box Colored bands
- · \Box Trend vectors
- · \Box Speed bugs
- · □Other (please specify)

If you selected other, please specify

4) 2-2. What other indications exist that support low airspeed awareness, although it may not be the primary function? (Check all that apply)

- · □Pitch limit indicator
- · \Box Angle of attack indicator
- · □Other (please specify)
- If you selected other, please specify

Section 3 - ALERTING Functionality for Low Airspeed Conditions (prior to

stall warning)

5) 3-1. What additional visual indications are presented to the flight crew for a low airspeed alert, prior to stall warning? (Check all that apply)

[CFR 14 Part 25.1322, Paragraph (c) (2) provides requirements for alerting indications]

- · □Discrete indicator (lamp)
- · \Box Master caution light
- · □Indicator on Crew Alerting display
- · □Indicator on Primary Flight Display
- Change in display of current airspeed (i.e., flash, color change, etc)
- Change in display of angle of attack or angle of attack threshold (i.e., flash, color change, etc)
- · □Other (please specify)

If you selected other, please specify

6) 3-2. What aural indications are presented to the flight crew for a low airspeed alert, prior to stall warning? (Check all that apply, and specify in Comments)

[CFR 14 Part 25.1322, Paragraph (c) (2) provides requirements for alerting indications]

- · □Voice (please specify)
- □Tone (please specify)
- · □Other (please specify)

Additional comments

7) 3-3. What input parameters are used in the logic for the low airspeed alert? (Check all that apply)

- □Airspeed
- · □Airspeed rate of change
- □Angle of attack
- $\cdot \ \square$ Barometric altitude
- · □Radio altitude
- · □Minimum maneuver speed
- · □Stick shaker speed
- · □Manual or automatic flight state
- □Thrust/power parameters
- □Time
- · □Other (please specify)

If you selected other, please specify

8) 3-4. Is the low airspeed alert adjusted for the following conditions/configurations? (Check all that apply)

- □Flaps setting
- · □Speedbrake extension
- ·□CG

- · □Load factor/g-loading
- □ Icing conditions
- · □Other (please specify)

If you selected other, please specify

9) 3-5. What trip point is used to activate the low airspeed alert? (Check all that apply)

- $\cdot \ \ \Box X$ kts or X% in the low speed amber band
- · $\Box X\%$ above stall speed
- $\cdot \ \Box X$ degrees angle of attack
- · □Low airspeed alert is same as stall warning
- · □Other (please specify)

If you selected other, please specify

10) 3-6. How do you minimize nuisance alerts? (Check all that apply)

- · □Hysteresis (e.g. delay in reset)
- □Filtering
- \cdot \Box Large margins from normal operating speed
- · \Box Special combinations of input parameters
- ■Manual inhibit
- · □Automatic inhibit
- · □Other (please specify)

If you selected other, please specify

11) 3-7. What circumstances or conditions are used to inhibit the low airspeed alert? (Check all that apply)

- · □Baro Altitude
- $\cdot \ \square$ Radio Altitude
- · \Box Priorities with other alerts
- □Phase of flight (e.g., takeoff, approach)
- · □Non-normal configurations
- □Other (please specify)

If you selected other, please specify

12) 3-8. Is there a design requirement or goal for a minimum time margin between the low airspeed alert activation and stall warning activation? (assuming these are two independent points)

- · □Yes (please specify below)
- · □No

Additional comments

13) 3-9. Can you provide a description or illustration or logic diagram or equation that describes how the low airspeed alert is activated?

- _Yes (If so, email to the point of contact identified in the introduction)
- · □No

14) 3-10. How did you determine that the Low Airspeed Alert is timely (i.e., provides the pilot sufficient time to avoid stall warning, or some other identified point)? (Check all that apply)

- ■Analysis
- □In-service history
- □Flight test
- · □Flight simulator or lab testing
- · □Other (please specify)

If you selected other, please specify

15) 3-11. Is the alerting functionality you have described above implemented on all airplanes or only some through a customer option, STC or later add-on?

- · □All
- · \Box Some through option, STC or later add-on

16) 3-12. If you selected some through option, STC or later add-on, please specify the number of airplanes modified versus the number in the fleet:

Number of airplanes modified _

Number airplanes in the fleet _____

Section 4 - PROTECTION/LIMITING functionality (automated assistance)

for low airspeed or approach to stall conditions?

17) 4-1. What protection/limiting functionality is available to automatically assist the pilot for low airspeed conditions, prior to stall warning? (Check all that apply)

- · □Autothrottle "wakeup"/automatic thrust activation
- · \Box Stick pusher
- · \Box Automatic pitch control
- · □Increased column/stick forces
- · □Angle of attack protection
- · \Box Auto-slat extension
- · \Box Angle of attack limit
- · □Other (please specify)

If you selected other, please specify

18) 4-2. What protection/limiting functionality is available to automatically assist the pilot for approach to stall conditions, at/after stall warning? (Check all that apply)

- $\cdot \ \Box$ Stick pusher
- · □Automatic pitch control
- · □Increased column/stick forces
- · □Angle of attack protection
- · \Box Auto-slat extension
- □Angle of attack limit
- · □Other (please specify)

If you selected other, please specify

Appendix B – Survey Results

Appendix B contains the data which was collected through the survey questions in Appendix A, to identify where and how low airspeed alerting has been implemented in existing fleets.

