European Aviation Safety Agency — Rulemaking Directorate

Notice of Proposed Amendment 2013-11

Regular update of CS-25

RMT.0500 — 10/07/2013

EXECUTIVE SUMMARY

This Notice of Proposed Amendment (NPA) makes use of the 'systematic tasks' concept introduced in the revised EASA Management Board Decision amending and replacing the 'Rulemaking Procedure' (EASA MB Decision No 01/2012, dated 13 March 2012). This provision aims at improving the efficiency of the EASA rulemaking process.

The specific objective of this NPA is to propose an amendment of CS-25 based on the selection of non-complex, non-controversial, and mature subjects. The ultimate goal is to increase safety.

This NPA proposes the amendment and creation of several cabin safety related AMC, the creation of new security specifications and AMC for Chemical Oxygen Generators, and the creation of two new Appendices to AMC 25-11 (Electronic Flight Deck Displays).

The proposed changes are expected to contribute to an updated CS-25 reflecting available state-of-the-art and accepted means of compliance (complying with the objective of Article 19 of Regulation (EC) 216/2008), facilitate the certification process by decreasing the number of Certification Review Items (CRIs), and improve harmonisation with FAA. Overall, this would bring a moderate safety benefit, it would create no social or environmental impacts, and may provide a slight economic benefit by streamlining the certification process.

Applicability		**Process map**	
Affected regulations and decisions:	ED Decision 2003/02/RM, as last amended by ED Decision 2012/008/R, certification specifications and acceptable means of compliance for large aeroplanes (CS-25)	Concept Paper:	No
		Terms of Reference:	26/06/2013
		Rulemaking group:	No
		RIA type:	Light
		Technical consultation during NPA drafting:	No
Affected stakeholders:	Large aeroplane manufacturers, large aeroplane modifiers, avionics equipment suppliers, cabin safety equipment suppliers, and operators	Duration of NPA consultation:	3 months
		Review group:	No
		Focussed consultation:	No
Driver/origin:	Safety; EASA Rulemaking Procedure (EASA MB Decision No 01-2012), Article 3.5. on 'systematic tasks'	Publication date of the Opinion:	N/A
		Publication date of the Decision:	Q4/2013
Reference:	N/A		

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1. Procedural information

1.1. The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this Notice of Proposed Amendment (NPA) in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the Agency's Rulemaking Programme for 2013–2016 under RMT.0500 (http://www.easa.eu.int/rulemaking/annual-programme-and-planning.php).

The text of this NPA has been developed by the Agency. It is hereby submitted for consultation of all interested parties[3].

The process map on the title page contains the major milestones of this rulemaking activity to date and provides an outlook of the timescale of the next steps.

1.2. The structure of this NPA and related documents

Chapter 1 of this NPA contains the procedural information related to this task. Chapter 2 (Explanatory Note) explains the core technical content. Chapter 3 contains the proposed text for the new requirements. Chapter 4 contains the Regulatory Impact Assessment showing which options were considered and what impacts were identified, thereby providing the detailed justification for this NPA.

1.3. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[4].

The deadline for submission of comments is **10 October 2013.**

1.4. The next steps in the procedure

Following the closing of the NPA public consultation period, the Agency will review all comments.

The outcome of the NPA public consultation will be reflected in the respective Comment-Response Document (CRD).

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[1] Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1), as last amended by Commission Regulation (EU) No 6/2013 of 8 January 2013 (OJ L 4, 9.1.2013, p. 34).

[2] The Agency is bound to follow a structured rulemaking process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'. See Management Board Decision concerning the procedure to be applied by the Agency for the issuing of Opinions, Certification Specifications and Guidance Material (Rulemaking Procedure), EASA MB Decision No 01-2012 of 13 March 2012.

[3] In accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

[4] In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

2. Explanatory Note

In order to increase the efficiency of the rulemaking process, it has been decided to group together some subjects that are considered as non-complex, non-controversial, and mature. This concept was introduced in the revised EASA Management Board Decision amending and replacing the 'Rulemaking Procedure' (EASA MB Decision No 01-2012, dated 13 March 2012), see Article 3.5. on 'systematic tasks'.

Every year the Agency will make a review of potential applicable subjects, and, if enough substance is available, an NPA will be published.

The present NPA has been prepared for this purpose.

2.1. Overview of the issues to be addressed

This NPA proposes to amend CS-25 in order to deal with the following items:

— **Cabin Safety items:**

- Create several AMC paragraphs to include references to some FAA Advisory Circulars which have been previously accepted by the Agency as acceptable means of compliance in TC and STC applications,
- Amend several AMC paragraphs, clarify and correct their content, and add a reference to an FAA Advisory Circular which has been previously accepted by the Agency,
- Delete one AMC which is not, or is extremely rarely, used and which is not consistent with one FAA Advisory Circular reference, and
- Correct two editorial errors in Appendix F.

— **Security provisions:**

Harmonise with FAA NPRM (Docket No. FAA–2012–0812; Notice No. 13–01) (published on 09 January 2013) and draft AC 25.795-X on Chemical Oxygen Generators (COGs) (published on 11 January 2013).

— **Avionics:**

Add new Appendices to AMC 25-11 in harmonisation with FAA draft AC 25-11A change 1 (published on 1 November 2012).

2.2. Objectives

The overall objectives of the EASA system are defined in Article 2 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Chapter 2 of this NPA.

The specific objective is to propose an amendment of CS-25 based on the selection of non-complex, non-controversial, and mature subjects. The ultimate goal is to increase safety.

2.3. Summary of the Regulatory Impact Assessment (RIA)

A light RIA has been made, which concludes that Option 1 is recommended ('Select items that are non-complex, non-controversial, and mature and propose an amendment of CS-25'). Overall, it would bring a moderate safety benefit, it would create no social or environmental impacts, and may provide a slight economic benefit by streamlining the certification process.

2.4. Overview of the proposed amendments

Cabin Safety items

— Creation of AMC 25.562 to refer to FAA AC 25.562-1B and FAA AC 20-146.

— Creation of AMC 25.785 to refer to FAA AC 25-17A and FAA AC 25.785-1B.

— Deletion of AMC 25.785(d) on 'Seats and Safety belts'. The usage of this AMC is considered extremely rare, if not unheard of. It is not compatible with FAA AC 25-17A which is proposed as the AMC reference for CS 25.785. It is proposed to delete AMC 25.785(d) in order to avoid disharmonisation and inconsistency with FAA AC 25-17A.

— Amend CS 25.809(g) to correct a typo error.

— Creation of AMC 25.793, AMC 25.810, AMC 25.811, and AMC 25.819 to include a reference to FAA AC 25-17A in each.

— Amendment of AMC 25.809 to include a reference to FAA AC 25-17A. The content of the existing AMC 25.809, dealing with outside viewing aspects, is then transferred into a new AMC 25.809(a) entitled 'Emergency exit outside viewing'.

— Amendment of AMC 25.813 'Emergency Exit Access'. In the second paragraph, delete the text 'For Assist Spaces' and replace 'CS 25.813(b)' by 'CS 25.813'. Based on experience from certification projects, it has been concluded that the reference to the acceptability of AC 25-17A does not need to be limited to Assist Spaces.

— Amendment of AMC 25.853 'Compartment interiors'. Include a reference to FAA AC 20-178. This AC has been accepted on several EASA STC projects.

— Amendment of Appendix F as follows:

- Appendix F Part I (b)(4): Correct an editorial error. 'The burn length determined in accordance with subparagraph (7) of this paragraph…' the burn length subparagraph is (8) not (7)
- Appendix F part II (a)(3): Correct an editorial error. The paragraph should refer to CS 25.853(a) instead of CS 25.853(c).

Security provisions

It is proposed to amend CS 25.795 and AMC 25.795 to introduce new security specifications on chemical oxygen generators (COGs). The objective is to harmonise with FAA NPRM (Docket No. FAA–2012–0812; Notice No. 13–01) and the corresponding FAA draft AC 25.795-X.

This subject was initiated when the FAA became aware of a security vulnerability with certain types of oxygen systems installed inside the lavatories of most transport category aeroplanes, i.e. COGs. As a result, in April 2011, FAA issued Airworthiness Directive (AD) 2011–04–09, mandating that these oxygen systems be rendered inoperative until the vulnerability could be eliminated. Please refer to the FAA NPRM mentioned above for more details on the background linked to this AD. In the EU, the Agency did not issue an equivalent AD as the decision for such a security subject is to be taken by the competent bodies in the Member States.

FAA then chartered the Lavatory Oxygen Aviation Rulemaking Committee (LOARC). LOARC was tasked to make recommendations on new standards that would ensure the installation of a safe and secure COG system, including the best approach to implement those standards. The Agency had a member in the LOARC group.

The LOARC's recommendations have been used by FAA to propose an amendment of 14 CFR Part 25, §25.795 (above mentioned NPRM) and a new Advisory Circular 25.795-X (Chemical Oxygen Generator Security Standards) published in January 2013.

The proposal would create new standards for COGs installed in large aeroplanes. This would address potential security vulnerabilities with those devices, and provide performance-based options for acceptable COG installations.

The Agency agrees with the LOARC recommendations and the FAA NPRM/Draft AC.

CS 25.795 would be amended with the creation of a new subparagraph (d) requiring that each COG or its installation must be designed to be secure from deliberate manipulation by meeting at least one of the following four conditions:

(a) by providing effective resistance to tampering;

(b) by providing an effective combination of resistance to tampering and active tamper-evident features;

(c) installation in a location or manner wherein any attempt to access the COG would be immediately obvious; or

(d) by a combination of these approaches, provided the Agency finds it to be a secure installation.

A new AMC 25.795(d) is proposed providing guidance and means of compliance.

Compared to the FAA draft AC 25.795-X, the following change was made:

In paragraph 4.f 'System Performance When Installed', subparagraph (2) is deleted.

Reason: This subparagraph, mentioning the possibility for applicants to use oxygen system technologies that are certified using an Equivalent Safety Finding (ESF) to CS/FAR 25.1443, is not specifically linked to the subject of this AMC and does not need to be included.

CS 25.1450(b) would also be amended to make reference to the requirements of CS 25.795(d).

It can be noticed that the new COG specification is not limited to lavatory installations.

Finally, it is reminded that CS-25 does not mandate the installation of COGs, therefore, other means of providing supplemental oxygen can be used which eliminate the security vulnerability (for instance stored gas systems).

Note: The proposed changes to CS-25 in Chapter 3 of this NPA are based on the text of the FAA NPRM and draft AC. To ensure the greatest possible harmonisation with FAA, the Agency will amend CS-25 only once the FAA final rule and final AC are available and have been found acceptable to the Agency.

