European Union Aviation Safety Agency

Notice of Proposed Amendment 2022-07

Regular update of CS-25

RMT.0673

EXECUTIVE SUMMARY

The objective of this Notice of Proposed Amendment (NPA) is to reflect the state of the art of large aeroplane certification based on experience gathered from in-service occurrences and certification projects.

This NPA proposes to amend CS-25 (certification specifications and acceptable means of compliance for large aeroplanes) in the following areas:

Item 1: Ditching survivability

Item 2: AMC 25.1309 System design and analysis – Development assurance and AMC 20 references

Item 3: Installed systems and equipment for use by the flight crew

Item 4: Performance and handling characteristics in icing conditions

Item 5: Brakes and braking systems certification tests and analysis

Item 6: Oxygen equipment and supply

Item 7: Air conditioning 'off' – maximum time period

Item 8: Cabin crew portable oxygen equipment

The proposed amendments are expected to provide safety benefits, would have no social or environmental impacts, and would provide economic benefits by streamlining the certification process.

Domain:	Design and production		
Related rules:	CS-25		
Affected stakeholders:	Large aeroplane DAHs		
Driver:	Safety and efficiency/proportionality	**Rulemaking group:**	No
Impact assessment:	No	**Rulemaking Procedure:**	Standard

EASA rulemaking procedure milestones

Start Terms of Reference	**Public consultation**	**Proposal to the Commission** EASA Opinion	**Adoption by the Commission** Implementing Rules	**Decision** Certification Specifications, Acceptable Means of Compliance, Guidance Material
27.4.2015	6.7.2022	N/A	N/A	2024

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1. About this NPA

1.1. How this NPA was developed

The European Union Aviation Safety Agency (EASA) developed this Notice of Proposed Amendment (NPA) in line with Regulation (EU) 2018/1139[1] (the 'Basic Regulation') and the Rulemaking Procedure[2]. This Rulemaking Task (RMT).0673 is included in the European Plan for Aviation Safety (EPAS) for 2022-2026 [https://www.easa.europa.eu/document-library/general-publications/european-plan-aviation-safety-2022-2026]. The scope and timescales of the task were defined in the related Terms of Reference (ToR)[3].

EASA developed this NPA in accordance with Article 4 of the Rulemaking Procedure. It is hereby submitted to all interested parties for consultation in accordance with Article 115 of the Basic Regulation, and Article 6(1), (3) and (4) of the Rulemaking Procedure.

The major milestones of this RMT are presented on the cover page.

1.2. 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 the submission of comments is **6 October 2022**.

1.3. The next steps

Following the public consultation, EASA will review all the comments received.

Based on the comments received, EASA will publish a decision to amend the related certification specifications (CSs) and acceptable means of compliance (AMC).

The individual comments received on this NPA and the EASA responses to them will be reflected in a comment-response document (CRD), which will be published on the EASA website[5].

1 Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (OJ L 212, 22.8.2018, p. 1) (https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1535612134845&uri=CELEX:32018R1139).

2 EASA is bound to follow a structured rulemaking process as required by Article 115(1) of Regulation (EU) 2018/1139. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the 'Rulemaking Procedure'. See MB Decision No 01-2022 of 2 May 2022 on the procedure to be applied by EASA for the issuing of opinions, certification specifications and other detailed specifications, acceptable means of compliance and guidance material ('Rulemaking Procedure'), and repealing Management Board Decision No 18-2015 (https://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-no-01-2022-rulemaking-procedure-repealing-mb).

3 https://www.easa.europa.eu/document-library/terms-of-reference-and-group-compositions/tor-rmt0673

4 In case of technical problems, please send an email to crt@easa.europa.eu with a short description.

5 https://www.easa.europa.eu/document-library/comment-response-documents

2. In summary — why and what

2.1. Why we need to amend the rules — issue/rationale

The aviation industry is complex and rapidly evolving. CSs and AMC need to be updated regularly to ensure that they are fit for purpose, cost-effective, and can be implemented in practice.

Regular updates are issued when relevant data is available following an update of industry standards, feedback from certification activities, or minor issues raised by the stakeholders.

Lessons learnt from accident and incident investigations may also be addressed in regular updates when the topic is not complex and not controversial.

Item 1: Ditching survivability

Item 1.1 Planned and unplanned ditching

For many years it has been an accepted certification practice to show compliance with CS-25 ditching specifications (i.e. CS 25.563, CS 25.801) by addressing two scenarios: a 'planned ditching' and an 'unplanned ditching'.

In the 'planned ditching' case, it was typically assumed that there is sufficient time to prepare the aeroplane and occupants for a planned water landing in open seas. Allowances were generally made for jettisoning or burning off fuel, or closing of openings (e.g., outflow valves) and generally optimising the aeroplane to maximize the chances of occupant survival. The flotation analysis needed to account for structural damage that was likely to occur during the planned water landing.

In the 'unplanned ditching' case, it was generally assumed that sufficient time did not exist to prepare the aeroplane and occupants. The event was usually associated with a failed or aborted takeoff at an airport adjacent to a large body of water. Flight crew actions such as closing openings in the fuselage or reducing the aeroplane weight by burning fuel were generally assumed to not occur. As such, the aeroplane would initially sit lower in the water and may sink at a faster rate than in the 'planned ditching' event. Accordingly, aeroplane evacuation was more time-critical. The flotation analysis did not account for structural damage resulting from the water landing.

The analysis of the Hudson River accident (Airbus A320 US Airways flight 1549 on 15 January 2009, in New York City, USA), revealed the need to reinforce the structural analysis associated with the investigation of 'planned ditching' scenarios for CS-25 large aeroplane certification considering, as much as practicable, the variation of the flight parameters with respect to the optimal attitude angles at impact of the aeroplane with water, to cover most of the realistic scenarios. This would address intermediate scenarios between the 'planned ditching' and the 'unplanned ditching' scenarios, as illustrated by this accident. In this manner, the different types of ditching scenarios are covered.
In this accident the aeroplane experienced loss of thrust in both engines, a situation not addressed in the current ditching requirements. In response, CS 25.671(d) was amended (CS-25 Amendment 24) to require that the aeroplane is designed so that it is controllable if all engines fail at any time of the flight, and a flare to a ditching can be achieved.

The current certification specifications related to ditching (CS 25.563, CS 25.801, CS 25.671) lack detailed provisions addressing the 'planned dicthing' and 'unplanned ditching' scenarios:

- Independently from the request by the applicant for certification with ditching provisions[6], EASA considers that, following an 'unplanned ditching', the flotation time and the attitude of the aeroplane must allow the occupants to safely leave the aeroplane.
- In addition, when ditching provisions are requested for certification, EASA considers that the airframe structures must withstand ditching loads, by considering reasonable variations in the flight parameters when the aeroplane impacts the water, and the flotation time and attitude of the aeroplane must also allow the occupants to enter into a liferaft. This is associated with a 'planned ditching' scenario.
- AFM procedures for ditching with reduced engine power / no engine power conditions are not completely addressed, in particular the aspects related to the preparation of the aeroplane before performing the ditching.

Without describing in the certification specifications the 'planned ditching' and 'unplanned ditching' scenarios with sufficient level of detail, new applicants are not aware of the expected certification practice and may miss the opportunity to address the intermediate ditching scenarios involving a variation of flight parameters.

The ditching emergency exits required to allow occupant evacuation are considered to be already adequately addressed in existing certification specifications.

In practice, most of the CS-25 large aeroplanes are certified with ditching provisions to provide the possibility to operators to operate their aeroplanes on flights over water.

Item 1.2 Structural ditching analysis

CS-25 does not include guidance material (GM) and acceptable means of compliance (AMC) to support applicants in the development of the structural ditching analysis as required under CS 25.563 (for 'planned ditching').

The absence of such GM and AMC material implies that the expected structural reinforcement and strength of the aeroplane may not be incorporated at a level sufficient to adequately protect occupants, thereby potentially resulting in an unacceptable risk leading to occupants injuries or fatalities after a 'planned ditching'.

Since the Hudson River accident, EASA issued an Interpretative Material (IM) Certification Review Item (CRI) on 'Structural Ditching Conditions' for new aeroplane designs. In that IM CRI, the scenarios of 'planned ditching' and 'unplanned ditching' are addressed. The content of this CRI was taken into account in the recommendations made by the 'Transport Aircraft Crashworthiness and Ditching Working Group[7]' which issued a report to the FAA (revision B dated 20 September 2018).

In this EASA IM CRI, a variety of flight parameters for 'planned ditching' are considered in order to allow a conservative analysis addressing scenarios where the aeroplane does not reach the optimal attitude parameters during the flare to ditching.

[6] E.g. to allow the operation on overwater flights as prescribed in point CAT.GEN.MPA.150 (Ditching – aeroplanes) of Regulation (EU) No 965/2012

[7] A working group established by the Aviation Rulemaking Advisory Committee (ARAC) following a task assigned by the FAA, refer to the notice in US Federal Register Vol.80, No. 107, dated 4 June 2015.