		1-1. What ge	neral system ca	pabilites does	the airplane i	have to supp	ort new flight o	leck indicati	ons and alertin	g?	
Model Capabilities (Reference survey question in parentheses)	Airplane model (number in fleet at the time of data collection)	Primary Flight Display (with speedtape)	Alert message system (visual message list)	Master caution/war ning light	Aural tone and/or voice capability	Enhanced Ground Proximity Warning System	Angle of attack data	Flap data	Anti-ice active data	Other	OtherText
Round dial	Boeing DC9 All (433)	Na	Να	Yes	Yes	Yes	Yes	Yes	No	No	EGPWS is available as an
No SW cptr	Boeing 727 All (826)	No	No	No	Yes	Yes	Yes	Yes	No	No	SIC
	Boeing 747-200 (202)	Na	No	No	Yes	Yes	Yes	Yes	No	No	0.0
Round dial	Embraer 120 All (126)	No	No	Yes	Yes	No	Yes	Yes	Yes	No	
Have SW cptr to	Boeing 737 -300, -400, -500 Conv (1550)	No	No	Yes	Yes	Yes	Yes	Yes	No	No	EGPWS is available as an
support	Boeing MD 80 All (1916)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	STC
	Boeing MD 90 All (108)	Na	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
	Saab 340 All (197)	No	No	Yes	Yes	Yes	No	No	No	No .	
	Boeing 737 -300, -400, -500 EADI F/S (190)	No	No	Yes	Yes	Yes	Yes	Yes	No	No	
	Boeing 757 200 EADI F/S (971)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
	Boeing 767-200, -300 EADI F/S (880)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
Have EFIS & alert	Boeing 737 -300, -400, -500 EADI Spd Tape (58)	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	
capability.	Boeing 757-200, -300 EADI Spd Tape (37 -300 only)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
(1-1)	Boeing 767 -200, -300 EADI Spd Tape (46)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
	Bombardier CRJ-100, -200, -400, -440 (718)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	and store a spectrum store
	Bombardier CRJ -700, -701, -702 (215)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Ice Detector detected ice
	Bombardier CRJ -705, -900 (105 -900)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
	Embraer 135 All (137)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
	Embraer 140 All (74)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
	Embraer 145 All (503)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
	Embraer 170 All (76) Embraer 175 All (54)	Yes Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	- 71
PFD with visual	Embraer 199 All (51)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
low airspeed alert	Boeing 717 All (155)	Yes	Yes	Yes	Yes	Ves	Yes	Yes	No	No	
indication only. (3-1)	Boeing MD10/11 All (257)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
<i>C</i> -11	Airbus A300.600 or A310 All (A300.158; A310.70)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
	Dealer 737 CBR 700 000 (3008)		12							12	
	Boeing 737 -600, -700, -800, -900 (3908) Boeing 747-400 (675)	Yes	No Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
Visual & aural low airspeed alert	Boeing 767-400 (38)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	2
indication. (3.1, 3-2)	Boeing 777 All (981)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
	Airbus A318/319/320/321/330/340/380 All (767) (318-321724; 330-38043)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	

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		700	Na	Dila	Yes	Tostiline inscale
	Boeing 767 200, 300 EADI (75 (680)	Na	filo -	1 do	100	
lava I FIS & alarr apolitiky 13)	Boeing 737, 300, 400, 500 EADI Spil Tape (58)	Yao	Wes	Y'BS	An.	
	Boeing 757 200, 300 EADI Spd Tape (37 300 only)	Yen	Yes	Viela	Na	
	Boning 767 -200, 300 EAOI Spd Tape (46)	Fas	Vies	YRS	140	
		Yea	Ves	Yea	No	
		Vis	Via	Yes	Ma	
		Veis	Ves	Yes	No	
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(3.4)	Baeing MD10/11 AU (257)	16	111	Yis	Mo	
	Active \$200,500 or \$110 \$0 (\$200 150: \$11679)	111	See.	Yee	ho	
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found & survey in a	Boeing T37 -600, -700, :800, -300 (3908) Soeing 147 400 (675)	10	Ves	Yes Yes	100	
Inual & nural low		190	Ves	Yes	Ma	
million				15*	1.44	
2.1. 3.7)	Boeing 777 All (981)	Ten	Yas	Virs	Ma	
	Airbus A310/319/320/321/330/340/230 Ali (767) (316-321-728, 330-380-43)	(as	yes.	Viac.	140	

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Number 1, appartitions (Milderence payory Apendant or Defections)	Alexiana month (number in lines of the time of data collection)	Pite/: Resit Indicator	Single of attach lives ato	came	Omesteet
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	Seats 340 (0) (197)	Nic	110	110	
	Boeing 737 300, 400, 500 EAD) F/S (190)	No	NIX:	Hac	
	Boelna 757 200 EADI F/S (971)	Visa	- Alba	- Her-	
	Boeing 767-200, 300 EAD) F/5 (880)	YIRS	No:	Hila	
Inve ETIS & alert	Boeing 737 399, 498, 598 EADI 5pd Tape (58)	Ves	fie	6la:	
capatility.	Boeing 757 200. 300 EABI Spd Tage (37 300 only)	Vira,	lic	lila-	
1.15	Bueing 767 200, 300 EADI Spd Tape (46)	Ves.	No	lila	
	Bombardier CRJ-100, 200, 400, 440 (718)	No	Use	1 der	
	Bumbardiet CRJ -700, -701, -702 (215)	No	the:	1.ka	
	Benilardier CRJ 705, 360 (105-300)	No	No	tila	
	Embrowr 135 All (137)	Yee	No	(Ma	
	Embroer 140 All (74)	Yep .	Mis.	Rin	
	Embraur 145 All (503)	191	No	IVe	
In the second second second	Emilianer 17k All (76) Emiliaer 175 All (54)	Tes	/ile No	14a	
TD moto craund	Embraet 19(All (51)	This This	Mc Mc	1Na	
treet multiproved wheth	Buning MT All (155)	files	The-	11sta	
(3.1)	Bosing MD10/11 All (257)	Tei .	100	No-	
- W	Alman 4300-669 av 4310 All (4368-166: 4310-79)	(we	~	lin	
	Boning 737 -506, 700, 800, 900 (1908)	Ves	Yes	102	The Angle of stack indicator is an available option, the "other" is the pilot selectable digit path vector
Visual 5 moral low	Boeing 737-500, 490-300 (3906) Boeing 747-400 (675)	Yes	1 des	Vas	There is a pilot colectable flight path actor
Sitepsell alert	Boning 767-400 [35]	Yes	Yes	Yes	Piol selectable holi palit inclo
11 (1996) alert Indication. (1.1, 3.2)	Boeing /// Ali (981)	Ves-	Yes	Yes	The Angle of attack instants is an available option the "other" is the plint associate flight path vestor
	Aisbus A318/319/128/321/330/340/350 All (757) (316 527 -724 - 530 580 -40)	Year	tor	tàx-	