Avionics

It is proposed to amend AMC 25-11 'Electronic Flight Deck Displays' to add new Appendices, in harmonisation with the FAA draft AC 25-11A change 1. This AMC 25-11 amendment was previously planned to be proposed through a separate rulemaking task

RMT.0112 (25.037b) (‘Avionics Phase 2’). Rulemaking task RMT.0112 is, therefore, deleted.

Two new Appendices are proposed:

— Appendix 6 for Head-Up Displays (HUD)

— Appendix 7 for Weather Displays (WD)

These new Appendices were developed by the Avionics Systems Harmonisation Working Group (ASHWG) (chartered by FAA), and the Agency was represented in this group.

The following change was made relative to the FAA published draft AC 25-11A change 1:

Chapter 2.2.1 ‘Prevention of head injury’:

The following text is deleted: ‘the head injury criteria defined in CS 25.562(c)(5). Additionally, the HUD installation must comply with[…]’.

Reason: Flight deck seats are excluded from the scope of CS 25.562, although they are included in the FAR Part 25 equivalent paragraph.

Note: The proposed changes to CS-25 in Chapter 3 of this NPA are based on the text of the FAA draft AC. To ensure the greatest possible harmonisation with FAA, the Agency will amend CS-25 only once the FAA final AC is available and has been found acceptable to the Agency.

3. Proposed amendments

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

(a) deleted text is marked with ~~strike through~~;

(b) new or amended text is highlighted in grey;

(c) an ellipsis (…) indicates that the remaining text is unchanged in front of or following the reflected amendment.

3.1. Draft Certification Specifications (CS-25) (Draft EASA Decision)

BOOK 1

— Amend CS 25.562 as follows:

CS 25.562 Emergency landing dynamic conditions

(see AMC 25.562)

…

— Amend CS 25.785 as follows:

CS 25.785 Seats, berths, safety belts and harnesses

(see AMC 25.785, AMC 25.785(g))

…

(d) Each occupant of a seat ~~(see AMC 25.785(d))~~ that makes more than an 18degree angle with the vertical plane containing the aeroplane centreline […]

…

— Amend CS 25.793 as follows:

CS 25.793 Floor surfaces

(see AMC 25.793)

…

— Amend CS 25.795 by creating a new subparagraph (d) as follows:

CS 25.795 Security considerations

(see AMC 25.795, AMC 25.795(a)(1), (a)(2), AMC 25.795(b)(1), (b)(2), (b)(3), AMC 25.795(c)(1), (c)(2), (c)(3), AMC 25.795(d))

…

(d) Each chemical oxygen generator or its installation must be designed to be secure from deliberate manipulation by one of the following:

(1) By providing effective resistance to tampering,

(2) By providing an effective combination of resistance to tampering and active tamper-evident features,

(3) By installation in a location or manner whereby any attempt to access the generator would be immediately obvious, or

(4) By a combination of approaches specified in subparagraphs (d)(1), (d)(2) and (d)(3) of this paragraph.

— Amend CS 25.809(g) as follows:

CS 25.809 Emergency exit arrangement

(See AMC 25.809, AMC 25.809(a), AMC 25.809(a)(3))

…

(g) There must be provisions to minimise the probability of jamming of the emergency exits resulting from fuselage ~~d Het Verloren Symbooleformation~~ deformation in a minor crash landing.

…

— Amend CS 25.810 as follows:

CS 25.810 Emergency egress assisting means and escape routes

(See AMC 25.810, AMC 25.810(c)(2))

…

— Amend CS 25.811 as follows:

CS 25.811 Emergency exit marking

(See AMC 25.811, AMC 25.811(e)(4))

…

— Amend CS 25.819 as follows:

CS 25.819 Lower deck service compartments (including galleys)

(See AMC 25.819)

— Amend CS 25.1450(b) by creating a new subparagraph (b)(3) as follows:

CS 25.1450 Chemical oxygen generators

…

(b) Each chemical oxygen generator must be designed and installed in accordance with the following requirements:

…

(3) Comply with CS 25.795(d)

— Amend Appendix F as follows:

Appendix F

Part I – Test Criteria and Procedures for Showing Compliance with CS 25.853, 25.855 or 25.869

…

(b) *Test Procedures* –

…

(4) *Vertical test*.

…

The burn length determined in accordance with subparagraph (~~7~~8) of this paragraph must be measured to the nearest 2·5 mm (tenth of an inch).

…

Appendix F

Part II – Flammability of Seat Cushions

(a) *Criteria for Acceptance*.

…

(3) Each specimen tested (…) as determined by the test specified in CS 25.853(~~c~~a), does not exceed the corresponding burn length of the dress covering used on the cushion subjected to the oil burner test.
…

BOOK 2

— Create a new AMC 25.562 as follows:

AMC 25.562

Emergency landing dynamic conditions

FAA AC 25.562-1B, *Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes*, dated 01/10/06, and FAA AC 20-146, *Methodology for Dynamic Seat Certification by Analysis for Use in Parts 23, 25, 27, and 29 Airplanes and Rotorcraft*, dated 5/19/03, are accepted by the Agency as providing acceptable means of compliance with CS 25.562.

— Create a new AMC 25.785 as follows:

AMC 25.785

Seats, berths, safety belts and harnesses

FAA AC 25.785-1B, *Flight Attendant Seat and Torso Restraint System Installations*, dated 05/11/10, and relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.785.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Delete AMC 25.785(d), *Seats and Safety Belts*.

— Create a new AMC 25.793 as follows:

AMC 25.793

Floor surfaces

Relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.793.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Create a new AMC 25.795(d) as follows:

AMC 25.795(d)

Security of chemical oxygen generators

1. Purpose

CS 25.795(d) requires each chemical oxygen generator (COG) or its installation to be designed so it meets one of several criteria. The means of compliance described in this AMC provides guidance to supplement the engineering and operational judgment that must form the basis of any compliance findings related to a COG installed on an aeroplane.

2. Definition of Terms

For this AMC, the following definitions should be used:

(a) **Access** - The ability to manipulate the COG with the intent of making alterations for a purpose for which the COG was not originally designed. This includes gaining access to the area surrounding the COG.

(b) **Activation** - Release of the firing mechanism of the COG for the purpose of initiating the chemical reaction inside.

(c) **Alteration** - A change in the configuration of the COG once 'access' has been gained for the purpose of using the COG for other than its intended function.

(d) **COG** - chemical oxygen generator.

(e) **Immediately obvious** - Where an attempt to gain 'access' to the COG would be readily recognised as suspicious (prior to gaining 'access'). This would only be in locations with 'unrestricted access' that are 'observable'.

(f) **Intervention** - The actions crew members must take to prevent damage to the aeroplane once an alert is activated indicating that the COG is being tampered with. The time it takes to intervene with someone in the lavatory has not been determined, however, it can be assumed that it will take several minutes to resolve the issue.

(g) **Observable** - A crew member is able to see if a person attempts to gain 'access' to a COG installation during the course of the crew member's normal duties.

(h) **Tamper evident** - A unique feature that provides an active and obvious contemporaneous alert to crew members that someone is trying to gain 'access' to the COG and immediate crew 'intervention' is necessary.

(i) **Tamper resistance** - The level of deterrence for gaining 'access' to the COG.

(j) **Unrestricted access** - An area of the cabin passengers can enter without overcoming locks or other mechanical closure means.

3. Related Certification Specifications

CS 25.795	Security considerations
CS 25.1301	Equipment - Function and installation
CS 25.1309	Equipment, systems, and installations

CS 25.1322 Flight Crew Alerting

CS 25.1450 Chemical oxygen generators

4. Compliance with CS 25.795(d)

(a) Acceptable means of determining if a COG or its installation is designed to be secure

Several criteria may be used for determining if a COG installation is secure or has a security vulnerability. COG installations with a security vulnerability must include design features to prevent potential misuse of the COG. Figure 1, Criteria for Assessing an Installation, includes assessment criteria that can be used for determining if a COG installation has a security vulnerability. Table 1 includes guidance to assist in answering the questions in Figure 1. For installations identified as having security vulnerabilities, such as those for which the answers to the assessment statements in Figure 1 result in the answer to question number 4 being yes, the design should be changed. Alternatively, the COG can be replaced with an acceptable oxygen source that is not a security threat.