Some examples of the expectations related to the structural ditching analysis for 'planned ditching' are the following:

- The probable behaviour of the aeroplane is to be investigated by model tests or by analysis supported by test;
- The behaviour of the aeroplane must be such that it does not cause immediate injury to the occupants or make it impossible for them to escape, according to the applicable certification specifications;
- The demonstration of adequate aeroplane structural strength that allows to reach a sufficient flotation time (considering the probable structural damage and leakage resulting from the ditching) should be included in the analysis;
- The structural ditching substantiation should be based as a minimum on the Maximum Design Landing Weight, in line with CS 25.721 for emergency landings (on land). Acceptable minimum values or variation for three other key parameters for ditching (descent rate, forward speed at impact, and aeroplane attitude) should also be considered. For descent rate, alignment is sought with CS 25.721.
- The optimum ditching conditions and associated aeroplane configuration to ditch should address parameters such as aeroplane weight, flap setting, aeroplane speed and descent rate in the approach, and optimum aeroplane attitude at impact following the flare. These optimum conditions should be included in the AFM.

Item 1.3 Buoyancy – evacuation analysis

CS-25 does not define what is an adequate time to evacuate all passengers and crew from the aeroplane after a ditching event (per CS 25.801(d)).

Therefore, for each new certification project, applicants and EASA have to agree on means of compliance with CS 25.801(d). Applicants are not informed in an early phase of EASA's expectations when addressing both planned and unplanned ditching scenarios, which may lead to the need to perform substantial modifications at an advance phase of the design development.

A dedicated AMC would therefore be beneficial to inform applicants on EASA's expectations. Some examples (non exhaustive list) of what should be included in the analysis are:

- The placement and number of the exits qualified for ditching;
- The unplanned ditching assumptions such as the positions of the environmental control system (ECS) outflow valves (e.g. open),
- The assumption that an exit is conservatively considered to be no longer usable when water comes in over the top of the door sill.

EASA issued a Means Of Compliance (MOC) CRI on 'Unplanned Ditching – Evacuation' for new aeroplane design more than 15 years ago. The content of this CRI can now be considered for the development of a new AMC in CS-25. The content of this CRI was taken into account in the recommendations made by the 'Transport Aircraft Crashworthiness and Ditching Working Group' which issued a report to the FAA (revision B dated 20 September 2018).

Item 2: Amendment of AMC 25.1309 – Development assurance and AMC 20 references

a) AMC 25.1309, section 13. ASSESSMENT OF MODIFICATIONS TO PREVIOUSLY CERTIFICATED AEROPLANES, does not include guidance on the evaluation of existing development assurance data to perform a modification.
Experience gathered from modified CS-25 large aeroplanes shows that such assessment has not always been adequately performed, thereby leading to development errors not being captured.

b) AMC 25.1309 does not include references to some recent AMC 20 documents:
- AMC 20-152A Development Assurance for Airborne Electronic Hardware (AEH)
- AMC 20-189 The Management of Open Problem Reports (OPRs)
- AMC 20-193 Use of multi-core processors

Item 3: Installed systems and equipment for use by the flight crew

EASA recently amended CS-27 (Amendment 8) and CS-29 (Amendment 9) to introduce new certification specifications (CS 27/29.1302) for a human factors (HF) assessment of installed systems and equipment intended for use by flight crew members, and the corresponding AMC and GM material.

These new rotorcraft CSs, AMC and GM have been drafted taking as a baseline CS 25.1302 and AMC 25.1302. Indeed, HF principles applied to cockpit and system designs are relevant to all aircraft types, including the new generation of complex rotorcraft.

While the text of CS 27/29.1302 is substantially identical to the text of CS 25.1302, the content of AMC 25.1302, used to develop the rotorcraft AMC and GM, has been significantly restructured and reworded in order to adapt it to the different types of operations and the related operational scenarios which could be performed by rotorcraft.

Additionally, some improvements and clarifications have been introduced on the basis of the experience gained and lessons learned during recent certification projects for large aeroplanes.Therefore, these improvements and clarifications should be considered to be also introduced in AMC 25.1302 to align it with the recently published AMC and GM for the rotorcraft.

Item 4: Performance and handling characteristics in icing conditions

In AMC 25.21(g) (Performance and handling characteristics in icing conditions), paragraph 4.6.5 reads as follows:

> ‘For failure conditions that are extremely remote but not extremely improbable, the analysis and substantiation of continued safe flight and landing, in accordance with CS 25.1309, should take into consideration whether annunciation of the failure is provided and the associated operating procedures and speeds to be used following the failure condition’.

According to AMC 25.1309:

> -‘Remote failure conditions are those having an average probability per flight hour of the order of 1×10^{-5} or less, but greater than of the order of 1×10^{-7}.
>
> -Extremely remote failure conditions are those having an average probability per flight hour of the order of 1×10^{-7} or less, but greater than of the order of 1×10^{-9}.

-Extremely improbable failure conditions are those having an average probability per flight hour of the order of 1×10^{-9} or less.'

Therefore the condition 'extremely remote but not extremely improbable' is not logical and does not provide the intended interval of probabilities, i.e. greater than 10^{-9} and equal to or lower than 10^{-5} Indeed, probabilities greater than 10^{-7} and equal to or lower than 10^{-5} are not addressed by the current text.

Item 5: Brakes and braking systems certification tests and analysis

At Amendment 18 to CS-25, EASA introduced the content of the Certification Memorandum on 'Respecting Brake Energy Qualification Limits' into AMC 25.735. A new sub-paragraph (2) was inserted in paragraph 4 ("DISCUSSION") section a. ("Ref. CS 25.735(a) Approval"). This necessitated a renumbering of the subsequent sub paragraphs to (3) and (4). However, during this renumbering, an editorial change within the text of renumbered sub paragraph (4) was omitted. This text (" not addressed under paragraph 4a(2) of this AMC.") should read " not addressed under paragraph 4a(3) of this AMC."

In addition, AMC 25.735 was reviewed for additional editorial errors, and it is apparent that the layout of the text in the AMC could cause the applicability of some parts to be mis-interpreted.

Item 6: Oxygen equipment and supply

EASA identified that the content of some Means of Compliance approved by EASA during past certification projects is not adequately reflected in paragraph 3.3 (Ventilation) of AMC 25.1441(b) (Risk assessment related to oxygen fire hazards in gaseous oxygen systems).

Item 7: Air conditioning 'off' – maximum time period

At amendment 23 of CS-25, EASA amended AMC 25.831(a) Ventilation.

The new paragraph 3 addresses the operations with the air conditioning system 'off'. Sub-paragraph (e) of this paragraph specifies that 'the period during which the aeroplane is operated with the air conditioning system 'off' is intended to be of short duration. Therefore, the maximum time period allowed for the operation of an aeroplane in this configuration should be defined by the applicant and specified in the appropriate operating manuals, along with any related operating procedures that are necessary to ensure that the above items are addressed'.

Since this amendment, discussions with applicants revealed that the term 'the maximum time period' created some concerns. Indeed, on some aeroplanes the method used to detect and alert the flight crew about a configuration with air conditioning 'off' may not be based on an elapsed time but on other criteria like transition to the Climb phase, or reaching a certain height or altitude.

Item 8: Cabin crew portable oxygen equipment

During various CS-25 type certification projects EASA identified a misinterpretation by applicants of the content of CS 25.1443(d) and (e).

CS 25.1443 (d) requires that 'If first-aid oxygen equipment is installed, the minimum mass flow of oxygen to each user may not be less than 4 litres per minute, STPD. (…)'

CS 25.1443 (e) requires that 'If portable oxygen equipment is installed for use by crew members, the minimum mass flow of supplemental oxygen is the same as specified in subparagraph (a) or (b) of this paragraph, whichever is applicable'.

These paragraphs do not state that the installation of portable oxygen equipment (POE) is optional and that, if installed, the usage could be limited to first aid application.

POE is a required safety equipment as stated per CS 25.1447(c)(4) (i.e. if certification for operation above 7620 m (25 000 ft) is requested): 'Portable oxygen equipment must be immediately available for each cabin crew member'.

A generic Interpretative Material Certification Review Item (CRI) has been used by EASA and applicants to clarify the meaning of the specifications applicable to POE to be used by cabin crew members.

The content of this CRI is sufficiently mature and generic to be introduced in CS-25.

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 1 of the Basic Regulation. The proposal of this NPA will contribute to achieving the overall objectives by addressing the issues described in Section 2.1.

The specific objective of this proposal is to amend CS-25 based on the above selection of non-complex, non-controversial, and mature subjects, with the ultimate goal being to increase safety.

2.3. How we want to achieve it — overview of the proposed amendments

Item 1: Ditching survivability

Item 1.1 Planned and unplanned ditching

It is proposed to amend CS 25.563 (Structural ditching provisions) and CS 25.801 (Ditching) to reflect in the specifications the planned and unplanned ditching scenarios that have been considered in practice, including the need to consider the variation of flight parameters for the planned ditching scenario.

Item 1.2 Structural ditching analysis

It is proposed to create an AMC 25.563 (Structural ditching provisions) to provide consolidated guidance and acceptable means of compliance related to the structural ditching analysis applicable for the 'planned ditching' scenario, where an optimum configuration of the aeroplane is considered at the time of contact with water, with a variation of parameters with respect to that optimum configuration.

Item 1.3 Buoyancy – evacuation analysis

It is proposed to amend AMC 25.801, to provide consolidated guidance and acceptable means of compliance related to the adequate buoyancy time analysis to allow all passengers and crew to evacuate the aeroplane.