		S.I. Wine an	nal visual with	colour and grow	mont on the High	a onw hir # low	angest alon (discon and	Seemaking 7	
Maasi Lapakin Ridowesi Salar Astimur a Astimur a	Africano nextal mandar in float at the line of time coloring)	Diano Lo (2) pho Dianip)	inimites tradition Frim	loomanan an Cirva Alertian Pagang	Premiury Flager Deptwy	Company of Excitoring acception of Based, Street Charge of Co		Umer	Diffuer Yanz	
Round dial	Bosing DC9 A0 (433)	Nip.	No	No.	No:	No:		Ne		
No SW care	Basing 727 All (026)	No-	No	No	No	N=		Ne		
as sol the	Breeling 747 300 (202)	Nu-	Nv-	Nec	101	N	Ne	11		
Danual and	Emminuer 120 Alt (186) Emming 171 200 400, 5(0.Come (1950)	tin.	No.	lio-	Hile-	Ho.	lat -	Yns:-	Ossistiviteserment consisting technical masses	
of the We word	Brieling MIT (III All (100))	14-	NG	Do	lie	No.	0	he		
national (1	1.00	0	1.				
	Boanna Akir en Akir prins	66.	140	A.H	Ma	et.		11		
		0n	Di-	2.00	100	h		No		
	Boeing (\$7-300, 400, -500 EAD(E/S (100)	No.	No	146	94o	(te		Hc.	the second se	
	Bouing (51-200 EADI F/S (971)	140	No	140	780	No		Ha.	10.4to balaw langet apoint	
	Banding 767-200, -300 EAD/ F/S (380)	144	No	140	Voie	No	140	142		
Have EFIS & alort	Binning 737 -398 -409, 508 EADI Spat Tape (58)	No	No	Nis	No	His	he-	64-		
anab cy.	Binning 757 300 100 EADI Spit Taper (37 300 serve)	lin.	N6	pin	<u>Qu</u>	14	14	ble.		
11-11	Boulog 767 (20), 109 EAD Sud Tope (45)	au.	No	Fac	100	14	14C	140		
	Bombardier CR.I.100, 200, 400, 440 (190)	No-	No	No.	No	No	No	Vec.	English Carthomore and dog magazon	
	Bombantier CR.J. 200, 701, 202 (215)	180	Dia:	film	Ne	Phone:	(No.	Yest		
	Borohandius CRJ 705, 510 (105 510)	Rp.	No	140-	No.	14		Vice-		
	Endouse CIS All (117)	Blo	lbo.	14	Trees	Dan.	14.	14	and the second s	
	Enumouse 146 All (74)	Bo	line.	14	-	Canal.	12	4		
	Emilane: 345 All (90)]	Qr.	Ma:	115		Vine	16	He		
		hiu-	/No.	The second se	(a)	1092				
(phones among)		blu	Alla	Hei	Ves.	ties		No.		
HW/ Ampreed slaw		tju -	No	1Ma	YED	Veri		No		
with an in the second of the	Breing 717 AB (195) Breing MUNOTT AN (297)	10a 10a	Ha:	Nr.	Yes	Trea .		ns IE		
if.dr.		14:	Ves	10-	115	the state	-	Yes.	To serve a second constant of the second space second seco	
		1					-			
	Emailing 757, 600, 100, 800, 300 (2000)	his:	No	Ma	Net	Yest	EH-	Ne		
Vhuel & awril low		hip.	Wind.	80	Vina .	Van.		41-		
implet data	Baning 707-409 [18]	ns.	Vinc	160	* mg	Wein.	Ma	No.		
1001112-202010. [274] 2.2]	basing 777 M (1911)	60-	Tes	in .	100	Ves.	0	14.		
1. Y	Alaman Addit/154/328/32/0396/14/384-Ali (197) (318-325724, 329-398-43)	MDO		190	710	110	740	TAT	University considered. If dynamic proversity and speculates of IPTD, 2) and frequencies (assume an EDAM & PED, 3) APP decomment at appeared + 17	