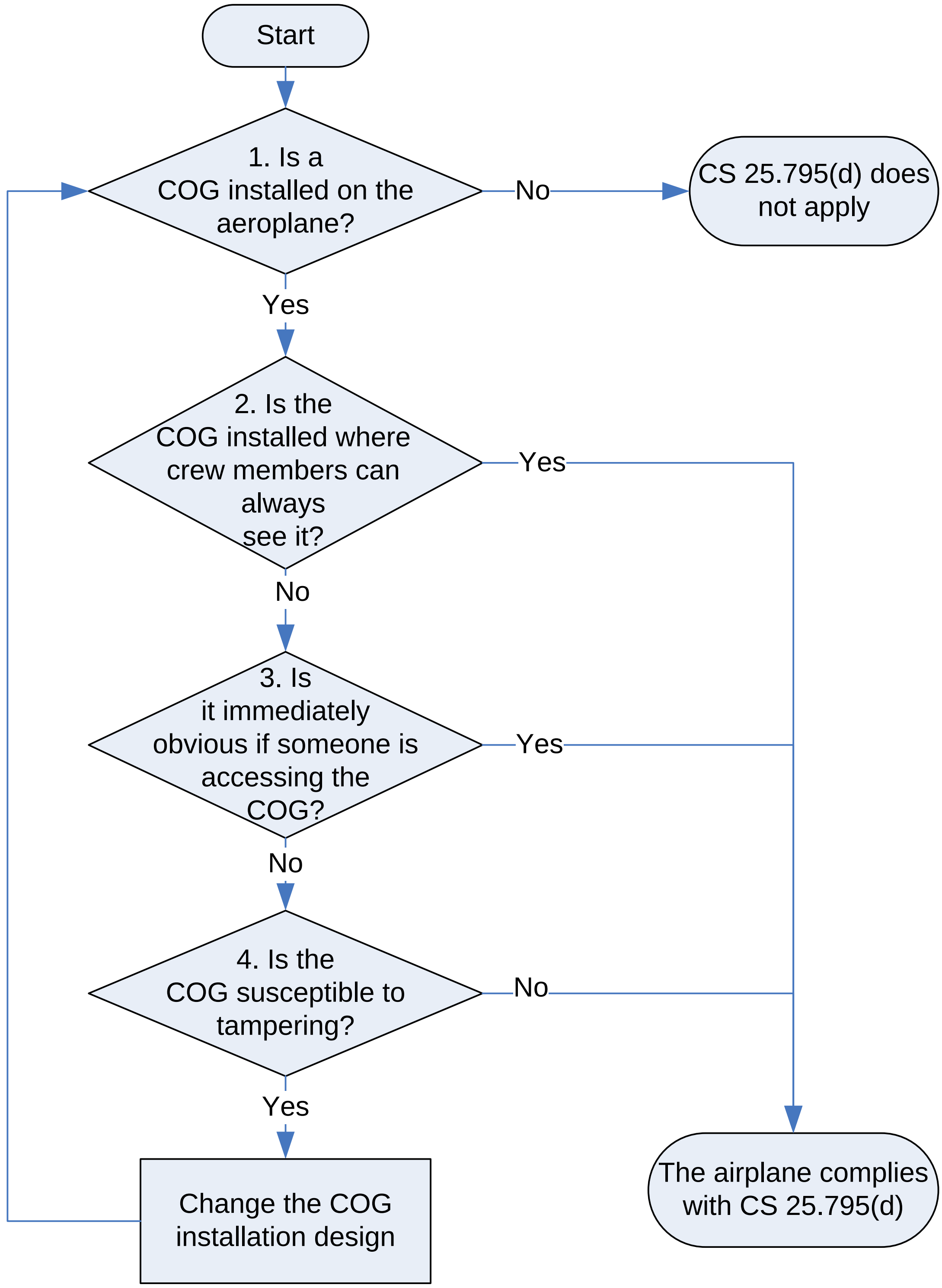

Figure 1: Criteria for assessing an installation

Question Number	Notes and questions to assist with assessment statement analysis
1.	Review the instructions for continued airworthiness. Review drawing system. Inspect the aeroplane's configuration.
2.	Crew members can observe the COG installation. heck the area where the COG is installed. Isolated areas such as galleys, lavatories, crew rests, enclosed occupied compartments, lower lobe lavatory complexes are potential areas of concern and require further evaluation. Are crew members close to the COG installation during their normal duties? Are there physical barriers between the crew member and the area being evaluated? Is there significant distance between the crew member and the area being observed? How accessible is the COG? Is the COG installation surrounded by curtains? Curtained areas are also considered potential areas of concern and may require further evaluation.
3.	Are there locks on doors/access panels? Are there tamper resistance fasteners on panels? Alarms or some other active alerting tamper indication method is part of the installation's design.
4.	Check if the COG can be compromised in place. Assess the vulnerability of the adjacent materials to contain the compromised device. Assess the ability of the compartment to contain the event. Check if the COG can be removed.

Table 1: Assessment statement analysis

(b) **Installation of tamper-resistant features**

Tamper resistant design features can be used, in whole or in part, to make a COG installation secure. There are different types of tamper resistant design features, and their functionality largely depends on the installation. The principal benefit of tamper resistance is to delay exploitation of the COG as a weapon. However, it is not likely that an existing COG installation that can be accessed from within the lavatory could be modified with tamper resistant design features sufficient to prevent a successful attack. This is because typical measures of tamper resistance, such as 'special' tools and fasteners, could likely be overcome given enough time. These measures are normally used as one of several layers of security. Thus, the reliance on such measures is only one element of the security system.

(1) A tamper resistant installation employs multiple elements, which may include:

(i) the COG's location;

(ii) the method of mounting;

(iii) physical protection (through shielding or mechanical isolation of key components); and

(iv) internal design.

(2) Eliminating access to the COG is the most straightforward way to make the COG tamper-resistant. Typically, this can be done by placing the COG in a location where significant disassembly of the cabin interior would be required to gain access. For example, the COG for a lavatory could be located so the entire lavatory module would have to be removed to access the COG.

(c) **Installation of tamper-evident features**

(1) For COGs that can be accessed from isolated compartments, such as lavatories, some form of active tamper evidence (for example, an alarm) would be needed in addition to the installation of tamper-resistant features. This is necessary so that the time to intervene and stop the attack is less than the time required to carry out the attack. In this case, passive tamper-evident features, such as a tamper-evident seal, are not effective because they provide an after-the-fact notification of tampering. The effectiveness of a tamper evidence system depends on intervention; it cannot be assumed that the 'alarm' by itself would inhibit the attack.

(2) Once an alert is activated indicating the COG is being tampered with, actions by crew members and other available authorised responders are necessary to prevent catastrophic damage to the aeroplane. Therefore, there is a critical relationship between the tamper evidence system and the training and capability of the crew to respond. To be most effective, crew training should be accomplished prior to the alarm feature being deployed into the fleet. The time needed to successfully respond to the alarm may be several minutes and depends on several factors. The time available to respond to a threat and intervention times are functions of not only the design features but also many complex and human factors-dependant variables that are difficult to define. These variables include, but are not limited to, the individual capabilities and numbers of flight attendants/authorised responders relative to the terrorists/accomplices, as well as the extensiveness of the training received.

(d) **System safety considerations** The applicant should consult AMC 25.1309 for guidance on compliance with CS 25.1309.

(e) **Hazard classification.** Failure of tamper-resistant or tamper-evident features should be considered major.

(f) **System performance when installed**

A tamper evidence system installed for compliance with CS 25.795(d) is intended to notify crew members that someone is trying to gain access to a COG, presumably for the purpose of creating a potentially catastrophic in-flight fire. The system should provide aural and visual warnings to immediately notify crew members so they can provide direct response in a timely fashion. For example, visual indication should be provided so the crew can identify which COG location is being tampered with while performing their normal duties. Aural alerts should be distinct from other alerts and clearly audible to the crew members expected to respond to the alert. If an alert is provided to the flight crew, the alert should be presented in accordance with CS 25.1322.

5. Areas that are immediately obvious

For COG installations located where any attempt at tampering would be 'immediately obvious', additional safety measures are not required. Immediately obvious areas include the main passenger cabin and other areas where occupants are always present. While some measure of tamper resistance is encouraged for these locations, none is required to meet CS 25.795(d). 'Private' compartments (such as a lavatory) or visually divided sections of larger cabin areas are assessed independently. The 'immediately obvious' criterion applies to the specific location of each COG installation, not simply the general area in which it is located. In addition, the installation must be evaluated under all conditions that may exist during a flight. So, for example, if tampering would be 'immediately obvious' except when a curtain is pulled to provide privacy, the installation must be evaluated based on the curtain being arranged in a way that most conceals the installation.

— Amend AMC 25.809 as follows:

AMC 25.809

Emergency exit arrangement

Relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.809.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

~~The requirement to provide a view of the outside in all ambient lighting conditions suggests the use of externally mounted lighting (although other means may be acceptable). In the landing gear collapsed cases, the rolling and pitching effects on the fuselage may redirect a fixed lamp's beam away from the area illuminated in the all landing gears extended condition. Furthermore, in the case of inflatable escape slides the toe end ground contact point will probably move in the opposite direction to that of the lamp beam.~~

~~In recognition of these effects, and in order to maintain reasonable demands on the complexity and power of external lighting equipment, the rule does not require the entire viewable area to be visible in all ambient lighting conditions. The only specific illumination requirement is for the likely areas of evacuee ground contact, with all landing gears extended, for passenger exits.~~

~~However, it is recommended that as large a field of view as is practicable should be provided, taking into account aspects such as fuselage curvature and door/window/hatch location, in order to provide the best chance to identify external evacuation hazards before exits are opened.~~

~~In the case of a flight crew emergency exit, a flight deck window as conventionally configured, used in conjunction with a suitably accessible and powerful portable illumination device (e.g. flashlight) will provide an acceptable means for viewing outside conditions.~~

~~Flight deck seats, consoles etc., as conventionally configured, are not considered to be obstructions in the meaning of this term in CS 25.809(a)(2) in the case where flight deck windows are the viewing means and the exit is an overhead hatch. Furthermore, it is~~

~~considered that the distance between flight deck windows, as conventionally configured, and an overhead hatch is such that the criterion for the viewing means to be adjacent to the exit is satisfied.~~

— Create a new AMC 25.809(a) as follows:

AMC 25.809(a)

Emergency exit outside viewing

The requirement to provide a view of the outside in all ambient lighting conditions suggests the use of externally mounted lighting (although other means may be acceptable). In the landing gear collapsed cases, the rolling and pitching effects on the fuselage may redirect a fixed lamp's beam away from the area illuminated in the all landing gears extended condition. Furthermore, in the case of inflatable escape slides, the toe end ground contact point will probably move in the opposite direction to that of the lamp beam.

In recognition of these effects, and in order to maintain reasonable demands on the complexity and power of external lighting equipment, the rule does not require the entire viewable area to be visible in all ambient lighting conditions. The only specific illumination requirement is for the likely areas of evacuee ground contact, with all landing gears extended, for passenger exits.

However, it is recommended that as large a field of view as is practicable should be provided, taking into account aspects such as fuselage curvature and door/window/hatch location, in order to provide the best chance to identify external evacuation hazards before exits are opened.

In the case of a flight crew emergency exit, a flight deck window as conventionally configured, used in conjunction with a suitably accessible and powerful portable illumination device (e.g. flashlight) will provide an acceptable means for viewing outside conditions.

Flight deck seats, consoles, etc., as conventionally configured, are not considered to be obstructions in the meaning of this term in CS 25.809(a)(2) in the case where flight deck windows are the viewing means and the exit is an overhead hatch. Furthermore, it is considered that the distance between flight deck windows, as conventionally configured, and an overhead hatch is such that the criterion for the viewing means to be adjacent to the exit is satisfied.

— Create a new AMC 25.810 as follows:

AMC 25.810

Emergency egress assisting means and escape routes

Relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.810.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Create a new AMC 25.811 as follows:

AMC 25.811

Emergency exit marking

Relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.811.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Amend AMC 25.813 as follows:

AMC 25.813

Emergency Exit Access

The term 'unobstructed' should be interpreted as referring to the space between the adjacent wall(s) and/or seat(s), the seatback(s) being in the most adverse position, in vertical projection from floor level to at least the prescribed minimum height of the exit.

~~For Assist Spaces,~~ R~~r~~elevant parts of the FAA Advisory Circular 25-17A Transport Airplane Cabin Interiors Crashworthiness Handbook, dated 05/18/09 ~~is~~are accepted by the Agency as providing acceptable means of compliance with CS 25.813~~(b)~~.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Create a new AMC 25.819 as follows:

AMC 25.819

Lower deck service compartments (including galleys)

Relevant parts of FAA AC 25-17A, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, are accepted by the Agency as providing acceptable means of compliance with CS 25.819.

— Amend AMC 25.853 as follows:

AMC 25.853

Compartment interiors

Relevant parts of the FAA Advisory Circular 25-17A *Transport Airplane Cabin Interiors Crashworthiness Handbook*, dated 05/18/09, AC 25.853-1 Flammability Requirements for Aircraft Seat Cushions, dated ~~17/9/~~9/17/86, ~~and~~ AC 25-18 Transport Category Airplanes Modified for Cargo Service, dated ~~6/1/~~1/6/94, and AC 20-178 Flammability Testing of Aircraft Cabin Interior Panels After Alterations, dated June 4, 2012, are accepted by the Agency as providing acceptable means of compliance with CS 25.853.