Item 2: Amendment of AMC 25.1309 – Development assurance and AMC 20 references

It is proposed to amend AMC 25.1309 to:

a) Introduce in section 13. ASSESSMENT OF MODIFICATIONS TO PREVIOUSLY CERTIFICATED AEROPLANES, changes related to the assessment of the impact that a modification may have on the development assurance data previously used for showing compliance with CS 25.1309.

b) Add in section 3 (Related documents) and section 9 (Compliance with CS 25.1309) references to the following AMC 20 documents:

- AMC 20-152A Development Assurance for Airborne Electronic Hardware (AEH)
- AMC 20-189 The Management of Open Problem Reports (OPRs)
- AMC 20-193 Use of multi-core processors.

Item 3: Installed systems and equipment for use by the flight crew

It is proposed to amend CS 25.1302 to clarify the text and align it with CS 29.1302. These changes do not modify its substance.

It is proposed to amend AMC 25.1302 as follows:

— The existing material has been restructured. All the informative elements and some explanatory material have been moved to new GM1 and GM2 25.1302.

— Several clarifications have been made throughout the text.

— A new figure has been introduced to show the methodical approach to the certification for design-related HFs issues (refer to paragraph 3.1).

— The new ‘level of involvement (LoI)’ concept (refer to points 21.A.15(b)(5) and (6) of Part 21) has been reflected wherever the involvement of EASA was described.

— The certification strategy has been clarified and expanded (refer to paragraph 3.3.1).

— Methodological considerations applicable to HF assessments, including scenario-based approaches, have been added (refer to paragraph 3.3.2).

— Some definitions have been reworded, and new definitions have been added.

— A paragraph has been added in Section 5 to provide guidance regarding the possibility to take some credits for compliance demonstration from previous compliance certification processes.

— Additional clarifications have been added in Section 5 in order to describe the main criteria to be considered while assessing the representativeness of the test articles used during compliance demonstration

Item 4: Performance and handling characteristics in icing conditions

It is proposed to amend paragraph 4.6.5 of AMC 25.21(g) to specify failure conditions that are ‘remote or extremely remote’. This would harmonise with the equivalent range of probabilities provided in FAA Advisory Circular (AC) 25-25A paragraph 2.6.4.

Item 5: Brakes and braking systems certification tests and analysis

It is proposed to amend AMC 25.735 as follows:

- In paragraph 4.a.(4), replace the reference to paragraph 4.a.(2) by a reference to paragraph 4a(3).
- Move the final two sentences of paragraph 4.a.(1)(e) to paragraph 4.a.(1)so that it is clear they do not ONLY apply to 4.a.(1)(e).

- Add an introduction sentence and a numbering before the sub-paragraphs (a) to (d) which follow 4.a.(4) to make it clear that they do not only apply to 4.a.(4) Replacement and Modified Equipment, but also to 4.a.(3) Refurbished and Overhauled Equipment.
- Amend the text of 4.a.(4)(b) "Major Changes" to include changes to the brake as well as the wheel.

Item 6: Oxygen equipment and supply

It is proposed to amend paragraph 3.3 (Ventilation) of AMC 25.1441(b) (Risk assessment related to oxygen fire hazards in gaseous oxygen systems) such as to provide a more generic text that reflects already approved Means of Compliance and harmonises with the content of section 1.2 of FAA Policy Statement PS-ANM-25.1441-01 (Mitigating Fire Hazards in Gaseous Oxygen Systems) dated 9 December 2014.

Item 7: Air conditioning 'off' – maximum time period

It is proposed to amend AMC 25.831(a) to remove the word 'time' in paragraph 3.(e) in order to provide a more generic wording allowing applicants to propose different criteria to control the flight duration with the air conditioning 'off'.

Item 8: Cabin crew portable oxygen equipment

It is proposed to introduce the content of the generic Interpretative Material CRI used by EASA and applicants to clarify the meaning of the specifications applicable to POE to be used by cabin crew members. This would be achieved as follows:

- create AMC 25.1443(e) (Minimum mass flow of portable oxygen equipment) to explain when CS 25.1443(a) or (b) specifications are applicable,
- amend AMC 25.1447(c)(4) (Equipment standards for portable oxygen equipment) to add guidance and acceptable means of compliance for POE installed to allow cabin crew mobility in aeroplanes where the passenger oxygen system design allows to level off at altitudes between 3048 m (10 000 ft) and 7620 m (25 000 ft) after a depressurisation event,
- create AMC 25.1449 (Means for determining use of oxygen) to highlight that the specification applies to all POE and and indicate acceptable means of compliance.

2.4. What are the expected benefits and drawbacks of the proposed amendments

The proposed amendments reflect the state of the art of large aeroplane certification. Overall, this would provide a moderate safety benefit, would have no social or environmental impacts, and would provide some economic benefits by streamlining the certification process.

3. Proposed amendments

The amendment is arranged to show deleted, new or amended, and unchanged text as follows:

— deleted text is ~~struck through~~;

— new or amended text is highlighted in blue;

— an ellipsis '[…]' indicates that the rest of the text is unchanged.

3.1. Draft certification specifications and acceptable means of compliance for large aeroplanes (draft EASA decision amending CS-25)

Item 1: Ditching survivability

Item 1.1 Planned and unplanned ditching

Amend CS 25.563 as follows:

CS 25.563 Structural ditching provisions

(See AMC 25.563)

~~Structural strength considerations of ditching provisions must be in accordance with CS 25.801 (e).~~ If certification with ditching provisions is requested, those parts of the airframe structure that are necessary to maintain flotation of the aeroplane must withstand ditching loads, considered as ultimate, associated with a planned emergency landing on water. The airframe loads must account for reasonable variations in the flight parameters when the aeroplane enters the water.

Amend CS 25.801 as follows:

CS 25.801 Ditching

(See AMC 25.801)

(a) Whether or not ditching certification is requested, it must be shown that following an unplanned ditching, the flotation time and trim of the aeroplane will allow the occupants to leave the aeroplane.
~~(a)~~ (b) If certification with ditching provisions is requested, the aeroplane must comply with ~~meet the requirements of this paragraph and~~ CS 25.563, CS 25.807(i), CS 25.1411, ~~and~~ CS 25.1415~~(a).~~ and the following:
~~(b)~~ (1) Each practicable design measure, compatible with the general characteristics of the aeroplane, must be taken to minimise the probability that in an emergency landing on water, the behaviour of the aeroplane would cause immediate injury to the occupants or would make it impossible for them to escape.
~~(c)~~ (2) The probable behaviour of the aeroplane in an emergency ~~a water~~ landing on water must be investigated by model tests or by analytical methods supported by tests. ~~by comparison with aeroplanes of similar configuration for which the ditching characteristics are known~~. Features ~~Scoops, wing-flaps, projections, and any other factor~~ likely to affect the hydrodynamic characteristics of the aeroplane, must be considered.

~~(d)~~ (3) It must be shown that following a planned emergency landing on water, ~~under reasonably probable water conditions,~~ the flotation time and trim of the aeroplane will allow the occupants to leave the aeroplane and enter ~~the life~~ rafts ~~required by CS 25.1415~~. The flotation and evacuation assessment must account for probable damage resulting from the conditions prescribed in CS 25.563. ~~If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the aeroplane has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume.~~

~~(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behaviour of the aeroplane in a water landing (as prescribed in sub-paragraphs (c) and (d) of this paragraph), the external doors and windows must be designed to withstand the probable maximum local pressures.~~

Item 1.2 Structural ditching analysis

Create AMC 25.563 as follows:

AMC 25.563 Structural ditching provisions

1 *Purpose.*

This AMC primarily provides guidance and acceptable means of compliance with the ditching certification specifications of CS 25.563 (Structural ditching provisions).

It also includes guidance that may be used when showing compliance with the following certification specifications that are applicable to ditching certification:

- CS 25.801, Ditching,
- CS 25.809(g) Emergency Exit Arrangement,
- CS 25.1581, Aeroplane Flight Manual.

Note: The following certification specifications are also related to diching certification: CS 25.807(i) Emergency Exits, CS 25.1411 Safety Equipment, General, and CS 25.1415 Ditching Equipment.

2 *Definitions*

2.1 *Buoyancy.* On aeroplanes, buoyancy features allow the aeroplane to float and include, but are not limited to, the portion of the following features that displace water: fuel tanks, pressure vessel, and any other items that can be shown to remain intact after the ditching event and displace water (e.g., structure and systems of the aeroplane, landing gear, the bell jar volume of the landing gear wheel wells).

2.2 *Ditching Exit.* To qualify as a ditching exit, the exit sill must be initially above the waterline and it should remain above the waterline for the duration of the evacuation during a planned or unplanned ditching.

Note: If it can be shown to still be conservative, an exit may qualify as a ditching exit if it does not remain above the waterline for the full duration of the evacuation. The substantiation of conservatism should include an assessment of how long the ditching exit remains above the waterline, the number of persons expected to be remaining in the aeroplane when the ditching exit(s) sill goes below the waterline and the number of other ditching exits remaining above the waterline.

2.3 *Evacuation Time.* The time for all occupants to exit the aeroplane. The evacuation is assumed to start when the aeroplane comes to rest in the water. For a planned ditching the evacuation time ends when the last aeroplane occupant leaves the aeroplane and enters a raft. For an unplanned ditching, the evacuation time ends when the last aeroplane occupant leaves the aeroplane and enters a slide/raft, the water or steps on the wing.