		1.5. Writest warral trolling	mun are preserved to D	e tight case for a low a	quebased ayair hiron (a ang) manuniti.
Model Capabilities (Reference survey question in sureptices)	a Anplane model (number in feet at the time of data collection)	Voice (please sae any)	Tome (please specify)	(диция (диники вілег до)	LommentText
Round dial	Boeing DC9 All (423)	No	160	No	
No SW cpo	Boeing 727 All (826)	Nu	194	Ne	
	Boging 747-200 (202)	(10	No	No	
Round dias	Embrae: 170 Ali (176)	liko		Yes	The sign of the control of the makes monthly is short service to a percented by cares
Hater SIV con to	Boning 717-300, 400, 500 Cany (1560)	17/61	Ma i	(flc	
momore character to	Honing MD 86 All (3016)	110	18	NG	
supmor	Burelon MD 20 AN (107)	live		140	
	Snair 340 All (197)	Dán	la Es	lic	
	Bosing 737 309, 400, 500 EADI F/S (190) Bosing 757 200 EADI F/S (971)	tilp	No	Mo	
	Boeing 757-200 EADF7/5 (571) (Bueing 757-200, 300 EADF7/5 (880)	Ne	No.	No	
sta and	Stored in our planter our black				
llove FFIS & alen	Boning 737 300, 400, 500 EADI Spd Tape (58)	(No	(NO)	No	
capability.	Baeing 757-200, 300 EADI 5pd Tape (37-300 anly)	Idu	No.	No	
(Bosing 767 (200), 300 EADI Spil Tape (46)	1 án	No	No	
	Bombardier CRJ 190, 209, 409, 440 (716)	100	No	110	1
	Bombardier CRJ -700, 701, 707 (715)	No	No	No	
	Bombardier CR.I -705, 908 (105 386)	No	No	Ng	
		(tio)	Fla	Yes	
	Embraner 140 All (74) Embraner 145 All (503)	No No	No.	Yes Yes	The same childred or size shaker motor or old encommon
		Ma	No	Vee	respond to the second to the s
NED with distant		lla	Min I.	Ven	The same at horse
invi airspeed alen	Embrasic 190 All (51)	lika	No	Yee	
militation only.	Baelan 717 All (155)	(No.	Kin	No	
10	Bealing MU10111 All (257)	No	Na	No	
	Alibus A300 500 or A318 All (A300.151; A310-70)	Ne	6	Ym	"Cavalry chatrys" when AP assessment & succession
	Boeing 737 -500, -700, -800, -900 (3905)	Yes	110	No	Service Evilation evailable to enable voice - AIRSPEED LOW AIRSPEED LOW*
Visual & aural low	Boeing 747-400 (675)	lio	Yes	Nc.	
alispeed slert	Boning 767-400 (38)	Na	Yes	No	
indication. (3-1, 3-2)	Hosing 777 All (981)	Ì4p	Ves	siz	Standurd ElCAS caution rone
	Airbes A318/379/320/220/30/340/380 AB (767) [310 521 - 724: 550 380 43)	Yes	No	Ho	"Speed-Speed-Speed" below 2500h

		7.2. White	introl permitte	Allerg and lum	al fa Ita tagir	for the los	w singlesed wi	en?					
Maplini Lapadonje (Rođenova seriori operatoj or posotoj m	Anythine modul (number in Next is the time time of data colliscom)	Airopead	Annyans a spits si change	Rogie ol ethicit	Dermonik altruas	Radie Millioudu	Aliconomic retained war	Sili i shake quared	Manual or automatic II nic stars		Time	Litisr	Office Loss
Reveal dist.	Booling DCB All (433)	No	No	ha	hee	Gla	Mer	the.	1946	Mo	1940	1 (m	
No 5W cptr	Baging 727 All (826)	Nic	No	Nu	193	No	100	Na	1010	1940	Ne.	100	
nd 244 bbs	Baning /47 200 (202)	No.	bla:	tha .	No.	110	f μ)	(fa	1040	1110	lun -	ina.	-
	impanar 120 All (120)	this -	110	me	No.	lla	14	THE	No	Mic	100	110	
Round dial	Beesing 737 -300 - 493 -500 Crony (1508)	In	No	R	No.	no.	TA	ING	Nin	Ma	Tin	No	
Nave SW spalar syptian	Boeing MD 80 All (1015)	140	Mo	900		Ha.	14	Ma_	Mb	01a	No	14=	
CHE-	Causing MD So Art (100)	No.	No	tin.	10	in .	-	110	No	1944	11=	0-	
	Samly 340 AB (197)	Win	Na	0.000	He	Get	14	Ma	\$205	Ulm	Jin	h	S
	Baeing 737 -300, 400 -500 EADI F/5 (190)	Wes.	No	Ne	lie	Ne.	he :	Pig	1040	(Nor	Ha	No	
	Baeing 757-200 EADI F/S (971)	946	Pla-	Nu	No	The	No:	Ma	040	2110	Tiu	100	
	Bassing 7%7-200, -109 EADI F-5 (080)	Ves	Na	Ne	le	Ne	16	Nu	his	Nu	lin	1Ner	
Have EF15 & elen	Baeling 737 - 300, 400. 500 EADI Spil Tape (50)	Min	No	Nei	No	hde:	han.	No	na.	Dia	Na	No	
capability, (1.1)	Boeng 757-200, 300 EADI Spd Tape (37-300 only)	No.	140	140.	No	6400	NAU-	the -	040	Ha	No	140	
beau	Boeling 757 200, 300 EADI Spd Tape (46)	No -	110	10	Ne	(4)	Alex.	No.	No	110	140	110	-
	Bombardier CR2 100, 200, 400, 440 (718)	ha	Na	Yaz	1/p	l)ka	f April	tha .	(Han	11ka	hin	Pas	A 4 4 4 4 4
	Bomupdier CRJ 700, 701, 702 (215)	No	No	Yer	Ne.	(der	P40	No	740	Ma	MO.	Yee	Watt & AuA Iat
		Nir	No	YNE	Even.	Nei	Dillo .	Na	No	3947	10	105	
	Biodenese (135 A)((137)	ND	(ND	346		()e	Vier -	Ves	Ma	Vila	Na	type:	-
	Finderaner Talle All (7.4) Einsteinen Talle All (2003)	NO.	No	YWT.	(IVE:	9	(file)	Vice	10	XIO	Tie	110	
	Emoran 1/0 AB (/1)	740 1745	Na CMS-	Yes	line Disc	fee Ma	100	Vies	No	No.	240	ho No	-
Incite view official	Emprover 175 All (59)	Nue .	Ves	Ves	No	Ne	No. Vier	1740	No	Wes	hin	The .	-
Day all (peed aler)	Emprant 199 40 (51)	Nin .	THE	Wat	Hip	No.	1/la	Vec	No	Yes	flp	like	
une analise orde	Banung X17 All (155)	Vie	No	Hay	the	Ma	Fee	Vec	No	Min	be	He	1
(L4)	Aright Miller	Mary .	No.	t in	. No.	lac	14	Nes.	No	Die	lle	fic.	-
	Annum & 108.500 m 6310 AN (6300 118, 6310 20)	1996 -	Ves-	Say	No	jile:	-	Ma	17m	-	Tin	ne	
	P		112	10								Jus -	
And Street and	Baning 737 800, 700, 800, 900 (3008) Baning 747 400 (075)	Ves. Yes	Na	Nu	No.	l Az No	Yes Ves	Vec	Aur	110	lin	Na-	
West letters in linues	Boning 767-400 (015)	19 112 .	100	the .	We .	No	Yes	Yes	Din	Dig	Ma	No	-
alrapand annt Imlication	Second in any high	1.14	174	1.14	100		1.00		- Pitte		1.14		
(3-1, 3-2)	Booing /// All (SEI)	105	Nā	t ia	Nr.	IW.	194	Yes	tio	Ha	Hir.	lia	
	Airoes AJ18/319/220/321/110/240/360 All (762) (318 821-724; 330-360 -43)	TTR.	m	-	le:	Ver.	Pate))ig	lin	Vm	Mach the alphaen antimmed