Note: 'Relevant parts' means 'the parts of the AC 25-17A that address the applicable FAR/CS-25 paragraph'.

— Amend AMC 25-11 as follows:

AMC 25-11

Electronic Flight Deck Displays

Content

…

List of Appendices

…

CHAPTER 1
BACKGROUND

…

6. Background

a. Electronic displays can present unique opportunities and challenges to the design and certification process. In many cases, showing compliance with certification specifications related to the latest flight deck display system capabilities has been subject to a great deal of interpretation by applicants and the Agency. At the time the first electronic displays were developed, they were direct replacements for the conventional electromechanical components.The initial release of AMC 25-11 established an acceptable means of compliance for the approval of cathode ray tube (CRT) based electronic display systems used for guidance, control, or decision-making by the flight crews of large aeroplanes. This initial release was appropriate for CRTs, but additional specifications were needed to update AMC 25-11 to address new technologies. Additional appendices have been added to address Head-Up Displays (Appendix 6) and Weather Displays (Appendix 7).

…

CHAPTER 3

ELECTRONIC DISPLAY HARDWARE

16. Display Hardware Characteristics

…

b. Installation

…

(7) When a display is used to align or overlay symbols with realworld external data (for example, HUD symbols), the display should be installed such that positioning accuracy of these symbols is maintained during all phases of flight. Appendix 6 of this AMC and SAE ARP 5288, *Transport Category Aeroplane Head Up Display (HUD) Systems*, provide~~s~~ additional details regarding the symbol positioning accuracy for conformal symbology on a HUD.

…

Appendix 1

Primary Flight Information

…

2.1 Airspeed and Altitude

Airspeed and altitude displays should be able to convey to the flight crew a quick-glance sense of the present speed or altitude. Conventional round-dial moving pointer displays inherently give some of this sense that may be difficult to duplicate on moving scales. Scale length is one attribute related to this quick-glance capability.

The minimum visible airspeed scale length found acceptable for moving scales has been 80 knots; since this minimum is dependant on other scale attributes and aeroplane operational speed range, variations from this should be verified for acceptability. A displayed altitude that is geometrically derived should be easily discernable from the primary altitude information, which is barometrically derived altitude. To ensure the pilot can easily discern the two, the label "GSL" should be used to label geometric height above mean sea level. See section 5.4.4 of Appendix 6 for HUD-specific airspeed considerations.

…

~~2.2 Airspeed and Altitude for HUD~~

~~To reduce display clutter, during the precision approach phase of flight, HUD formats have been accepted that provide an alphanumericonly display of airspeed and altitude. Acceptance of these display formats is predicated on the unique characteristics of the precision approach operation and the availability of compensating features for the lack of visual awareness of high and low speed limits.~~

~~The compensating features for HUD formats that provide an alphanumericonly display of airspeed and altitude is that the information display should also provide clear and distinct alerts to the~~

~~flight crew when these and any other required parameters exceed well defined tolerances around the nominal approach range, and when these alerts have associated procedures that require the termination of the approach.~~

~~Previously accepted display formats also included effective cues for acceleration and speed deviation so that the pilot could manually achieve tight speed control to preclude unintended proximity to low speed limits. When an alphanumericonly~~

~~indication of airspeed and altitude HUD format is displayed, there should still remain an overall awareness of the following indications:~~

~~• Airspeed/altitude,~~

~~• Airspeed/altitude trends,~~

~~• Deviations from selected airspeed/altitude targets,~~

~~• Low and high airspeed limits, and~~

~~• Selected airspeed/altitude setting changes.~~

2.~~3~~2 Low and High Speed Awareness Cues

…

4. Flight Path Vector or Symbol

The display of flight path vector (FPV or velocity vector) or flight path angle (FPA) cues on the primary flight display is not required, but may be included in many designs.

The FPV symbol can be especially useful on HUD applications. See section 5.4.5 of Appendix 6 for HUD-specific FPV considerations. ~~The FPV display on the HUD should be conformal with the outside view when the FPV is within the HUD field of view. During flight situations with large bank, pitch, and/or wind drift angles; the movement of the FPV may be limited by the available display fieldofview.~~

~~In some designs, the pilot can manually cage the FPV which restricts its motion to the vertical axis, thereby making it an FPA.~~

…

Appendix 4

Acronyms used in this AMC

AC	(FAA) Advisory Circular
AMC	Acceptable Means of Compliance
ARAC	Aviation Rulemaking Advisory Committee
ARP	Aerospace Recommended Practices
AS	Aerospace Standard
CCD	Curser Control Device
CFR	Code of Federal Regulations
CRT	Cathode Ray Tube
CS-AWO	EASA Certification Specifications for All Weather Operations
DEP	Design Eye Position
EASA	European Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation ~~Electronics~~ Equipment
FAA	Federal Aviation Administration

FOV	Field-of-view
GUI	Graphical User Interface
HDD	Head down Display
HUD	Head up Display
JAA	Joint ~~Airworthiness~~ Aviation Authorities
LCD	Liquid Crystal Display
PF	Pilot flying
PNF	Pilot not flying
SAE	SAE International (formerly Society of Automotive Engineers)
TCAS	Traffic Alert and Collision Avoidance System

Appendix 6

Head-Up Display

CONTENTS

1.0 Introduction

1.1 Purpose

This Appendix provides additional guidance related to the unique aspects, characteristics, and functions of head-up displays (HUDs) for transport category aeroplanes. This appendix also addresses issues related to the design, analysis, and testing of HUDs. It addresses HUDs that are designed for a variety of different operational concepts and functions. This guidance applies to HUDs that are intended to be used as a supplemental display in which the HUD contains the minimum information immediately required for the operational task associated with the intended function. It also applies to HUDs that are intended to be used effectively as primary flight displays. This appendix addresses both the installation of a single HUD, typically used by the left-side pilot, as well as special considerations related to dual HUDs, one for each pilot.

1.2 Definition of Head-Up Display (HUD)

A HUD is a display system that projects primary flight information (for example, attitude, air data, and guidance) on a transparent screen (combiner) in the pilot's forward field-of-view, between the pilot and the windshield. This allows the pilot to simultaneously use the flight information while looking along the forward path out of the windshield, without scanning the head-down displays. The flight information symbols should be presented as a virtual image focussed at optical infinity. Attitude and flight path symbology needs to be conformal (that is, aligned and scaled) with the outside view.

1.3 Other resources

For guidance associated with specific operations using HUDs, such as low visibility approach and landing operations, see the relevant requirements and guidance material (e.g. EASA Certifications Specifications for All Weather Operations (CS-AWO), and FAA Advisory Circular (AC) 120-28D, *Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout*). In addition, Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 5288, *Transport Category Aeroplane Head Up Display (HUD) Systems*; SAE Aerospace Standard (AS) 8055, *Minimum Performance Standard for Airborne Head Up Display (HUD)*; and SAE ARP5287, *Optical Measurement Procedures for Airborne Head Up Display*; provide guidance for designing and evaluating HUDs.

2.0 Unique safety considerations

2.1 Aircraft and systems safety

2.1.1 Systems

Installing HUD systems in flight decks may introduce complex functional interrelationships among the flight crew members and other display and control systems. Consequently, a functional hazard assessment which requires a top-down approach from an aeroplane-level perspective should be developed in accordance with CS 25.1309. Developing a functional hazard assessment for a particular installation requires careful consideration of the role that the HUD plays within the flight deck in terms of integrity of function and availability of function, as well as the operational concept of the installation to be certified (e.g. dual- versus single-HUD installation and the type and amount of information displayed). Chapter 4 of this AMC provides material that may be useful in preparing the functional hazard assessment.

2.1.2 Aeroplane flight manual procedures

All alleviating flight crew actions that are considered in the HUD safety analysis need to be validated for incorporation in the aeroplane flight manual procedures section or for inclusion in type-specific training.

2.1.3 Availability of primary flight information

Since the flight information displayed on the HUD is visible only to one pilot, it cannot be used as the single remaining display to comply with CS 25.1333(b). The rule requires that, after the loss of other flight information displays, 'one display of the information essential to the safety of flight' remains available to both pilots, not just one pilot.

2.2 Crew safety

2.2.1 Prevention of head injury

HUD equipment introduces potential hazards that are not traditionally associated with head-down electronic flight deck displays. The HUD system must be designed and installed to prevent the possibility of pilot injury in the event of an accident or any other foreseeable circumstance such as turbulence, hard landing, or bird strike. The installation of the HUD, including the overhead unit and combiner, must comply with the occupant injury requirements of CS 25.785(d) and (k) and the retention requirements of CS 25.789(a).

2.2.2 Special considerations for dual-HUD installations

In a dual-HUD installation, both pilots could possibly experience incapacitating injuries as a result of flight or gust loads. This possibility becomes a safety-of-flight issue, since the entire flight crew would be incapacitated. If analysis of the installation geometry indicates that flight or gust loads may produce occupant contact with the HUD installation, then the Agency may need to provide an issue paper providing project-specific means of compliance.

2.2.3 Non-interference with emergency equipment

CS 25.803, CS 25.1411, and CS 25.1447 require that the HUD installation must not interfere with, or restrict the use of other installed equipment such as emergency oxygen masks, headsets, or microphones. The installation of the HUD must not adversely affect the emergency egress provisions for the flight crew, or significantly interfere with flight crew access. The system must not hinder the flight crew's movement while conducting any flight procedures.

3.0 Design

3.1 Intended function of HUDs

The applicant is responsible for identifying the intended function of the HUD. The description of the intended function should include the operational phases of flight and the concept of operation, including how, when, and for what purpose(s) the HUD is to be used. For example, the HUD may display situational information and/or guidance information during all phases of flight.

3.1.1 General

In most applications, HUDs provide an indication of primary flight references, which allow the pilot to rapidly evaluate the aircraft attitude, energy status, and position during the phases of flight for which the HUD is designed. HUDs are usually designed to present information to enhance pilot performance in such phases of flight as during the transition between instrument and visual flight conditions with variable outside visibility conditions. While HUDs may be designed to display enhanced and synthetic visual imagery, particular means of compliance guidance for this purpose is not found in this Appendix. Refer to FAA AC 20-167, *Airworthiness*

Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment, for guidance.

3.1.2 Display of primary flight information

3.1.2.1 HUD as de facto primary flight display

If a HUD displays primary flight information, it is considered a *de facto* primary flight display while the pilot is using it, even if it is not the pilot's sole display of this information. The pilot should be able to easily recognise the primary flight information - it should not be ambiguous or confusing when taking into account information on other flight deck displays.