2.4 *Flotation Time.* The time from when the aeroplane comes to rest in the water to when the aeroplane condition is such that occupants can no longer safely evacuate.

Note: For certification, the flotation time is generally considered to be the time from when the aeroplane comes to rest in the water to when the first ditching exit sill goes below the waterline, or when the attitude of the aeroplane is such that it would require extraordinary effort to move through the cabin to reach available ditching exits. However, if it can be shown to still be conservative, the flotation time may be extended. A showing of conservatism should include an assessment of number of persons expected to be remaining in the aeroplane when the ditching exit sill(s) goes below the waterline, the number of ditching exits remaining above the waterline and the attitude of the aeroplane.

2.5 *Inadvertent Water Entry.* Runway overshoot (at take-off or landing) or runway undershoot (at landing), where the aeroplane alights on water. This type of event is considered to be a minor crash, where the aeroplane inadvertently ends up in water where it is supported or partially supported by land. It is possible that during the departure from land to water the aeroplane encounters varying terrain such as berms, rocks etc. It is not uncommon for aeroplanes to be severely damaged. However, these events rarely include scenario where the aeroplane is floating after it comes to rest. It is more typical for the aeroplane to be resting on the lake or sea bed or partially supported on land. This is not considered to be a ditching event and it is not addressed by the ditching requirements or this AMC. Rather, this type of event is addressed by other crashworthiness specifications such as CS 25.561, CS 25.721 and CS 25.963.

2.6 *Ditching*. An emergency landing on water, either planned or unplanned (see definitions below). In principle the phases of a ditching event are as follows:

(a) The “Approach” phase addresses what happens before the initial contact with the water;
(b) The “Impact” phase addresses what happens from the first water contact to immersion into the water;
(c) The “Deceleration” phase addresses what happens while the aeroplane is gliding to a stop in the water;
(d) The “Flotation” phase addresses the depth and attitude of the aeroplane in the water over time;
(e) The “Evacuation” phase addresses the time it takes to fully evacuate the aeroplane.

2.7 *Planned Ditching.* An event where the flight crew knowingly makes an emergency landing on water. In ideal cases, the flight and cabin crews have sufficient time to fully prepare the aeroplane and the passengers, and execute the ditching in accordance with the Aeroplane Flight Manual (AFM) procedures. It is recognised that some circumstances may degrade the ability of the flight crew to execute the ditching exactly per the AFM procedures. Therefore, an assessment should address variations in the aeroplane assumptions (e.g. attitude (pitch) and descent velocity) to account for potential degraded conditions.
All phases of ditching (defined above) should be evaluated when showing compliance with ditching certification specifications.
Planned ditching events may also involve reduced power/no power conditions, as defined below.

2.8 *Reduced Power/No Power condition ditching conditions.* An event where the flight crew knowingly makes an emergency landing on water but with reduced engine power or no engine power available. The flight and cabin crews may or may not have sufficient time or opportunity to fully prepare the aeroplane and passengers for ditching. The flight crew is able to perform the emergency landing in accordance with AFM procedures for a reduced/no power landing on water. It has been shown that for this condition the amount of control the flight crew has over the high lift devices is the dominant factor in maintaining water impact loads within the structural capability of the aeroplane. This condition is addressed by AFM procedures (see section 9). For such event, the applicant may focus on the approach phase of the ditching event (defined above) when showing compliance with ditching certification specifications.

2.8 *Unplanned Ditching.* An emergency landing on water that is typically associated with a failed or aborted takeoff, or landing overrun at an airport adjacent to a large body of water where the aeroplane is in water deep enough to float (i.e., the aeroplane is not supported by land). The flight and cabin crews do not have sufficient time or opportunity to prepare the aeroplane and passengers for this type of ditching event Typically no actions are taken before the ditching to improve the flotation characteristics of the aeroplane (e.g. close the Environmental Control System (ECS) outflow valves). For such event, the applicant may focus on the flotation and evacuation phases of the ditching event (as defined above) when showing compliance with ditching certification specifications.

3 *General.*

Successful emergency water landings depend on several crucial factors. The aeroplane should possess good hydrodynamic characteristics, the ditching procedures should be attainable, and the airframe should be intact enough for orderly evacuation. The natural variability of potential ditching events and the inherent difficulties of an emergency water landing do not support a precise definition of a design ditching condition. These characteristics lead to the following structural and aeroplane features that should provide a level of structural performance for a reasonable chance of a successful ditching. Therefore structural substantiation of ditching capability per CS 25.563 necessitates the consideration of the following aspects:

1. Hydrodynamic behaviour during a planned ditching event should be predictable and well behaved.
2. The predicted hydrodynamic, aerodynamic and inertial loads experienced by the aeroplane during the ditching should be based on methods shown to be reliable or conservative.
3. Reasonable variations of flight parameters should be considered to ensure that the execution of a successful ditching does not require exceptional pilot skills or strength and that the inherent uncertainties associated with a water impact do not jeopardise the ditching structural performance.
4. The airframe assessment of the ditching loads should demonstrate requisite strength and deformation to maintain the required floatation characteristics.

4 *Accepted Methods for Evaluating Hydrodynamic Behaviour.*

To show acceptable hydrodynamic behaviour, testing and/or numerical simulation should be used. Testing need not be on the configuration under consideration if sufficient similarity can be shown, and the testing need not be performed by the applicant if performed by a suitable organisation, (e.g. the applicant may use the content of document NACA-TN-2929 ‘Experimental investigation of the effect of rear-fuselage shape on ditching behavior’, dated April 1953). Numerical simulation of water impacts may be acceptable if validated and may be appropriate for unusual design features such as large cutouts, open bays, scoops and projections.

While the occurrence of emergency water landing is rare, there have been instances of water entry during approach, forced water landings due to fuel exhaustion and engine power loss from ingestion damage, etc. Hydrodynamic and structural performance in these incidents has generally been satisfactory for large aeroplanes. Consequently, applicable fleet history may also be used by the applicant to supplement test and simulation data if acceptable to EASA.

Note: These tests or simulations methods, supplemented by applicable fleet history, may also be used when showing compliance with CS 25.801(b)(1) and (b)(2).

The following should be considered:

a) *Test methods*:
Model test should define the approach conditions and describe the hydrodynamic behaviour until the aeroplane comes to rest after ditching.
For typical model tests, 1:10 or smaller scale models are "ditched" in a water tank. These models may be comparatively rigid or structurally similar (i.e. scale strength parts such as fuselage joints, flaps attachments and lower fuselage skins) to a full-scale aeroplane with the intent to understand the dynamic behavior after impact on water examining a variety of parameters. The models may be equipped with pressure transducers and linear and angular accelerometers, to assess the pitch, roll and yaw of the model. The motion of the aeroplane may be observed by high-speed imaging systems.

b) *Numerical methods*:
Numerical simulation techniques may be applied to determine the hydrodynamic behaviour of the aeroplane when it is in contact with water. This may be achieved by using commercially available software or specifically developed in-house tools that are validated. Some of these tools may be used for pressure (loads) generation at impact phase only, but typically the complete time period between initial contact to water and the aeroplane coming to rest is simulated.

5 *Accepted Methods for Developing Ditching Pressures and Loads.*

Ditching loads may be developed by analysis or by test. Analysis methods should be validated by applicable testing. The guidance in this section concentrates on the approach conditions and the impact analyses. Furthermore, CS 25.563 provides the relevant conditions:

- A planned ditching is the water entry of a controlled aeroplane,
- Reasonable variations must be accounted for as described in section 6 of this AMC.

Ditching loads, considered as ultimate, are to be applied to the airframe taking into account the hydrodynamic effects resulting from a water landing, with accompanying aerodynamic and inertia loading. The hydrodynamic loads act directly on the lower skins of the fuselage or on lower wing structure.

The methods that follow are acceptable methods for developing loads when showing compliance with CS 25.563:

a) *Test methods*:
Water pressures, in terms of magnitude and (fore-aft, lateral) distribution, that occur during the impact phase may be determined based on ditching model testing, with a model equipped with a sufficient amount of properly distributed pressure transducers. Typically, accelerometers are also installed to measure accelerations.

Ditching model test results need to be properly scaled to aeroplane size. It would be conservative to envelope the measured (scaled) peak water pressures and apply these directly to design the bottom structure of the aeroplane. If on the other hand the measured data are modified (for example, smoothing of peak pressures) this should be further substantiated.

In document reference NASA-TM-X-2445 ('Ditching Investigation of a 1/30-Scale Dynamic Model of a Heavy Jet Transport Airplane'), dated February 1972, a table of scaling coefficients as applied in published aeroplane model tests is provided:

Quantity	Scale Factor
Length	λ
Force	λ^3
Moment of Inertia	λ^5
Mass	λ^3
Time	$\lambda^{(1/2)}$
Speed	$\lambda^{(1/2)}$
Linear accel.	1
Angular accel.	$\lambda^{(-1)}$
Pressure	λ

The underlying physics are based on similitude of Froude's law which allows using the scale (linear or non-linear) as a transfer function from measurement to real aeroplane. The model scale, λ, is the ratio of the model dimension to the full scale aeroplane dimension.