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Monthel L separateleges (References technologic) specific (separateleges)	Anything modul (number to flest score time of data collection)	Flaps soring	Speadbinke	Wealgot	4	L and Instat//p- conding	lahig quidnoin	(Citavior I	(dher) ser
Revert dini		No	luko-	Ho	540	600	no	1 No	1
to 5W optr		Ne	16	No	Ma	170	No	Nr.	
10 311 ppp	Baning /47 200 (202)	Ma	he:	16	iika.	100	1in .	he l	
	Emiltan 123 All (120)	wit-	10	60	Ma	110	74-	be:	
cound dial	Binesing 737 300 - 495 - 500 Cienty (1558)	Mr.	1 de	No	Ma	- Da	Min	lic	
lawy SW spects	Browing MD 00 All (1915)	1400	We.	Ma	lla_	Mr.	140	De .	
Nikipiti	Energy MD 10 An (100)	110		No	116		1		
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		Mp.	1/d Ho	No	1640	fig	No	No.	
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lave IF15 & alem	Sineling 757-300, 400, 500 EADI April Tager (SEL	Nn	Nei	No	No	Ne	Mn	1 Au	
apalumy,		NO.	PR:	tto	140	<i>f</i> ao	9400	10	
(4)	Bonning 767 (200, 1966 EAD) Spd Tape (46)	No	140	10 c	1040	140	No	he	
	Bomberdier CRJ-100, 200, 4x0, 440 (718)	Pps.	Tila	Na	in a	ha	hin	Viso	
	Bombardies CRJ 200, 701, 702 (215)	field and a second seco	200	No	640	ftu	140	Ves	Usen
		Yes	Ne	No	Dkg	Na	No	Veo.	
		The .	14	Na	alle-	Dig .	Yes	Mar	
		10	116	110	100	Na	(Dei ·	No	
	Emiseawi 145 Alt (203) Emiseawi 170 A0 (71)	Fac	100	Na	lic-	flui	1-	No	
Interior reneral		10 TB	- No	rite No	100	Na	780	16	
int solicizeed steri	Embrant Ell All (51)	Visi -	No	140	-	Na	The	H6	
nin no'at ordy.	Banung (1) Ali (155)	Tre:	be	Ves	Vec	Viet	- Vin	100	
1.0	among Minter Ad (15)	Ter	1k	Ves	LYes.	Yong	per.	lie .	
	Antan A 106 500 m A310 A0 (A300 Ma. A310 PO	m.	- -	Ves-	-	9 an	lun .	Î.	
			1.					17	Contra and
And a second	Booing 737 800, 700, 800, 300 (2008) Booing 747-400 (675)	16	12	Pos Pos	Visi Ves	Yes	Var	10	The advectments are make to the
Republi & postal low	Bosong 717-400 (075) Bosong 717-400 (38)	tins . Tris	lie.	Ves	Yes	765	1795	No.	divideby allocia alex the cent
ndisalian	and the second least					1.4	110		diverby append and the cand
11, 3.24	Boeing 777 Alf (981)	16	Aug.	Vot	745	bei .	400	Per	
	Airous A3183390328032103883480860 AH (F67) (518-121-724, 530-380-43)	TTN.	Yer	in	bler.	Ven	have	he	