3.1.2.2 Applicable instrument requirements for HUD

Primary flight information displayed on the HUD should comply with all the requirements associated with such information in CS-25 (e.g. CS 25.1303(b) for flight and navigation instruments that must be visible from each pilot station and CS 25.1333(b) for the operational requirements of those systems). CS 25.1321(b) specifies the requirements for arranging primary flight information. For specific guidance regarding the display of primary flight information, see the main body and Appendix 1 of this AMC.

3.1.3 Display of other flight information

Additional information may be related to the display of command guidance or specific flight parameter information needed for operating the aeroplane by reference to the HUD.

3.1.3.1 Command guidance

When the HUD is used to monitor the autopilot, it should display the following information:

- Situation information based on independent raw data;
- Autopilot operating mode;
- Autopilot engage status; and
- Autopilot disconnect warning (visual).

3.1.3.2 Flight parameter information

The HUD should also display additional flight parameter information, if required, to enable the pilot to operate the aeroplane during phases of flight for which the HUD is approved. This additional information may include:

- Flight path indication;
- Target airspeed references and speed limit indications;
- Target altitude references and altitude awareness (e.g. decision height and minimum descent altitude) indications; or
- Heading or course references.

3.2 HUD controls

3.2.1 Control placement

For compliance with CS 25.777, the flight crew must be able to see, identify, and reach the means of controlling the HUD, including its configuration and display modes, from the normal seated position. To comply with CS 25.777 and CS 25.1301, the position and movement of the HUD controls must not lead to inadvertent operation.

3.2.2 Control illumination

To comply with CS 25.1381, the HUD controls must be adequately illuminated for all normal ambient lighting conditions and must not create any objectionable reflections on the HUD or other flight instruments. Unless a fixed level of illumination is satisfactory under all lighting conditions, there should be a means to control its intensity.

3.2.3 Control integration

To the greatest extent practicable, HUD controls should be integrated with other associated flight deck controls to minimise the flight crew workload associated with HUD operation and to enable flight crew awareness.

3.2.4 Ease of use

HUD controls, including the controls to change or select HUD modes, should be implemented to minimise flight crew workload for data selection or data entry, and allow the pilot to easily view and perform all mode control selections from the seated position.

3.3 Visibility and Field-of-View (FOV)

3.3.1 Field-of-View

The design of the HUD installation should provide adequate display FOV in order for the HUD to function as intended in all anticipated flight attitudes, aircraft configurations, and environmental conditions, such as crosswinds, for which it is approved. The aeroplane flight manual should specify all airworthiness and operational limitations related to these factors.

3.3.2 Impact on pilot compartment view

3.3.2.1 Interior view

Whether or not the combiner is deployed and the HUD is in use, it must not create additional significant obstructions to either pilot's compartment view as required by CS 25.773. The HUD must also not restrict the view of any flight deck controls, indicators, or other flight instruments as required by CS 25.777 and CS 25.1321.

3.3.2.2 External view

The HUD should not significantly obscure the necessary pilot compartment view of the outside world for normal, non-normal, or emergency flight manoeuvres during any phase of flight for a pilot seated at the design eye position (DEP). The HUD should not significantly affect the ability of any flight crew member to spot traffic, distinctly see approach lights, runways, signs, markings, or other aspects of the external visual scene. The combination of the windshield and the HUD must meet the requirements of CS 25.773(a)(1).

3.3.2.3 HUD optical performance

As far as practicable, the optical performance of the HUD must not cause distortions that degrade or detract from the flight crew's view of external references or of other aircraft. The optical performance should not degrade or detract from the flight crew's ability to safely perform any manoeuvres within the operating limits of the aeroplane, as required by CS 25.773. Where the windshield optically modifies the pilot's view of the outside world, the motions and positions of conformal HUD symbols must be optically consistent (i.e. aligned and scaled) with the perceived outside view. To avoid distortions, the optical qualities of the HUD should be uniform across the entire FOV. When both pilot's eyes view the HUD from any off-centre position within the design eyebox, optical non-uniformities shall not produce perceivable differences in the binocular view. SAE ARP 5288, *Transport Category Aeroplane Head Up Display (HUD) Systems*, provides additional guidance.

3.3.3 Conformal symbols with limited HUD Field-of-View

The range of motion of conformal symbology can present certain challenges in rapidly changing and high-crosswind conditions. In certain cases, the motion of the guidance and the primary reference cue may be limited by the FOV. It should be shown that, in such cases, the guidance remains usable and that there is a positive indication that it is no longer conformal with the outside scene. It should also be shown that there is no interference between the indications of primary flight information and the flight guidance cues.

4.0 HUD design eyebox criteria

4.1 Design eye position

FAA AC 25.773-1, *Pilot Compartment View Design Considerations*, defines the design eye position (DEP) as a single point that meets the requirements of CS 25.773 and CS 25.777. For certification purposes, the DEP is the pilot's normal seated position. Fixed markers or some other means should be provided at each pilot station to enable the pilots to position themselves in their seats at the DEP for an optimum combination of outside visibility and instrument scan. The HUD installation must comply with CS 25.773 and CS 25.1321. The HUD must be able to accommodate pilots, from 1 575 m to 1 905 m (5 ft 2 in to 6 ft 3 in) tall, while they are seated at the DEP with their shoulder harnesses and seat belts fastened, to comply with CS 25.777. The design eyebox should be positioned around the DEP.

4.2 Design eyebox

4.2.1 Display visibility requirements

The fundamental requirements for instrument arrangement and visibility in CS 25.773, CS 25.777, CS 25.1301, and CS 25.1321 apply to HUDs. Each flight instrument, including the flight information displayed in the HUD, for use by any pilot must be plainly visible at that pilot's station with minimum practicable deviation from the normal position and forward line of vision. While seated at the design eye position, the pilot must be able to see the flight information displayed in the HUD. The optical characteristics of the HUD, particularly the limits of its design eyebox, cause the pilot's ability to fully view essential flight information to be more sensitive to the pilot's eye position, as compared to head-down displays. The HUD design eyebox is a three-dimensional volume, specified by the manufacturer, within which display visibility requirements are met. Thus, whenever the pilot's eyes are within the design eyebox, the required flight information must be visible in the HUD. The size of the design eyebox and the layout of flight information in the HUD should be designed so that visibility of the displayed symbols is not unduly sensitive to pilot head movements in all expected flight conditions. In the event that the pilot's view of displayed information is totally lost as a result of a head movement, the pilot must be able to regain the view of the display rapidly and without difficulty. The minimum monocular FOV required to display this required flight information should include the centre of the FOV and must be specified by the manufacturer. The HUD FOV should be designed by considering the intended operational environment and potential aircraft configurations.

4.2.2 Design eyebox position

The HUD design eyebox should be laterally and vertically positioned around the respective pilot's DEP. It should be large enough so that the required flight information is visible to the pilot at the minimum displacements from the DEP listed below. The symbols must be laid out and positioned such that excessive eye movements are not required to scan elements of the display. The displayed symbols which are necessary to perform the required tasks must be visible to the pilot from the DEP. The HUD DEP must be the same as that defined for the basic flight deck in accordance with FAA AC 25.773-1.

4.2.3 Design eyebox dimensions

The lateral and vertical dimensions of the design eyebox represent the total movement of a monocular viewing instrument with a 6.35 mm (0.25 inch) entrance aperture (pupil). The longitudinal dimension of the design eyebox represents the total fore-aft movement over which the requirement of this specification is met (refer to SAE AS 8055). When the HUD is a primary flight display, when airworthiness approval is predicated on the use of the HUD, or when the pilot can be reasonably expected to operate primarily by reference to the HUD, dimensions larger than the minimums shown below may be necessary.

4.2.3.1 Lateral: 38.1 mm (1.5 inches) left and right from the DEP (76.2 mm (3.0 inches) wide).

4.2.3.2 Vertical: 25.4 mm (1.0 inch) up and down from the DEP (50.8 mm (2.0 inches) high).

4.2.3.3 Longitudinal: 50.8 mm (2.0 inches) fore and aft from the DEP (101 6mm (4.0 inches) deep).

4.3 Conformal display accuracy

4.3.1 Symbol positioning

The accuracy of symbol positioning relative to the external references, or display accuracy, is a measure of the relative conformality of the HUD display with respect to the pilot's view of the real world through the combiner and windshield from any eye position within the HUD design eyebox. The display accuracy is a monocular measurement. For a fixed field point, the display accuracy is numerically equal to the angular difference between the position of a real-world feature (as seen through the combiner and windshield) and the HUD projected symbology.

4.3.2 Error budget

The total error budget for the display accuracy of the HUD system (excluding sensor and windshield errors) includes installation errors, digitisation errors, electronic gain and offset errors, optical errors, combiner positioning errors, errors associated with the cathode ray tube (CRT) and yoke (if applicable), misalignment errors, environmental conditions (e.g. temperature and vibration), and component variations.

4.3.2.1 Error sources

Optical errors are dependant upon both the head position and the field angle. Optical errors are comprised of three sources: uncompensated pupil and field errors originating in the optical system aberrations, image distortion errors, and manufacturing variations. The optical errors are statistically determined by sampling the HUD FOV and the design eyebox. (See 4.2.10 of SAE AS8055 for a discussion of FOV and design eyebox sampling).

4.3.2.2 Total accuracy

The optical errors shall represent at least 95.4 % (2 sigma) of all sampled points. The display accuracy errors are characterised in both the horizontal and vertical planes. The total display accuracy shall be characterised as the root-sum square errors of these two component errors.

4.3.2.3 Allowable margin for display errors

All display errors shall be minimised across the display FOV consistent with the intended function of the HUD. The following are the allowable display accuracy errors for a conformal HUD as measured from the HUD eye reference point:

Table A6-1

Topics within the guidance of this AMC

Location on the HUD Combiner	Error Tolerance in milliradians (mrad)
At HUD boresight	≤ 5.0 mrad
≤ 10° diameter	≤ 7.5 mrad (2 sigma)
≤ 30° diameter	≤ 10.0 mrad (2 sigma)
> 30° diameter	< 10 mrad + kr[(FOV)(in degrees) - 30)] (2 sigma) where, kr = 0.2 mrad of error per degree of FOV

4.3.2.4 Maximum error

The HUD manufacturer shall specify the maximum allowable installation error. In no case shall the display accuracy error tolerances cause hazardously misleading data to be presented to the pilot viewing the HUD.

4.4 Symbol positioning alignment

The symbols intended for use in combination with other symbols and scales to convey meaning must be aligned and positioned precisely enough not to be misleading to the pilot.

4.5 Overlapping symbols

Symbols that share space with other symbols must not partially obscure or interfere with the appearance of other symbols in a way that misleads the pilot.