Quantity (model) = Quantity(full scale aeroplane)*Scale Factor

Example: $Time_{model} = Time_{aeroplane} * \sqrt{1/30}$

b) *Analysis methods*:

(i) In order to quantify the structural capacity of aeroplane structures under hydrodynamic loading, the prediction of global and local structural loads and resulting deformations is of fundamental importance. The analysis, however, is very challenging as ditching is a time-dependent, highly nonlinear multi-physics problem with different length and time scales resulting in complex loading conditions and coupled fluid-structure interaction. Hydrodynamic phenomena affect the fluid-structure interaction and their occurrence may therefore influence the global aeroplane motion during the landing phase.

To circumvent some of these complexities, an uncoupled analysis is often performed. In uncoupled computational approaches, the fluid solution is obtained independent of the structural solution, and both computations are run separately. The aeroplane structure is typically represented by a Finite Element Model which represents the global aeroplane structural stiffness and mass distribution, whereas the applied hydrodynamic models are generally based on the momentum theory and the concept of added mass developed by von Kármán and Wagner.

Whatever analysis technique used, either coupled or uncoupled, validation of the analysis by model ditching test results is necessary, as well as an assessment of how any of the hydrodynamic phenomena described above is addressed.

(ii) Suitable analytical methods may include a comparison with aeroplanes of similar configuration for which the characteristics during the diching event (such as aeroplane attitude, movement of centre of gravity, and vertical and horizontal speeds/accelerations) are known. This approach takes care of generating loads and the structural assessment. Reference data for this technique can, for example, be found in document NACA-TN-2929 'Experimental investigation of the effect of rear-fuselage shape on ditching behavior', dated April 1953.

(iii) Analysis using sea plane float pressures per § 25.533 of the U.S. Federal Aviation Regulations (FAR) 14CFR Part 25. FAR Part 25 contains a set of regulations for water loads for seaplane designs which can be used for conventional large aeroplanes as well. These methods, however, may not be applicable to large aeroplane configurations with flat or essentially flat impact areas. Seaplane design methods may be used if these are shown to be appropriate for the specific aeroplane configuration to be certified. This involves the determination of seaplane design parameter equivalency based on ditching model testing and establishing similarity of the product to the ditching model(s) used. Design parameter equivalency should be established by analysis based on test data and product similarity should be established by consideration of geometric (dimensions and shape) characteristics, number of engines and their placement, wing configuration and mass properties.

FAR Part 25, §25.533(b) local pressures are to be developed for use in design of local stringers and skins and their attachments to supporting structure. These pressures are to simulate pressures occurring during high localized impacts on the hull but are not required to be extended over area that would induce critical loading in frames or overall structure. Note that for derivation of local pressures, FAR Part 25, § 25.533(b)(1) for unflared bottoms is considered to be more appropriate to conventional large aeroplane. With FAR Part 25, §25.533(c) distributed pressures are given with a distribution along the fuselage length, for the design of the
frames.

In addition, FAR Part 25, §25.527 would allow calculation of water reaction load factors along the fuselage.

When applying these FAR Part 25 seaplane requirements to conventional large aeroplane, some of the seaplane design parameters cannot be applied directly and may need some adjustment. For example, on a seaplane the so-called step defines the fore-body and afterbody of the hull, but it is a design feature not present on conventional large aeroplane. Also, seaplanes have a flared or unflared bottom structure, with a physical chine line, whereas conventional large aeroplane are (semi)circular in shape.
As a result, applicants typically do not apply the local and distributed pressure distributions in the fore-aft and lateral (transverse) direction exactly as prescribed in the FAR Part 25 seaplane requirements, but derive more rationale pressure distribution based on ditching model testing data. Similarly, the definition of a chine line (defining the wetted area where water pressures are applied) and an equivalent angle of dead rise angle as applicable to a (semi)circular shaped fuselage needs to be derived from ditching model test data. When using the local or distributed pressure equations contained in FAR Part 25, § 25.533 the aeroplane speed and weight at impact should be as defined in FAR Part 25, § 25.125(b)(2)(i)) established for the aeroplane assessment weight and corresponding to the flap setting established under the preferred AFM ditching procedure.

6 *Variation of Parameters.*

Considering the inherent complexity of the ditching event, the following parameters and characteristics should be used to define the structural loads with prescribed variations in certain impact parameters and approach configurations. In general, the ditching condition should consider the certified design ranges of aeroplane weight, center of gravity and allowable configurations.

Variation in certain parameters may be reduced if the aeroplane has reliable design features that control the variability.

Per CS 25.563, variations of flight parameters have to be considered:

- Pitch Attitude
- Forward Speed
- Sink rate
- Mass configuration (mass, center of gravity, moments of inertia)
- Flap setting
- Landing gear extended/retracted
- Engine Power Setting
- Rupture of Engines, Flaps or fairings

This list of parameters may not be complete depending on the aeroplane design.

Model test or simulations may deliver time histories of all investigated parameters plus pressure distributions, which can be integrated to obtain global loads. In this case no further pressure calculation is necessary.

The objective is to find conditions which show:

a) Smooth (hydro)dynamic behaviour (no nose-dive or re-bounce)
a) Accelerations less or equal to the inertia forces specified in CS 25.561(b). Higher load factors may be acceptable provided the structural components are designed for the higher loads and also provided it can be shown that the occupants are protected from serious injury under these loads.

As an example, this assessment may result in the following:

- Sink rate less than 5 feet/second
- Forward speed 100 knots @ maximum landing weight (MLW) and flaps fully extended
  - o Assumes fuel is dumped or burned off
- Pitch attitude between 7 degrees and 9 degrees
- Landing Gear retracted
- Landing parallel to waves

These conditions may be directly used for an AFM procedure and should be reviewed by pilots and flight physics specialists in order to confirm they are within the capability of the flight crew and aeroplane. The AFM procedure is then completed by defining the preferred ditching technique from level flight to the water surface.

The following apply for the assessment of the variation of parameters:

(1) An aeroplane vertical descent rate not less than 1.52 m/s (5 feet per second) relative to the mean water surface, unless a lower value is justified that fully accounts for likely variation over the value established under the preferred AFM ditching procedure.

(2) A forward aeroplane speed along the flight path not less than V_{REF} (as defined in CS 25.125(b)(2)(i)) established for the aeroplane assessment weight and corresponding to the flap setting established under the preferred AFM ditching procedure, unless a lower value is justified that fully accounts for likely variation over the value established under the preferred AFM ditching procedure.

(3) An increase in aeroplane attitude by at least 1 degree (nose up), as compared to the attitude established under the preferred AFM ditching procedure, and, separately a decrease in aeroplane attitude by at least 1 degree (nose down) as compared to the attitude established under the preferred planned AFM ditching procedure

The following apply for planned and unplanned ditching evaluation for all aeroplanes:

(1) For planned ditching, aeroplane weights may consider fuel jettisoning provisions or fuel burn off but may not be less than the Maximum Design Landing Weight (MLW) at the moment of water impact.
Unplanned ditching flotation is to be based on Maximum Take Off Weight (MTOW). Structural damage need not be considered for the unplanned ditching condition.

(2) Calm water states may be assumed.

(3) Fresh water is assumed for flotation calculations.

(4) Withstanding ditching loads implies an airframe assessment that needs to account for local loads (skin, stringers) and load factors for the fuselage and establish distributed pressures. Local damage may occur but the airframe structural integrity should be maintained. Any leakage should be accounted for in the flotation analysis. Additionally, breakaway or loss of large items (e.g. gear doors, belly fairing, flaps, and engines) and its effect on flotation and hydrodynamic behaviour should be considered.

(5) Only symmetrical conditions need to be considered and the resulting pressures can be considered as ultimate loads. A rational distribution may be used to develop the pressure distribution along the side of the fuselage.

7 *Fidelity of Loads*

The fidelity of the loads analysis depends on the process of structural substantiation, which follows the loads generation.

The greatest fidelity achievable by analyses is when, for each calculation point on the airframe, a pressure value is defined for each time step of the simulation. This can be used to develop a static design case to be loaded on a finite element model (FEM) or to be used by any other method for evaluating stresses. Also, a pressure time history can be built, which can be used in a structural substantiation.

For simplification, pressures can be averaged in time or space, or they may be integrated to local forces for frame or skin stress evaluation. This depends on stress methods used by the applicant.

8 *Airframe Assessment*

Fuselage structure should be assessed to verify that the frames can carry the distributed pressures loads, and consistent with flotation assumptions, the skins and stringers can withstand local pressures, and items of mass are retained (load factors).
Global aeroplane integrity (i.e. not exceeding the certification strength envelopes) for the planned ditching event should also be ensured.
In addition, as per CS 25.809(g), there must be provisions to minimise the probability of jamming of the emergency exits resulting from fuselage deformation in a planned emergency landing on water.

9 AFM procedures

AMC 25.1581 states that the AFM should include emergency procedures, including those for ditching. For ditching, the AFM should include, as a minimum, procedures for a planned emergency landing on the water and procedures for a reduced power or no power emergency landing on the water. The AFM ditching procedures should be coherent with the assumptions made in the ditching analysis and in the definition of the ditching conditions. For example, if the ditching conditions assume that the high-lift devices are to be extended during an emergency landing on water, then the AFM procedure should include the necessary steps to extend the high-lift devices. The AFM procedures should be verified for practicality and effectiveness as required by AMC 25.1309 Chapter 9, paragraph b.(5).

10. Cabin crew traning

The applicant should provide appropriate information to support cabin crew training for planned and unplanned ditching scenarios, concerning the design precautions (e.g. ditching exits, life lines, rafts portability, etc).