		55 What his point	la word to intiente	the here arrangend alard	e		
Model Capabillies (Rolenauce survey) generations) parathenes)	Airalana analist (maniher in flom at ine time of ana collection)	X, Ro or X is in the loss around another basid	Ng above stall mend	X fletjieva sugle of amiză	Low arapaed aver is more as mail warning	Dinug	Diber Jess
Risenst tilät	Boeny DCB All (433)	No	100	\$10	Na	Ne	
Nie NW crim	Boeing 727 Aft (#26)	Ne.	140	NO		Edu:	
in pri cini	Booling 747-200 (202)	1E	(Ap	140	16	(le-	-
	Embrane 120 All (126)	He	Inc	Que	Ver	100	
team dist.	Boeing 737 300, 401, 500 Conv (1000)	(he.	Ulto	Mo:	R-	la:	
NAME OF COMPANY	Busing MD on All (1916)	IE-	lin	Uto	(II	(JE)	2
	Honing MD Sk All (105)	Ne	1140	Mu	the	No	
	Swab 146 AD (197)	15	lite	1910	10-	100	
	Flowing 737 306, 400, -500 EADI F/S (190)	140	lite	1NG	No	Yes	(Difference from Larget arouand)/10 kts
	Boxing /57-200 EADI F/5 (971)	hka	No	Hin	(Up	Vics	Difference from Laget anspeed
	Eneling 757 200. 300 EADT F/S (III0)	Nic	114:	NP	Na	Vies	Difference from larget ar sprad
lave 1715 & aleri apolitiky. 171)	Boeing 737 .390, 400, 500 EADI Spd Tape (56)	No	No	Nit	Na	No	
	Dowing 757-200. 300 EADI Spd Tape (37. 300 only)	Ne	(No	No	No	No	
	Bueing 767. 200, 300 EADI Spd Tape (46)	No	No	Niu	No	No	
	Bomhaniler CRJ 100, 200, 400, 440 (718)	No	INc.	Vesi	No	No	
	Bombardier CRJ -700, 701, -702 (215)	(4u	10to	780	76	PAX	
_	Bombaniler CNJ 705, 500 (105 500)	Ne	Die	YHU	1043	Ne	
	Embasor (15 All (137)	Ma	NC.	ine.	Yes	Mail	
	Embraur 140 All (14) Embrace 145 All (301)	Mar .	(40 74a	Test	Vics Vics	No.	
	Endoure 170 All (16)	Tel	Inv.	17m	Yes	fán.	
ENTL with visital	Embrour 175 AU (54)	Ter .	16	Tes	Yes	Ne	
hity assigned alott	Emorana 190 All (51)	544	1No	The .	Yes	Ne	
main at the unity.	Hoema 117 All (135)	794	He.	(jsto	660	No.	
19	Becog MD10/11 All (257)	54	No	Win	Plei	He	
	31 Tun \$300 600 \$310 EB (\$300.15E \$210.05)	lint.	Vas	(Vac.	NI2	()=	
-	and the second sec						
	Boeing /3/. 600, 700, 200, 300 (2500)	Yes	No	MD.	64=	Nic	
elucină di nurnă Sow	Boeing 747-400 (675)	Yel	40	010	ENO.	Ellor	(1)
projection from provide	Boeing 767-400 (30)	Yes	No	No	1)la	No.	
udicamon, 3-1, 3-2	Bosing 777 All (001)	Yes	No	No	Ma	Ne	
	Ai Jun A310/319/320/321/330/340/360 Alt (767) (338-321-724: 336-380-43)	file	he	YPA	96	14	

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Rement diari	Bosing DC9 Att (411)	has	110	(Ma)	the	las:	16	Neri	
No SW cpir	Bowing 717 AD (826)	No	Ne	144	344	346	39	No.	
ine stil som	Dowing 747 300 (202)	116	1	1140	116	110	314	140	
	Endenne 178 All (199)	tos.	his	100	100	ie.		1.E	
Reund all al	Sering 717 100, Aug. 560 Come (2555)	The	the	N	240	THE	4	14	1
Havo SW LINE IN MOTION	Hending Mill 46 All (1016)	12	10	100	100	he .	de-	12	1
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	Boming 737 300, 400 .500 EABI F/5 (199)	1 ke	he	Ma		Me		Ma	
	Boeing 757 200 EAD(F(5 (971)	ihau	1 Mar	(has)	140		ille.	140	
·	Bowing (107.200, .300 EADI F/S (000)	No	140	140	140	No.	314	14	
Hove FEIS & slare	Boeing 737, 300, 400, 500 EADI Spd Topo (58)	Man	No	No.	ito	No.	the	NG.	
copodditty.	Booing /5/ 200, 500 LAUI Spit Tape (3/ 300 anay)	\$ ADV	110	the:	tis.	bas.	116	MD	
(1.1)	Soning 767, 200, 308 EA/N Spil Tupu (46)	Ne	1No	100		Ne	(M)	100	
	Bosnbard/es CRJ 106, 206, 498 446 (216)	BM	940	Ya		9.00	104	MAD:	
	Boenbeardier CRL/ 709, 701, 762 (215)	(fan	Meta.	Ten		140	All	14	
		d.As-	JY##	The course of th		(D+	100	14	
		制作	N RE	-		We	21/6	16	
	Entingen 142 AU (1) Entingen 142 AU (203)	Nn die	TYAN	Are .	0.5	The The	14	De-	1
		Pipe	Dfam.	(it)	(Ba).	Ne.	the-	No.	
faces with viscout	Embrar 1/5 All (54)	YPS.	15ee	195-	Nu -	ALC .	Me	14	
ing aligned steri		Mrs.	Ten	195	No	415	106	16	1
indite attorn only.	Bouittis 717 AU (153)	DE .	100	100	he	18	310	11.	1
an .	Bowing RUID/11 All (75/)	dia .	1.9	MS	(hte-	He	325	111	
	Airban, 2700.000 ur Alto Ali (4200.056, 5360.70)	¢	Sec	in.	lar	ð.ce	X.	12	
100	Bauring 7.17 400, 400, 400, -904 (1981)	722	700	Yes	Aug	lie	ka	his	The area is tradeed when manual an paint last decreased as as to now op: 00% of Ma
Visuel & aural low	Boeing 747 400 (675)	Neo-	¥80	Yes	296	1Ma	1ML	No	meaning in sansper summaring in
eleppeed alten	Boeing /1/7 400 (54)	Yeu.	Nea.	Yes	140	Ne	No.	Re-	achemiker Treamlin dermallydore
indication (J-1, 1-2)	Upsung (7) All (925)	Nes	lyes	Nee	No	NG.	his	he	spect spect
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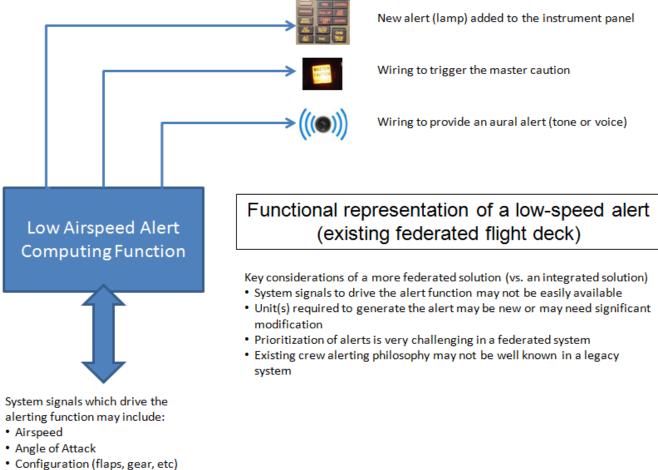
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	Boeing MD 90 All (108)	No	No				
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	Bombardier CRJ-100, -200, -400, -440 (718)	Yes	No				
	Bombardier CRJ -700, -701, -702 (215)	Yes	No				
	Bombardier CRJ -705, -900 (105 -900)	Yes	No				
	Embraer 135 All (137)	Yes	No		1.		
	Embraer 140 All (74)	Yes	No				
	Embraer 145 All (503)	Yes	No				
	Embraer 170 All (76)	Yes	No				
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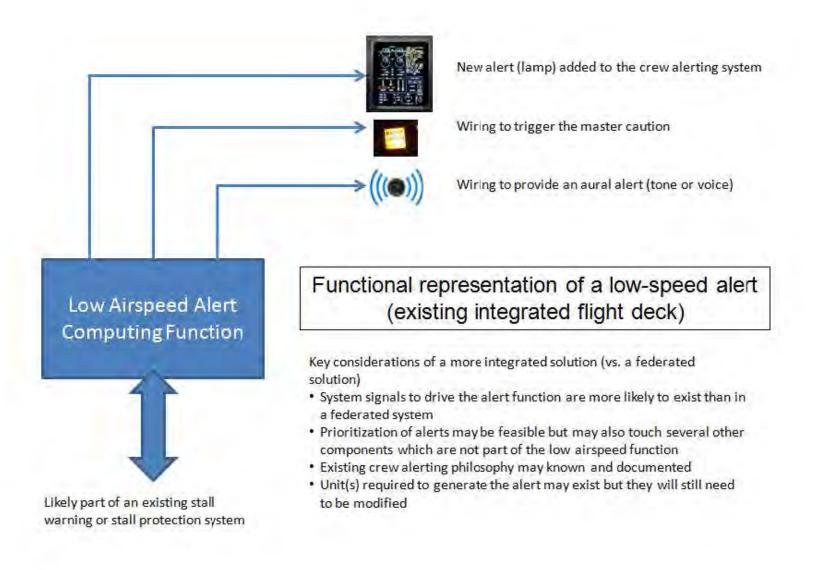
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Appendix C- Example Implementations