4.6 Alignment

4.6.1 Outside view

The HUD combiner must be properly aligned so that display elements such as attitude scales and flight path vector symbology are conformal (i.e. the position and motion are aligned and scaled). Proper combiner alignment is needed to match conformal display parameters as close as possible to the outside real world, depending on the intended function of those parameters.

4.6.2 Combiner

If the HUD combiner is stowable, means should be provided to ensure that it is in its fully deployed and aligned position before using the symbology for aircraft control. The HUD shall alert the pilot if the position of the combiner causes normally conformal data to become misaligned in a manner that may result in the display of misleading information.

4.7 Visual display characteristics

The following paragraphs highlight some areas related to performance aspects that are specific to the HUD. SAE ARP5288, *Transport Category Aeroplane Head Up Display (HUD) Systems* and SAE AS8055, *Minimum Performance Standard for Airborne Head Up Display (HUD)*, provide performance guidelines for a HUD. As stated in Chapter 3 of this AMC, the applicant should notify the Agency if any visual display characteristics do not meet the guidelines in ARP5288 and AS8055.

4.7.1 Luminance

4.7.1.1 Background light conditions

The display luminance (brightness) should be satisfactory in the presence of dynamically changing background (ambient) lighting conditions (0 to 10 000 foot Lamberts (fL) as specified in SAE AS8055), so that the HUD data are visible.

4.7.1.2 Luminance control

The HUD must have adequate means to control luminance so that displayed data is always visible to the pilot. The HUD may have both manual and automatic luminance control capabilities. It is recommended that automatic control is provided in addition to the manual control. Manual control of the HUD brightness level should be available to the flight crew to set a reference level for automatic brightness control. If the HUD does not provide automatic control, a single manual setting should be satisfactory for the range of lighting conditions encountered during all foreseeable operational conditions and against expected external scenes. Readability of the displays should be satisfactory in all foreseeable operating and ambient lighting conditions. SAE ARP 5288 and SAE AS8055 provide guidelines for contrast and luminance control.

4.7.2 Reflections

The HUD must be free of glare and reflections that could interfere with the normal duties of the minimum flight crew, as required by CS 25.773 and CS 25.1523.

4.7.3 Ghost images

A ghost image is an undesired image appearing at the image plane of an optical system. Reflected light may form an image near the plane of the primary image. This reflection may result in a false image of the object or an out-of-focus image of a bright source of light in the field of the optical system (e.g. a 'ghost image'). The visibility of ghost images within the HUD of external surfaces must be minimised so as not to impair the pilot's ability to use the display.

4.7.4 Accuracy and stability

4.7.4.1 Sensitivity to aircraft manoeuvring

The system operation should not be adversely affected by aircraft manoeuvring or changes in attitude encountered in normal service.

4.7.4.2 Motion of symbols

The accuracy of positioning of symbols must be commensurate with their intended use. Motion of non-conformal symbols must be smooth, not sluggish or jerky, and consistent with aircraft control response. Symbols must be stable with no discernible flicker or jitter.

5.0 Guidelines for presenting information

5.1 HUD and head-down display compatibility

5.1.1 General

If the content, arrangement, or format of the HUD is dissimilar to the head-down display, it can lead to flight crew confusion, misinterpretation, and excessive cognitive workload. During transitions between the HUD and head-down displays (whether required by navigation duties, failure conditions, unusual aeroplane attitudes, or other reasons), dissimilarities could make it more difficult for the flight crew to manually control the aeroplane or to monitor the automatic flight control system. Dissimilarities could also delay the accomplishment of time-critical tasks. Some differences may be unavoidable, such as the use of colour on the head-down display and a single colour (i.e. monochrome) on the HUD. The guidelines listed below are intended to minimise the potential for confusion, undue workload, and delays in flight crew task performance.

5.1.2 Exceptions

Deviation from the guidelines below may be unavoidable due to conflict with other information display characteristics or requirements unique to head-up displays. These deviations may relate to the minimisation of display clutter, minimisation of excessive symbol flashing, and the presentation of certain information conformal to the outside scene. Deviations from these guidelines require additional pilot evaluation.

5.1.3 Guidelines for HUD-head-down display compatibility

5.1.3.1 Consistent displays and format

The layout and arrangement HUD and head-down display formats of the same information need to convey the same intended meanings. For example, the relative locations of barometric altitude, airspeed, and attitude should be similar. Likewise, the acronyms and relative locations of flight guidance mode annunciations for thrust and lateral and vertical flight path should be similar.

5.1.3.2 Symbols

5.1.3.2.1 Shape and appearance

Symbols that have the same meaning should have the same shape and appearance. Likewise, HUD symbols that have similar shape and appearance as head-down display symbols should have the same meaning. It is not acceptable to use similar symbols for different meanings.

5.1.3.2.2 Special symbolic features

Special display features or changes may be used to convey particular conditions, such as an overlaid ‘X’ to mean failure of a parameter, a box around a parameter to convey that its value changed, a solid line/shape changing to a dashed line/shape to convey that its motion is limited, and so on. To the extent that it is practical and meaningful, the same display features should be used on the HUD as on the head-down display.

5.1.3.2.3 Relative location

Information that relates to the symbols should appear in the same general location relative to other information.

5.1.3.3 Alphanumeric information

Alphanumeric (i.e. textual) information should have the same resolution, units, and labelling. For example, the command reference indication for vertical speed should be displayed in the same foot-per-minute increments and labelled with the same characters as on the head-down displays. Likewise, the same terminology should be used for labels, modes, and alert messages on the HUD as on the head-down displays.

5.1.3.4 Analog scales or dials

Analog scales or dials should have the same range and dynamic operation. For example, a glideslope deviation scale displayed head-up should have the same displayed range as when it is displayed head-down, and the direction of movement should be consistent.

5.1.3.5 Flight guidance systems

Modes of flight guidance systems (e.g. autopilot, flight director, and autothrust) and state transitions (e.g. land 2 to land 3) should be displayed on the HUD. Except for the use of colour, the modes should be displayed using consistent methods (e.g. the method used head-down to indicate a flight director mode transitioning from armed to captured should also be used head-up).

5.1.3.6 Command information

When command information (e.g. flight director commands) is displayed on the HUD in addition to the head-down displays, the HUD depiction and guidance cue deviation scaling need to be consistent with that used on the head-down displays. This consistency is intended to provide comparable pilot performance and workload when using either head-up or head-down displays.

5.1.3.7 Sensor sources

Sensor system sources for instrument flight information (e.g. attitude, direction, altitude, and airspeed) should be consistent between the HUD and the head-down displays used by the same pilot.

5.1.4 Head-up to head-down transition

5.1.4.1 Transition scenarios

The applicant should identify conditions for which the pilot transitions between the HUD and the head-down display and develop scenarios for evaluation (e.g. simulation or flight test). These scenarios should include systems failures and events leading to unusual attitudes. Transition capability should be shown for all foreseeable modes of upset.

5.1.4.2 Unambiguous information

While the head-up and head-down displays may display present information (e.g. flight path, situational, or aircraft performance information) differently, any differences should not create confusion, misinterpretation, unacceptable delay, or otherwise hinder the pilot’s transition between the two displays. The pilot should be able to easily recognise and interpret information on the HUD. The information should not be ambiguous with similar information on other aircraft flight deck displays.

5.2 Indications and alerts

5.2.1 Monochrome attention-getting properties

To comply with CS 25.1322, and considering that most HUDs are predominantly monochrome devices, the HUD should emphasise the display of caution and warning information with the appropriate use of attention-getting properties such as flashing, outline boxes, brightness, size, and/or location to compensate for the lack of colour coding. The applicant should develop and apply a consistent documented philosophy for each alert level. These attention-getting properties should be consistent with those used on the head-down displays. For example, flashing icons on the HUD should indicate situations with the same level of urgency as flashing icons on the head-down displays.

5.2.2 Time-critical alerts on the HUD

For some phases of flight, airworthiness approval may be predicated on the use of the HUD. In these phases of flight, it can be reasonably expected that the pilot operates primarily by using the HUD, so the objective is to not redirect attention of the pilot flying (PF) to another display when an immediate manoeuvre is required (e.g. resolution advisory or windshear). The applicant should either provide in the HUD the guidance, warnings, and annunciations of certain systems, if installed, such as a Terrain Awareness and Warning System (TAWS), or a Traffic Alert and Collision Avoidance System (TCAS) and a wind shear detection system. If the provision of TCAS or windshear guidance is not practical on the HUD, the applicant should provide compensating design features and pilot procedures (e.g. a combination of means such as control system protections and an unambiguous reversion message in the HUD) to ensure that the pilot has equivalent and effective visual information for immediate awareness and response to the respective alerts.

5.2.3 Additional resources

Additional guidance on indications and alerts is in AMC No 1 to CS 25.1329, *Flight Guidance System*, and AMC No 2 to CS 25.1329, *Flight Testing of Flight Guidance Systems*, and AMC 25.1322, *Flight Crew Alerting*, and the associated rules.

5.3 Display clutter

This AMC addresses display clutter for traditional displays on the instrument panel. However, because the pilot must see through the HUD, special attention is needed to avoid display clutter that would otherwise unduly obscure the outside view.

5.4 Display of information

5.4.1 General

The HUD information display requirements depend on the intended function of the HUD. Specific guidance for displayed information is contained within the main body and Appendix 1 of this AMC. In addition, the following sections provide guidance related to unique characteristics of the HUD. As in the case of other flight deck displays, new and novel display formats may be subject to human factors evaluation of the pilot interface by an airworthiness authority.

5.4.2 Alternate formats for primary flight information

5.4.2.1 Phase of flight

There may be certain operations and phases of flight during which certain primary flight reference indications in the HUD do not need to have the analog cues for trend, deviation, and quick glance awareness that would normally be necessary. For example, during the precision approach phase, HUD formats have been accepted that provide a digital-only display of airspeed and altitude. Acceptance of these displays has been predicated on the availability of compensating features that provide clear and distinct warning to the flight crew when these and certain other parameters exceed well-defined tolerances around the nominal approach state (e.g. approach warning). These warnings have associated procedures that require a missed approach.

5.4.2.2 Digital displays

Formats with digital-only display of primary flight information (e.g. airspeed, altitude, attitude, and heading) should be demonstrated to provide at least one of the following:

— a satisfactory level of task performance;

— a satisfactory awareness of proximity to limit values like V_S, V_{MO}, and V_{FE}; and

— a satisfactory means to avoid violating such limits.

5.4.2.3 Go-around and missed approach

If a different display format is used for go-around than that used for the approach, the format transition should occur automatically as a result of the normal go-around or missed approach procedure.

5.4.2.4 Minimise format changes

Changes in the display format and primary flight data arrangement should be minimised to prevent confusion and to enhance the flight crew's ability to interpret vital data.