Item 1.3 Buoyancy – evacuation analysis

Amend AMC 25.801 as follows:

AMC 25.801 Ditching

1. CS 25.801(a) – Evacuation after an unplanned ditching

Although there are many possible scenarios that could result in an unplanned ditching, the following assumptions may be used for addressing compliance with the unplanned ditching specifications in CS 25.801(a):

(1) In order to simplify compliance determinations for an unplanned ditching scenario, no aeroplane damage should be considered. As such, the dynamics of entry into the water should not be considered, including analysis of dynamic pressures resulting from the aeroplane coming to rest; it may be assumed that the aeroplane is resting in the water immediately after an unplanned ditching.

(2) Because an unplanned ditching immediately after a failed or aborted takeoff could occur at high aeroplane weights, for the purposes of developing a flotation analysis, the worst case

combination of aeroplane weight and centre of gravity (CG) should be considered (typically expected to be maximum takeoff weight (MTOW) with the CG at the aft limit).

(3) All sources of water leakage into the aeroplane should be considered.

(4) Since not all aeroplanes are required to carry ditching equipment associated with overwater flights, it is not necessary to account for the time to retrieve and launch rafts.

(5) For the purposes of developing a flotation and evacuation analysis, an exit should be conservatively considered unusable when water comes in over the top of the door sill.

(6) Aeroplane flotation should be assumed to end when the first ditching exit goes below the waterline or the attitude of the aeroplane is such that it would require extraordinary effort to move through the cabin (e.g., 20 degrees). However, if it can be shown to be conservative, the flotation time may be extended. A showing of conservatism should include an assessment of the number of persons expected to be remaining in the aeroplane when the ditching exit sill(s) goes below the waterline, the number of ditching exits remaining above the waterline and the attitude of the aeroplane.

(7) In order to be credited with full passenger seat-to-exit ratio, each ditching exit should either remain above the waterline during the entire evacuation, or it should be available for use long enough to allow the number of evacuees equal to its seat-to-ditching exit ratio to use the exit (e.g., a ditching exit with a 35 passenger seat-to-exit ratio should either remain usable for the entire evacuation or long enough to allow at least 35 evacuees to exit the aeroplane through that exit in order to receive the full 35 passenger ratio). A lower passenger seat-to-exit ratio may be sought provided the exit remains above the waterline for the majority (greater than 50%) of the total aeroplane evacuation time. No passenger seat credit should be allowed for a ditching exit that does not remain above the waterline for the majority of the total aeroplane evacuation time.

(8) For non-overwing ditching exits, it is acceptable to assume that passengers will exit the aeroplane by entering slide/raft (if provided), or by jumping into the water and swimming away from the exit. For the overwing exits, it is acceptable to assume that passengers will exit onto the wing and, depending on the circumstances, either remain on the wing or jump into the water. No credit should be taken for aeroplane weight reduction resulting from evacuees exiting the aeroplane through overwing exits.

(9) For the purposes of preparing an evacuation timeline, the longest full-scale evacuation demonstration (FSED) exit preparation time for an exit of that type, for that aeroplane, or 15 seconds, whichever is greater, should be assumed prior to the initial occupant evacuation from the aeroplane.

(10) For the purposes of preparing an evacuation timeline, evacuation rates obtained from the aeroplane FSED are acceptable for preparing a ditching evacuation analysis if the evacuees exit in the same or similar manner as during the FSED and the assist means (if deployed) does not block the emergency exit opening. Alternatively, data developed by test and analysis for demonstrating compliance with CS 25.803 land evacuation specifications are also acceptable. However, the aisle flow rate may determine the evacuation rate at a pair of exits if it is fed by passengers from only one direction and the combined exit pair flow rate is greater than the available aisle rate.

Note: The evacuation rate for slides/rafts deployed from representative sill heights should not exceed 60 persons per minute per lane for a duration of 70 seconds.

(11) For the purposes of preparing an evacuation timeline it is acceptable to assume that the flow of evacuees to the emergency exits is not diminished by the retrieval or the donning of life vests.

2. CS 25.801(b) – Certification with ditching provisions

CS 25.801(b) requires an evaluation of the probable behaviour of the aeroplane at ditching and the hydrodynamic characteristics. This assessment can be performed in conjunction with the variation of parameters or the loads development if using numerical techniques and simulations.

Section 4 in AMC 25.563 provides 'Accepted Methods for Evaluating Hydrodynamic Behaviour' which can be used for showing compliance with CS 25.801(b)(1) and (b)(2).

CS 25.801(b)(3):
Since ditching events can occur with varying degrees of aeroplane and passenger preparedness, the following assumptions are appropriate for assessing the flotation of the aeroplane and evacuation of the occupants following a planned ditching:

(1) It should be assumed the aeroplane enters the water, in accordance with Aeroplane Flight Manual (AFM) ditching procedures, at the Maximum Design Landing Weight (MDLW); with the most adverse aeroplane centre of gravity. For the flotation analysis, the aeroplane weight may be reduced to account for items of mass in non-pressurised sections of the aeroplane that are shown to separate from the aeroplane as a result of the planned landing on the water.

(2) All sources of water leakage into the aeroplane should be considered, including leakage from probable damage resulting from the conditions prescribed in CS 25.563.

(3) For the purposes of developing a flotation and evacuation analysis, an exit should be conservatively considered unusable when water comes in over the top of the door sill.

(4) Aeroplane flotation should be assumed to end when the first ditching exit goes below the waterline or the attitude of the aeroplane is such that it would required extraordinary effort to move through the cabin (e.g., 20 degrees). However, if it can be shown to be conservative, the flotation time may be extended. A showing of conservatism should include an assessment of the number of persons expected to be remaining in the aeroplane when the ditching exit sill(s) goes below the waterline, the number of ditching exits remaining above the waterline and the attitude of the aeroplane.

(5) To receive its full passenger seat-to-exit ratio, each ditching exit should either remain above the waterline during the entire evacuation, or it should be available for use long enough to allow the number of evacuees equal to its seat-to-ditching exit ratio to use the exit (e.g., a ditching exit with a 35 passenger seat-to-exit ratio should either remain usable during the entire evacuation or long enough to allow at least 35 evacuees to exit the aeroplane through that exit in order to receive the full 35 passenger ratio). A lower passenger seat-to-exit ratio may be sought provided the exit remains above the waterline for the majority (greater than 50%) of the total aeroplane evacuation time. No passenger seat credit should be allowed for a ditching exit that does not remain above the waterline for the majority of the total

aeroplane evacuation time.

(6) For the purposes of preparing an evacuation timeline, the longest FSED exit preparation time for an exit of that type, for that aeroplane, or 15 seconds, whichever is greater, should be assumed prior to the initial occupant evacuation from the aeroplane.

(7) For the purposes of preparing the evacuation timeline, it should be assumed that the aeroplane has ditching equipment required for overwater flights. Therefore, it is necessary to account for the time to retrieve, launch rafts and board the life rafts.

(8) For the purposes of preparing an evacuation timeline, evacuation rates obtained from the aeroplane FSED are acceptable for preparing a ditching evacuation analysis if the evacuees exit in the same or similar manner as the FSED and the assist means (if deployed) does not block the emergency exit opening. Alternatively, data developed by test and analysis for demonstrating compliance with CS 25.803 emergency evacuation requirements are also acceptable. However, the aisle flow rate may determine the evacuation rate at a pair of exits if it is fed by passengers from only one direction and the combined exit pair flow rate is greater than the available aisle rate.

Note: The evacuation rate for slides/rafts deployed from representative sill heights should not exceed 60 persons per minute per lane for a duration of 70 seconds.

(9) For the purposes of preparing an evacuation timeline it is acceptable to assume that the flow of evacuees to the emergency exits is not diminished by the retrieval or the donning of life vests.

3. CS 25.801(d) - Flotation time and trim of the aeroplane
EASA accepts the relevant parts of Federal Aviation Administration (FAA) AC 25-17A 'Transport Airplane Cabin Interiors Crashworthiness Handbook', of 24 May 2016, as an acceptable means of compliance with CS 25.801(d).
Note: 'relevant parts' means the AC 25-17A parts that address the applicable Federal Aviation Regulation (FAR)/CS-25 paragraph(s).

Item 2: Amendment of AMC 25.1309 – Development assurance and AMC 20 references

Amend AMC 25.1309 as follows:

AMC 25.1309 System design and analysis

(…)
3. RELATED DOCUMENTS.

The following guidance and advisory materials are referenced herein:

a. _Advisory Circulars, Acceptable Means of Compliance._

(1) AMC 25.1322 Alerting Systems.

(2) AC 25-19/AMC 25-19 Certification Maintenance Requirements.

An agency of the European Union

(3) AMC 20-115 Software Considerations for Airborne Systems and Equipment Certification.
(4) AMC 25.901(c) Safety Assessment of Powerplant Installations.

(5) AMC 20-152A Development Assurance for Airborne Electronic Hardware (AEH)

(6) AMC 20-189 The Management of Open Problem Reports (OPRs)

(7) AMC 20-193 Use of multi-core processors
(…)

9. COMPLIANCE WITH CS 25.1309.
(…)

b. Compliance with CS 25.1309(b).