This appendix illustrates two possible functional implementations – one for a federated configuration and one for an integrated configuration. These are representative functional examples and will vary between aircraft types.



Icing on/off





Mr. Dan Elwell Chair, Aviation Rulemaking Advisory Committee Airlines for America 1301 Pennsylvania Ave, NW, Suite 1100 Washington, DC 20004 800 Independence Ave., SW. Washington, DC 20591

AUG 1 1 2014

Dear Mr. Elwell:

The FAA received the Low Airspeed Alerting Phase 2 Task Report from ARAC in March 2013. This report was developed by the Avionics Systems Harmonization Working Group (ASHWG) in response to a 2011 tasking from the FAA, which asked for industry information to support a potential requirement of low airspeed alerting in all airplanes operating under 14 CFR parts 121 and 129. The Phase II Final Report does not contain an assessment of the potential cost and benefits of implementation of such systems, as the ASHWG was awaiting completion of other studies on this subject. Those studies are now complete and their results should be available to the ASHWG soon.

Since receipt of the report, the FAA has internally evaluated several potential options for proposed alerting systems, based on our estimates of their cost and predicted effectiveness at preventing future loss-of-control accidents resulting from unobserved airspeed loss and stall. Per the FAA Office of Rulemaking Committee Manual, Part 3, section 2.4, the FAA may seek additional clarification from an ARAC working group on work related to a completed tasking through the ARAC Chair.

The FAA is requesting ARAC to reconvene the ASHWG to review the FAA's evaluation of the systems and the additional information now available from other concluded studies on this subject. Specifically, we propose to meet with available members of the ASHWG, present the options we have evaluated, and gather additional information as to their suitability for addressing the hazard of unobserved airspeed decay. The ASHWG should provide recommendations based on its review and plan to discuss the recommendations during the September 2014 ARAC meeting. The FAA would like to note that it has not initiated rulemaking on this matter; therefore, this discussion should be considered a continuation of the FAA's previous tasking on this topic.

Sincerely,

Designated Federal Officer

1103 1 1 AVA



The Boeing Company P.O. Box 3707, MC 09-76 Seattle, WA 98124-2207

April 6, 2015 B-H020-REG-15-TLM-25

Ms. Lirio Liu Director, Office of Rulemaking, ARM-1 Federal Aviation Administration 800 Independence Avenue, SW. Washington, D.C. 20591

Lirio.liu@faa.gov

- Subject: Avionics System Harmonization Working Group Phase 2 Low Airspeed Alerting (response to request for clarification)
- Reference: Federal Register Tasking Notice (76 FR 11844, March 3, 2011) and ARAC Low Speed Alerting Phase 2 Task Report, March 2013

Dear Ms. Liu,

On behalf of the Aviation Rulemaking Advisory Committee (ARAC), I am pleased to submit the attached letter from the Avionics Systems Harmonization Working Group (ASHWG). On August 11, 2014, the FAA requested that ARAC reconvene the ASHWG to review "the FAA's evaluation of the systems and additional information now available from other concluded studies on this subject." The FAA's request was described as an extension of the prior tasking which resulted in the March 2013 submittal of the Low Speed Alerting Phase 2 Task Report from ARAC.