5.4.3 Aircraft control considerations

For those phases of flight where airworthiness approval is predicated on the use of the HUD, or when it can be reasonably expected that the flight crew will operate primarily by reference to the HUD, the HUD should adequately provide the following information and cues.

5.4.3.1 Flight state and position

The HUD should provide information to permit the pilot to instantly evaluate the aeroplane's flight state and position. This information should be adequate for manually controlling the aeroplane and for monitoring the performance of the automatic flight control system. Using the HUD for manual control of the aeroplane and monitoring of the automatic flight control system should not require exceptional pilot skill, excessive workload, or excessive reference to other flight displays.

5.4.3.2 Attitude cues

Attitude cues must enable the pilot to instantly recognise unusual attitudes. Attitude cues must not hinder unusual attitude recovery. If the HUD is designed to provide guidance or information for recovery from upsets or unusual attitudes, recovery steering guidance commands should be distinct from, and not confused with, orientation symbology such as horizon pointers. This capability should be shown for all foreseeable modes of upset, including crew mishandling, autopilot failure (including 'slowovers'), and turbulence/gust encounters.

5.4.4 Airspeed considerations

5.4.4.1 Airspeed scale range

As with other electronic flight displays, the HUD airspeed indications may not typically show the entire range of airspeed. CS 25.1541(a)(2) states 'The aeroplane must contain Any additional information, instrument markings, and placards required for the safe operation if there are unusual design, operating, or handling characteristics.'

5.4.4.2 Low- and high-speed awareness cues

Low-speed awareness cues on the HUD should provide adequate visual cues to the pilot that the airspeed is below the reference operating speed for the aeroplane configuration (e.g. weight, flap setting, and landing gear position). Similarly, high-speed awareness cues should provide adequate visual cues to the pilot that the airspeed is approaching an established upper limit that may result in a hazardous operating condition.

5.4.4.3 Format of low- and high-speed awareness cues

The low- and high-speed awareness cues should be readily distinguishable from other markings such as V-speeds and speed targets (e.g. bugs). The cues should indicate the boundary value of speed limit, and they should also clearly distinguish between the normal speed range and the unsafe speed range beyond those limiting values. Cross-hatching or other similar coding techniques may be acceptable to delineate zones of different meaning.

5.4.5 Flight path considerations

5.4.5.1 General

The type of flight path information displayed (e.g. earth-referenced or air mass) may be dependant on the operational characteristics of a particular aircraft and the phase of flight during which the flight path is to be displayed.

5.4.5.2 Velocity/flight path vector

An indication of the aircraft's velocity vector, or flight path vector, is considered essential to most HUD applications. Earth-referenced flight path display information provides an instantaneous indication of where the aircraft is actually going. During an approach, this information can be used to indicate the aircraft's impact or touchdown point on the runway. The earth-referenced flight path shows the effects of wind on the motion of the aeroplane. The flight path vector can be used by the pilot to set a precise climb or dive angle relative to the conformal outside scene or relative to the HUD's flight path (pitch) reference scale and horizon displays. In the lateral axis, the flight path symbols should indicate the aircraft track relative to the boresight.

5.4.5.3 Air-mass-derived flight path

Air-mass-derived flight path may be displayed as an alternative, but it does not show the effects of wind on the motion of the aeroplane. In this case, the lateral orientation of the flight path display represents the aircraft's sideslip, while the vertical position relative to the reference symbol represents the aircraft's angle of attack.

5.4.6 Attitude considerations

5.4.6.1 General

For all unusual attitude situations and command guidance display configurations, the displayed attitude information should enable the pilot to make accurate, easy, quick glance interpretation of the attitude situation.

5.4.6.2 Pitch

The pitch attitude display should be such that, during all manoeuvres, a horizon reference remains visible with enough margin to allow the pilot to recognise pitch and roll orientation. For HUDs that are capable of displaying the horizon conformally, the display of a non-conformal horizon reference should appear distinctly different than the display of a conformal horizon reference.

5.4.6.3 Display of unusual attitude conditions

Extreme attitude symbology and automatically decluttering the HUD at extreme attitudes has been found acceptable (i.e. extreme attitude symbology should not be visible during normal manoeuvring).

5.4.6.4 Unusual attitude recovery

When the HUD is not designed to be used for recovery from unusual attitude, the applicant should provide a satisfactory demonstration of the following:

5.4.6.4.1 Compensating features (e.g. characteristics of the aeroplane and the HUD system).

5.4.6.4.2 Immediate annunciation on the HUD to direct the pilot to use the head-down primary flight display for recovery.

5.4.6.4.3 Satisfactory demonstration of timely recognition and correct recovery manoeuvres.

5.4.6.5 Flight crew awareness of HUD modes

The same information concerning current HUD system mode, reference data, status state transitions, and alert information that is displayed to the pilot using the HUD should also be displayed to the other pilot. The display of this information for the other pilot should use consistent nomenclature to ensure unmistakable awareness of the HUD operation.

6.0 Dual HUDs

6.1 Operational concept for dual HUDs

The applicant should define the operational concept using dual HUDs. The operational concept should detail the tasks and responsibilities of both PF and pilot-not-flying (PNF) with regard to using and monitoring head-down displays and HUDs during all phases of flight. It should specifically address the simultaneous use of the HUD by both pilots during each phase of flight, as well as cross-flight-deck transfer of control.

6.2 Flight crew awareness of other instruments and indications

With single HUD installations, the PF likely uses the HUD as a primary flight reference and the PNF monitors the head-down instruments and alerting systems for failures of systems, modes, and functions that are not displayed on the primary flight displays or HUD. However, in the case where both flight crew members simultaneously use HUDs, the flight crew should be able to maintain an equivalent level of awareness of key information that is not displayed on the HUD (e.g. powerplant indications, alerting messages, and aircraft configuration indications).

6.3 Roles and responsibilities

The applicant should define the operational concept to account for the expected roles and responsibilities of the PF and the PNF. The concept should also take into account the following considerations:

6.3.1 Impact on head-down vigilance

When both pilots of the flight crew use a HUD as the primary flight display, the visual head-down indications may not receive the same level of vigilance (as compared to a pilot using the head-down primary flight display).

6.3.2 Assurance of head-down scan

The applicant should explain how the scan of the head-down instruments is ensured during all phases of flight, and, if not, what compensating design features help the flight crew maintain awareness of key information that is only displayed on head-down displays (e.g. powerplant indications, alerting messages, and aircraft configuration indication). The applicant should describe which pilot scans the head-down instrument indications and how often. For any case in which at least one pilot is not scanning the head-down instruments full-time, the design should have compensating design features that ensure an equivalent level of timeliness and awareness of the information provided by the head-down visual indications.

6.3.3 Alerts

The design should effectively compensate for any cautions and warnings that do not have visual indications in the HUD that are equivalent to the head-down primary flight display. The purpose of the compensating design features is to make the pilot using the HUD aware of the alerts so there are no additional delays in awareness and response time. The flight crew should be able to respond to alerts without any reduction in task performance or degraded safety.

6.4 Reassessment

The applicant should globally reassess the alerting functions to ensure that the flight crew is aware of alerts and responds to them in a timely manner. The reassessment should review the design and techniques, the alerting attention-getting properties (e.g. visual master warning, master caution, and aural alerts), and other alerts in the flight deck. The flight crew's awareness of alerts might differ between single- and dual-HUD installations. With a dual-HUD installation, there may be periods when neither pilot is scanning the instrument panel. With a single-HUD configuration, the PNF refers only to the head-down instrument panel and may have responsibility for monitoring indications on that panel. With dual-HUD configurations, both pilots' attention may be turned to their HUDs, and they might miss an alert that would otherwise be plainly visible to a pilot not using a HUD.

7.0 Flight data recording

In addition to the data required by CS 25.1459(e) and applicable operational regulations, flight data recorders may also record the unique operational characteristics of HUDs. For example, they may include information such as the mode in which the HUD was operating, the status (e.g. in use or inoperative), and if the display declutter mode was operating.

8.0 Continued airworthiness

CS 25.1309, CS 25.1529 and Appendix H to CS-25 require instructions for the continued airworthiness of a display system and its components. The content of the instructions depends on the type of operation and intended function of the HUD.

Appendix 7

Weather Displays

1. Introduction

1.1 Purpose

This Appendix provides additional guidance for displaying weather information in the flight deck. Weather displays provide the flight crew with additional tools to help make decisions based on weather information.

1.2 Examples

Sources of weather information may include—but are not limited to—onboard weather sensors, data-linked weather information, and pilot/air traffic reports. The information from these sources can be displayed in a variety of graphical or text formats. Because many sources of weather information exist, it is important that the applicant identify the source of the information, assess its intended function, and apply the guidance contained within this AMC.

2.0 Key characteristics

In addition to the general guidelines provided in the body of this AMC, the following guidelines should be considered when establishing the intended functions of weather displays.

2.1 Unambiguous meanings

The meaning of the presentations (e.g. display format, colours, labels, data formats, and interaction with other display parameters) should be clear and unambiguous. The flight crew should not misunderstand or misinterpret the weather information.

2.2 Colour

2.2.1 The use of colour should be appropriate to its task and use.

2.2.2 The use of colour must not adversely affect or degrade the attention-getting qualities of the information as required by CS 25.1322(f).

2.2.3 Colour conventions (such as the conventions established in ARINC 708 and FAA AC 20-149, *Safety and Interoperability Requirements for Initial Domestic Flight Information Service-Broadcast*) should be followed.

2.2.4 The use of red and yellow must be in compliance with CS 25.1322(e). Compliance can be shown using the guidance in AMC 25.1322, *Flight Crew Alerting*, and this AMC.

Note 1: Paragraph 7(d) of FAA AC 20-149, *Safety and Interoperability Requirements for Initial Domestic Flight Information Service-Broadcast*, indicates an exclusion to the acceptability of RTCA/DO-267A, *Minimum Aviation System Performance Standards for Flight Information Services-Broadcast (FIS-B) Data Link, Sections 2.0 and 3.0*, for CS-25 aeroplanes.

Note 2: Refer to paragraph 31.c(5) in Chapter 5 of this AMC for information on guidelines on colour progression.

2.3 Multiple sources of weather information

2.3.1 The weather display should enable the flight crew to quickly, accurately, and consistently differentiate among sources of the displayed weather information. Time-critical information should be immediately distinguishable from dated, non-time-critical information.

2.3.2 If more than one source of weather information is available, the source of the weather information should be indicated on the selector and the resulting display.

2.3.3 When simultaneously displaying information from multiple weather sources (e.g. weather radar and data link weather), the display should clearly and unambiguously indicate the source of that information. In other words, the flight crew should know the source of the symbol and whether it is coming from data-linked weather or real-time weather sources. These guidelines also apply to symbols (e.g. winds aloft and lightning) that have the same meaning but originate from different weather information sources.