(…)

(4) *Acceptable Application of Development Assurance Methods.* Paragraph 9.b(1)(iii) above requires that any analysis necessary to demonstrate compliance with CS 25.1309(b) must consider the possibility of development errors. Errors made during the development of systems have traditionally been detected and corrected by exhaustive tests conducted on the system and its components, by direct inspection, and by other direct verification methods capable of completely characterising the performance of the system. These direct techniques may still be appropriate for systems containing non-complex items (i.e. items that are fully assured by a combination of testing and analysis) that perform a limited number of functions and that are not highly integrated with other aeroplane systems. For more complex or integrated systems, exhaustive testing may either be impossible because all of the system states cannot be determined or impractical because of the number of tests that must be accomplished. For these types of systems, compliance may be demonstrated by the use of development assurance. The level of development assurance (function development assurance level (FDAL)/item development assurance level (IDAL)) should be commensurate with the severity of the failure conditions the system is contributing to.

Guidelines, which may be used for the assignment of development assurance levels to aeroplanes and system functions (FDAL) and to items (IDAL), are described in the Document referenced in 3.b(2) above. Through this Document, EASA recognises that credit can be taken from system architecture (e.g. functional or item development independence) for the FDAL/IDAL assignment process.

Guidelines, which may be used for providing development assurance, are described for aeroplane, ~~and~~ system, and equipment development in the Document referenced in 3.b(2), ~~and~~ for software development in the Document referenced in 3.a(3), for airborne electronic hardware development in the Document referenced in 3.a(5), for the management of open problem reports in the Document referenced in 3.a(6), and for the use of multicore processor in the Document referenced in 3.a(7)~~above~~. ~~(There is currently no agreed development assurance standard for airborne electronic hardware.)~~

13. ASSESSMENT OF MODIFICATIONS TO PREVIOUSLY CERTIFICATED AEROPLANES.

The means to assure continuing compliance with CS 25.1309 for modifications to previously certificated aeroplanes should be determined on a case-by-case basis and will depend on the applicable aeroplane certification basis and the extent of the change being considered. The change could be a simple modification affecting only one system or a major redesign of many systems, possibly incorporating new technologies. The minimal effort for demonstrating compliance ~~to~~ with

CS 25.1309 for any modification is an assessment of the impact on the original previous system safety assessment and on the associated development assurance data. The result of this assessment may range from a simple statement that the existing system safety assessment (and any associated development assurance data) still applies to the modified system in accordance with the original means of compliance, to the need for new means of compliance encompassing the plan referred to in paragraph 9b. (STC applicants, if the TC holder is unwilling to release or transfer proprietary data in this regard, the STC applicant may have to create the System Safety Assessment and the associated artefacts for development assurance. Further guidance may be found in paragraph 6 of Document referenced in paragraph 3b(2).) It is recommended that the Agency be contacted early to obtain agreement on the means of compliance.
(…)

Item 3: Installed systems and equipment for use by the flight crew

Amend CS 25.1302 as follows:

CS 25.1302 Installed systems and equipment for use by the flight crew

(See AMC 25.1302)

This paragraph applies to installed systems and equipment intended for to be used by the flight crew members' use in the operation of when operating the aeroplane from their normally seated positions on the flight deck. This Those installed systems and equipment must be shown, individually and in combination with other such systems and equipment, to be designed so that qualified flight crews trained in itstheir use can safely perform their tasks associated with its the intended function of the systems and equipment by meeting the following requirements:

(a) Flight deck The controls must be installed to allow and information intended necessary for the accomplishment of these the tasks and information necessary to accomplish these tasks must be provided.

(b) Flight deck The controls and information required by paragraph (a), which are intended for use by the flight crew use, must:

(1) Be presented in a clear and unambiguous form, at resolution and with a precision appropriate to the flight crew task.

(2) Be accessible and usable by the flight crew in a manner consistent with appropriate to the urgency, frequency, and duration of their tasks; and

(3) Enable Make the flight crew awareness , if awareness is required for safe operation, of the effects their actions may have on the aeroplane or its systems resulting from flight crew actions, if they require awareness for the safe operation of the aeroplane.

(c) Operationally relevant behaviour of the installed systems and equipment must be:

(1) Predictable and unambiguous; and

(2) Designed to enable the flight crew to intervene in a manner that is appropriate to accomplish their the tasks.

(d) To the extent practicable, The installed systems and equipment must enable the flight crew to manage the errors that resulting from the kinds of flight crew interactions with the systems and equipment that can be reasonably expected in service, assuming the flight crew is acting acts in good faith. This subparagraph (d) does not apply to skill-related errors associated with manual control of the aeroplane.

Replace AMC 25.1302 by the following:

AMC 25.1302 Installed systems and equipment for use by the flight crew

Table of Contents

1)_INTRODUCTION

1.1_Background

Demonstrating compliance with the design requirements that relate to human abilities and limitations is subject to interpretation. Findings may vary depending on the novelty, complexity or integration of the system design. EASA considers that describing a structured approach to selecting and developing acceptable means of compliance is useful in supporting the standardisation of compliance demonstration practices.

1.2_Applicability

(a) This acceptable means of compliance (AMC) provides the means for demonstrating compliance with CS 25.1302 and complements the AMC of several other paragraphs in CS-25 (refer to paragraph 2, Table 1 of this AMC) that relate to the installed systems and equipment used by the flight crew for the operation of an aeroplane. In particular, this AMC addresses the design and approval of installed systems and equipment intended for use by the flight crew from their normal seating positions in the flight deck.

(b) This AMC applies to flight crew interfaces and system behaviour for all the installed systems and equipment used by the flight crew while operating the aeroplane in normal, abnormal/malfunction and emergency conditions. flight crew

(c) This AMC does not apply to flight crew training, qualification or licensing requirements.

1.3_Definitions

For the purposes of this AMC, the following definitions apply:

— **Abnormal/malfunction condition**: For the purposes of this AMC, abnormal/malfunction or emergency operating conditions refer to conditions that do require the flight crew to apply procedures different from the normal procedures included in the aeroplane flight manual (AFM).

— **Alert**: A flight deck indication that is meant to attract the attention of the crew, and identify to them an operational or aeroplane system condition. Warnings, cautions, and advisories are considered alerts.

— **Assessment**: The process of finding and interpreting evidence to be used by the applicant in order to establish compliance with a specification. For the purposes of this AMC, the term 'assessment' may refer to both evaluations and tests. Evaluations are intended to be conducted using partially representative test means, whereas tests make use of conformed test articles.

— **Automation**: The technique of controlling an apparatus, a process or a system by means of electronic and/or mechanical devices, which replaces the human organism in the sensing, decision-making and deliberate output.

— **Catachresis**: Applied to the area of tools, 'catachresis' means the use of a tool for a function other than the one planned by the designer of the tool; for instance, the use of a circuit breaker as a switch.

— **Clutter**: An excessive number and/or variety of symbols, colours, or other information that may reduce the access to the relevant information, increase interpretation time and the likelihood of interpretation error.

— **Conformity**: Official verification that the flight deck/system/product conforms to the type design data.

— **Control device**: A control device is a piece of equipment that allows the flight crew to interact with the virtual controls, typically used with the graphical user interface; control devices may include the following:

  — keyboards,

  — touchscreens,

  — cursor-control devices (keypads, trackballs, pointing devices),

  — knobs, and

  — voice-activated controls.

— **Cursor-control device**: A control device for interacting with the virtual controls, typically used with a graphical user interface on an electro-optical display.

— **Design eye reference point (DERP)**: A point in the flight deck that provides a finite reference enabling the precise determination of geometric entities that define the layout of the flight deck.

— **Design feature:** A design feature is an attribute or a characteristic of a design.

— **Design item:** A design item is a system, an equipment, a function, a component or a design feature.

— **Design philosophy**: A high-level description of the human-centred design principles that guide the designer and aid in ensuring that a consistent, coherent user interface is presented to the flight crew.

— **Design-related human performance issue**: A deficiency that results from the interaction between the flight crew and the system. It includes human errors, but also encompasses other kinds of shortcomings such as hesitations, doubts, difficulties in finding information, suboptimal strategies, inappropriate levels of workload, or any other observable item that cannot be considered to be a human error, but still reveals a design-related concern.

— **Display**: A device that transmits data or information from the aircraft to the crew.

— **Emergency condition**: Refer to Abnormal condition.

— **Flight crew member**: A licensed crew member charged with duties that are essential for the operation of an aircraft during a flight duty period.

— **Flight deck:** The area of the aircraft where the flight crew work and where the primary flight controls are located.

— **Flight deck controls**: The interaction with a control means that the flight crew manipulates in order to operate, configure, and manage the aircraft or its flight control surfaces, systems, and other equipment.

This may include equipment in the flight deck such as:

  — control devices,

  - buttons,
  - switches,
  - knobs,
  - flight controls, and
  - levers.

- **Human error**: A deviation from what is considered correct in some context, especially in the hindsight of the analysis of accidents, incidents, or other events of interest. Some types of human error may be the following: an inappropriate action, a difference from what is expected in a procedure, an incorrect decision, an incorrect keystroke, or an omission. In the context of this AMC, human error is sometimes referred to as 'crew error' or 'pilot error'.
- **Multifunction control**: A control device that can be used for many functions, as opposed to a control device with a single dedicated function.
- **Operationally relevant behaviour**: Operationally relevant behaviour is meant to convey the net effect of the system logic, controls, and displayed information of the equipment upon the awareness of the flight crew or their perception of the operation of the system to the extent necessary for planning actions or operating the system. The intent is to distinguish such system behaviour from the functional logic within the system design, much of which the flight crew does not know or does not need to know, and which should be transparent to them.
- **System function allocation**: A Human Factors (HF) method for deciding whether a particular function will be accomplished by a person, technology (hardware or software) or some mix of a person and technology (also referred to as 'task allocation').
- **Task analysis**: A formal analytical method used to describe the nature and relationships of complex tasks involving a human operator.