The ARAC reviewed the response from ASHWG and approved the information for transmittal to the FAA during its March 19, 2015, meeting. I want to thank all the members of the ASHWG for supporting the request from FAA and their quick response.

Sincerely,

Todd Sigler ARAC Chair

Enclosure

Mr. Craig R. Bolt Assistant Chair, Aviation Rulemaking Advisory Committee (ARAC) Pratt & Whitney 400 Main Street, Mail Stop 165-30 East Hartford, CT 06108

23 February, 2015

Dear Mr. Bolt,

The Avionics Systems Harmonization Working Group (ASHWG) has reviewed the report provided by Mr. Wilborn and Mr. Jacobsen from the FAA, titled "Part 121/129 Low Airspeed Alerting Analysis, Review of Design Mitigations."

Many thanks to Mr. Wilborn and Mr. Jacobsen for providing the ASHWG with the opportunity to review and comment.

The report included two low speed alerting design mitigation options:

- Option 1: Add low airspeed aural caution Implement an aural alert to trigger at an airspeed above the stall warning speed by an appropriate margin
- Option 2: Ensure compliance with latest §25.1329(h) requirements on low speed awareness (must protect against, or alert to, low airspeed)

ASHWG Feedback on the Options:

It is not completely clear what the difference is between the two design mitigation options. Both would seem to require at least an aural low speed alert. What would the rest of the Option 1 requirements be if they are not the same as the CFR 14 25.1329(h) requirements?

The analysis should consider a third design mitigation, to demonstrate that existing aircraft are compliant with the latest 25.1329(h) using the latest Acceptable Means of Compliance.

There was no additional ASHWG feedback on the methodology described in the report. However, there is some feedback on the technical challenges the manufactures may face in implementing a feasible (let alone compliant) solution:

An interface to the various Stall Warning Computers may be needed for a
particular aircraft type, in order to obtain a "Maneuvering Speed" value which is
basically an Angle of Attack before that for Stick Shaker. That will likely turn
many of the "Software Only" change fields in the report to "Software+Hardware"
change and increase complexity. For example, on one particular aircraft a
Maneuvering Angle of Attack (AOA) equivalent to Maneuvering Speed was

needed, and that had to come from a Stall Margin/Yaw Damper computer to provide that signal.

NOTE: The ASHWG members will provide any updates for specific aircraft that should change from a "Software Only" to a "Software + Hardware" update. This will be provided no later than 13 March, 2015.

• As an alternative, Maneuvering AOA could be probably calculated from raw AOA but would need to be corrected for Flap position and for some aircraft types, thrust. That would still likely require aircraft wiring changes.

Regarding the cost data in the report:

- 1. Cost The costs appear to be off by nearly an order of magnitude.
 - a. Need to consider
 - OEM design/cert non-recurring. This may include development costs to determine a suitable 'maneuvering speed' or 'maneuvering AOA' if that data does not exist. This may require simulator or aircraft testing.
 - ii. Supplier design/cert non-recurring, and
 - iii. Updating training simulators for 3 different simulator suppliers.
 - b. Each of the three is easily \$200-500K, with the supplier cost easily approaching \$1M many times.
 - c. The cost of certification for the OEM and supplier is significant.
 - Recommend that a minimum cost of \$600k be used in the analysis for the SW only changes, \$1M for SW+HW (minor) and \$2.5M for SW+HW(major).
- 2. Some applications may incur additional costs:
 - a. May have more than one LRU
 - i. One for the visual effect (PFD), and
 - ii. One for the aural effect (EGPWS or warning/alerting system) of the alert.
 - iii. OEM design costs also must consider airframe wiring when multiple LRUs are involved.

iv. Recommend that for a complex change (more than one LRU) the total cost be doubled for the analysis.

The cost / benefit analysis may consider a different set of benefits for freighter fleets, as well as account for any regional or global differences in the cost per fatal accident. The level of safety should be equivalent, however, regardless of the flight operations. For example, the expected cost per fatality in the EU is estimated around \in 2 M rather than \$ 9.1 M - this will have an effect on the cost-benefit ratio.

In addition to the report, a follow up file titled "LAA Fleet Projection for Cost Benefit" was provided to the ASHWG, providing additional detail for the fleet projection used in the cost-benefit calculations for the low airspeed alert analysis.

Regarding the fleet data/sizing, the FAA report should clarify the scope and intent of the Part 121/129 rules and how might they read. For example, what are the target fleets for retroactive implementation of the low speed alert? Certain fleets were considered to be excluded for various reasons when the ASHWG survey was developed. A Part 121 rule applies to all models unless stated otherwise.

Additional feedback regarding the fleet data/sizing

1) The graph plotted on the far right of the table shows the gray area as "Flt Env Prot". Many airplanes included in there do not have Flight Envelope Protection that would meet any requirement, so the gray area should also state that it includes airplanes that already have a low airspeed alert.

2) The B747-800 in the FBW section should be moved to Non-FBW and listed as B747-8.

3) The B777-300 shows only 2 airplanes. There are closer to 500. The search should include the 777-300ER.

4) The 767-400 has the Boeing standard low airspeed alert as a basic feature. Change from SW Only to None.

5) The 747-400 has the Boeing standard low airspeed alert as an option and most have it. Change from SW Only to None.

6) The 757-200, 767-200, and 767-300 should be changed from SW Only to HW & SW. Most will require a HW change to a SW loadable EICAS computer.

Best regards,

all

Clark Badie, Avionics Systems Harmonization Working Group