2.3.4 If weather information is overlaid on an existing display, it should be easily distinguished from the existing display. It also should be consistent with the information it overlays in terms of position, orientation, range, and altitude.

2.3.5 When fusing or overlaying multiple weather sources, the resulting combined image should convey its intended meaning and meet its intended function, regardless of any differences in the sources in terms of image quality, projection, data update rates, data latency, or sensor alignment algorithms, for example.

2.3.6 If weather information is displayed on a head-up display, the guidance of this AMC including its Appendix 6 should be followed.

2.3.7 When the source of the weather information source is not the onboard sensors, some means to identify its relevance (e.g. a time stamp or the age of the product) should be provided. Presenting the product age is particularly important when combining information from multiple weather products. In addition, the effective time of forecast weather should also be provided.

2.3.8 If a weather-looping (animation) display feature is provided, the system should provide the means to readily identify the total elapsed time of the image compilation so the flight crew does not misinterpret the movement of the weather cells.

2.3.9 For products that have the ability to present weather for varying altitudes (e.g. potential or reported icing, radar, and lightning strikes), information should be presented that allows the flight crew to distinguish or identify which altitude range applies to each feature.

2.3.10 Weather information may include a number of graphical and text information features or sets of information (e.g. text and graphical Aviation Routine Weather Reports (METARs) and winds aloft). The display should provide a means to identify the meaning of each feature to ensure that the information is correctly used.

2.3.11 If the flight crew or system has the ability to turn a weather information source on or off, the flight crew should be able to easily determine if the source is on or off.

2.3.12 When weather information is presented in a vertical situation display, the lateral width of the weather swath (like that of the terrain swath) should be carefully considered to ensure that weather information that is relevant to the current phase of flight or flight path is displayed. An unsuitable lateral swath width could either mislead the flight crew to abort an operation for weather that poses no hazard, or fail to abort an operation when the weather does pose a hazard. If swath dimensions are automatically controlled, then careful consideration should be given to include only the area that would be relevant to the operation. Means may be provided for the flight crew to select the swath widths that they consider suitable for the phase of flight and prevailing weather conditions. The lateral width of the weather swath (like that of the terrain swath) should be made readily apparent to the flight crew (e.g. use the same swath as is used for the terrain, or display its boundaries on the plan view weather display). Generally, if the vertical situation displays terrain and weather at the same time, the choice of flight path-centred or track/heading-centred swath should be consistent. If the weather overlay is designed to show a smaller vertical swath than is represented by the altitude scale, then the boundaries of this swath should be clearly depicted on the display.

2.3.12.1 Weather information displayed on a vertical situation display should be accurately depicted with respect to the scale factors of the display (i.e. vertical and horizontal).

2.3.12.2 Consideration should be given to making the width of the information on the weather display consistent with the width used by other systems, including the Terrain Awareness and Warning System (TAWS), if displayed.

3.0 On-board weather radar information

3.1 Background

On-board weather radar provides forward-looking weather detection, including in some cases windshear and turbulence detection.

3.2 Minimum performance standards

The display of on-board weather radar information should be in accordance with the applicable portions of RTCA/DO-220, *Minimum Operational Performance Standards for Airborne Weather Radar with Forward-Looking Windshear Capability*. TSO-C63d allows exceptions to the minimum performance standards of RTCA/DO-220 for Radar Equipment Class A and B.

3.3 Hazard detection

The weather display echoes from precipitation and ground returns should be clear, automatic, timely, concise, and distinct so the flight crew can easily interpret, analyse, and avoid hazards. The radar range, elevation, and azimuth indications should provide sufficient information for flight crews to safely avoid the hazard.

4.0 Predictive windshear information

4.1 General

If provided, windshear information should be clear, automatic, timely, concise, and distinct so the flight crew can easily interpret, detect, and minimise the threat of windshear activity.

4.2 Presentation methods

When a windshear threat is detected, the corresponding display may be automatically presented or selected by the flight crew at an appropriate range to identify the windshear activity and minimise the windshear threat to the aeroplane.

4.3 Pilot workload

Pilot workload necessary for the presentation of windshear information should be minimised. When the flight deck is configured for normal operating procedures, it should not take more than one action to display the windshear information.

4.4 Windshear threat symbol

The size and location of the windshear threat symbol should allow the flight crew to recognise the dimension of the windshear and its position. The symbol should be presented in accordance with RTCA/DO-220.

4.5 Relative position to the aeroplane

The relative position and azimuth of the windshear threat with respect to the nose of the aeroplane should be displayed in an unambiguous manner.

4.6 Range

The range selected by the flight crew for the windshear display should allow the flight crew to distinguish the windshear event from other information. Amber radial lines may be used to extend from the left and right radial boundaries of the icon extending to the upper edge of the display.

5.0 Safety aspects

5.1 Functional hazard assessment (FHA)

Both the loss of weather information and the display of misleading weather information should be addressed in the FHA. In particular, the FHA should address failures of the display system that could result in the loss of the display and failures that could result in the presentation of misleading weather information.

5.2 Misleading information

The functional hazard assessment should address the effects of displaying misleading information. In accordance with Chapter 4 of this AMC, the display of misleading weather radar includes information that would lead the flight crew to make a bad decision or introduce a potential hazard. Examples include, but are not limited to, storm cells displayed in the incorrect position, at the wrong intensity, or mis-registered in the case of a combined (e.g. fused) image.

4. Regulatory Impact Assessment (RIA)

4.1. Issues to be addressed

Amend or create several cabin safety related AMCs to reflect current means of compliance that are accepted by the Agency.

Create new security provisions (rule and AMC) for COGs, in order to protect the aeroplane against a security threat which may create an in-flight fire.

Add new guidance for certification of Head-Up Displays and Weather Displays (amendment of AMC 25-11).

4.1.1. Safety risk assessment

- Cabin safety items: the proposed amendments would facilitate and streamline the certification process by upgrading several AMCs, to reflect experiences from certification projects, and to correct editorial errors. It is not based on the identification of a new safety threat. The safety effect should be neutral.
- Security provisions: the proposed new security provisions would remove a safety risk arising from an in-flight fire caused by a deliberate act of sabotage.
- Avionics: the proposed amendment would provide new guidance and means of compliance to the designers for the development of weather displays and head-up displays. There is no safety threat involved in this item, however, the proposed certification standard would help ensuring that state-of-the-art technologies (HUDs and Weather Displays) are safely designed and integrated into the cockpit, in compliance with applicable certification specifications.

4.1.2. Who is affected?

Large aeroplane manufacturers, large aeroplane modifiers, avionics equipment suppliers, cabin safety equipment suppliers, and operators are affected by this NPA.

4.1.3. How could the issue/problem evolve?

If CS-25 is not amended as proposed, there will be an increase in cost and time of the certification process for new CS-25 Large Aeroplanes. The Agency and the applicants would have to use additional Certification Review Items. The Agency would also not fully comply with the objective of Article 19 of the Basic Regulation.

4.2. Objectives

The specific objective is to propose an amendment of CS-25 based on the selection of non-complex, non-controversial, and mature subjects. The ultimate goal is to increase safety.

4.3. Policy options

The policy of the Agency is to regularly select items that are non-complex, non-controversial, and mature, and propose an amendment of CS-25. Therefore, there is only one possible option, i.e. Option 1.

Option 0 would not meet the objective of the Agency.

Table 1: Selected policy options

Option No	*Short title*	**Description**
0		Baseline option (no change in rules; risks remain as outlined in the issue analysis).
1		Select items that are non-complex, non-controversial, and mature and propose an amendment of CS-25.

4.4. *Analysis of impacts*

4.4.1. *Safety impact*

A moderate safety benefit should be reached by the proposed amendment, first from the mitigation of a security threat that has the potential to create an uncontrolled in-flight fire, and secondly by providing new guidance helping applicants to ensure compliance of HUDs and WDs with adequate certification specifications.

4.4.2. *Environmental impact*

For applicants who intend to install COGs on a new Large Aeroplane project, the new COG security specifications may induce a small weight increase if the applicant decides to use protection means based on resistance to tampering and active tamper-evident features. However, such weight impact, embedded into a new design, is believed to be minimal, as also stated in the FAA NPRM amending 14 CFR Part 25. Therefore, the associated impact on the environment from the increase of emissions by the engines is deemed negligible. In addition, even if the Agency decided not to adopt these security provisions, applicants would have to comply with FAA Part 25 rules to gain FAA Type Certification.

4.4.3. *Social impact*

No impact.

4.4.4. *Economic impact*

Concerning the proposed COG security specifications, we refer to the FAA impact assessment, which concluded that the proposed rule would impose minimal costs because it would only apply to new type-certificated aeroplane models so that the manufacturer would be able to design the most cost-effective emergency oxygen system for the model before construction would start on the first aeroplane. The Boeing 787 and the Airbus A350 are two new type certificate projects which include designs for supplemental oxygen systems that would be in compliance with this proposed rule. It is believed that similar emergency oxygen systems could be designed for future type-certificated aeroplanes at a minimal cost.

The upgraded cabin safety related AMCs and AMC 25-11 will aid the design and certification process and thereby reduce costs.

4.4.5. *General aviation and proportionality issues*

No impact.

4.4.6. *Impact on 'Better Regulation' and harmonisation*

The proposed amendment would contribute to an updated CS-25 reflecting available state-of-the-art and accepted means of compliance (complying with the objective of Article 19 of the Basic Regulation), facilitate the certification process by decreasing the number of Certification Review Items, and improve harmonisation with FAA.

4.5. Comparison and conclusion

4.5.1. Comparison of options

Option 1 only would permit to meet the objective of the Agency.

Overall it would bring a moderate safety benefit, it would create no social or environmental impacts, and may provide a slight economic benefit by streamlining the certification process.

Therefore, Option 1 is the preferred option.

4.5.2. Sensitivity analysis (optional)

N/A

4.5.3. Monitoring and ex post evaluation

N/A

5. References

5.1. Affected regulations

N/A

5.2. Affected CS, AMC and GM

ED Decision 2003/02/RM, as last amended by ED Decision 2012/008/R, certification specifications and acceptable means of compliance for large aeroplanes (CS-25).

5.3. Reference documents

— FAA NPRM (Docket No. FAA–2012–0812; Notice No. 13–01) (published on 09 January 2013), and

— FAA draft AC 25.795-X on Chemical Oxygen Generators (COGs) (published on 11 January 2013),

available under: http://www.regulations.gov/#!docketDetail;D=FAA-2012-0812

— FAA draft AC 25-11A change 1 (published on 1 November 2012). Document not anymore available online (consultation period closed).