1.4_Abbreviations

The following is a list of abbreviations used in this AMC:

AC	Advisory Circular
AFM	Aeroplane Flight Manual
AMC	Acceptable Means of Compliance
ATC	Air Traffic Control
CRM	Crew Resource Management
CS	Certification Specification
DOT	Department of Transportation
EASA	European Union Aviation Safety Agency
ECL	Electronic Check List
ED	EUROCAE Document

FADEC	Full Authority Digital Engine Control
FAA	Federal Aviation Administration
FMS	Flight Management System
GM	Guidance Material
HF	Human Factors
HMI	Human–Machine Interface
ICAO	International Civil Aviation Organization
ISO	International Standards Organization
LoI	Level of Involvement
MoC	Means of Compliance
MMEL	Master Minimum Equipment List
PANS	Procedures for Air Navigation Services
QAK	Quick Access Key
SAE	Society of Automotive Engineers
STC	Supplemental Type Certificate
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Alert and Collision Avoidance System
VOR	Very high frequency Omnidirectional Range

2)_RELATION BETWEEN CS 25.1302 AND OTHER SPECIFICATIONS, AND ASSUMPTIONS

2.1_The relation of CS 25.1302 to other specifications

(a) This AMC provides dedicated acceptable means for demonstrating compliance with CS 25.1302. To help the applicant reach the objectives of CS 25.1302, some additional guidance related to other specifications associated with the installed systems and equipment that the flight crew use to operate the aeroplane is also provided in Section 4. Table 1 below contains a list of these specifications related to flight deck design and flight crew interfaces for which this AMC provides additional design guidance. Note that this AMC does not provide a comprehensive acceptable means of compliance for any of the specifications beyond CS 25.1302.

Table 1: Certification specifications relevant to this AMC

CS-25 BOOK 1 references	***General topic***	***Referenced material in this AMC***
CS 25.771(a)	Unreasonable concentration or fatigue	Error, 4.5. Integration, 4.6. Controls, 4.2. System behaviour, 4.4.
CS 25.771(b)	Controllable from either pilot seat	Controls, 4.2. Integration, 4.6.
CS 25.773	Pilot compartment view	Integration, 4.6.

CS-25 BOOK 1 references	***General topic***	***Referenced material in this AMC***
CS 25.777(a)	Convenient operation of the controls	Controls, 4.2. Integration, 4.6.
CS 25.777(b)	Fully and unrestricted movement	Controls, 4.2. Integration, 4.6.
CS 25.779	Motion and effect of flight deck controls	Controls, 4.2
CS 25.1301(a)	Intended function of installed systems	Error, 4.5. Integration, 4.6. Controls, 4.2. Presentation of information, 4.3. System behaviour, 4.4.
CS 25.1302	Crew error	Error, 4.5. Integration, 4.6. Controls, 4.2. Presentation of information, 4.3. System behaviour, 4.4.
CS 25.1309(a)	Intended function of required equipment under all operating conditions	Controls, 4.2. Integration, 4.6.
CS 25.1309(c)	Unsafe system operating conditions and minimising crew errors which could create additional hazards	Presentation of information, 4.3. Errors, 4.5.
CS 25.1321	Visibility of instruments	Integration, 4.6.
CS 25.1322	Warning, caution and advisory lights	Integration, 4.6.
CS 25.1329 and Appendix B VII	Automatic pilot system	System behaviour, 4.4.
CS 25.1335	Flight director systems	System behaviour, 4.4
CS 25.1523	Minimum crew	Controls, 4.2. Integration, 4.6.
CS 25.1543(b)	Visibility of instrument markings	Presentation of information, 4.3.
CS 25.1549	Powerplant instruments	Presentation of information, 4.3.
CS 25.1555(a)	Control markings	Controls, 4.2.
CS 25.1557	Miscellaneous marking and placards	Presentation of information, 4.3.

(b) Where acceptable means of compliance in other AMCs are provided for specific equipment and systems, those means are assumed to take precedence if a conflict exists with the means provided in this AMC.

2.2_Flight crew member capabilities

In order to demonstrate compliance with all the specifications referenced by this AMC, all the certification activities should be based on the assumption that the aeroplane will be operated by qualified flight crews who are trained in the use of the installed systems and equipment.

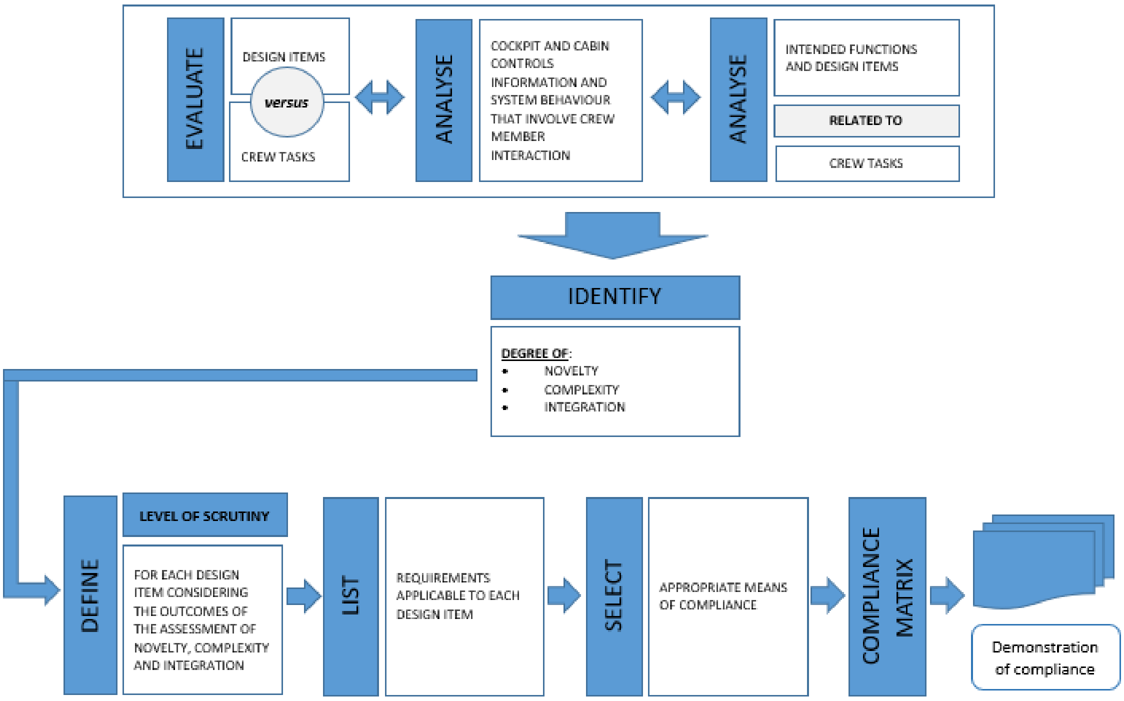
3)_HUMAN FACTORS CERTIFICATION

3.1_Overview

(a) This paragraph provides an overview of the Human Factors (HF) certification process that is acceptable to demonstrate compliance with CS 25.1302. This includes a description of the recommended applicant activities, the communication between the applicant and EASA, and the expected deliverables.

(b) Figure 1 illustrates the main steps in the HF certification process.

Paragraph 3 — Figure 1: Methodical approach to the certification for design-related human performance issues



3.2_Certification steps and deliverables

3.2.1_Identification of the flight deck controls, information and systems that involve flight crew interaction

(a) As an initial step, the applicant should consider all the design items used by the flight crew with the aim of identifying the controls, information and system behaviour that involve flight crew interaction.

(b) In case of a modification, the scope of the functions to be analysed is limited to the design items affected by the modification and its integration.

(c) The objective is to analyse and document the flight crew tasks to be performed, or how tasks might be changed or modified as a result of introducing a new design item(s).

3.2.2_The intended function of the equipment and the associated flight crew tasks

(a) CS 25.1301(a) requires that 'each item of installed equipment must be of a kind and design appropriate to its intended function'. CS 25.1302 establishes the requirements to ensure that the design supports the flight crew in performing his tasks . In order to demonstrate compliance with CS 25.1302, the intended function of a system and the tasks expected to be performed by the flight crew must be known.

(b) An applicant's statement of the intended function should be sufficiently specific and detailed so that it is possible to evaluate whether the system is appropriate for the intended function(s) and the associated flight crew tasks. For example, a statement that a new display system is intended to 'enhance situational awareness' should be further explained. A wide variety of different displays enhance the situational awareness in different ways. Some examples are terrain awareness, vertical profiles, and even the primary flight displays. The applicant may need to provide more detailed descriptions for designs with greater levels of novelty, complexity, or integration.

(c) The applicant should describe the intended function(s) and associated task(s) for:

(1) each design item affected by the modification and its integration;

(2) flight crew indications and controls for that equipment; and

(3) the prominent characteristics of those indications and controls.

This type of information is of the level typically provided in a pilot handbook or an operations manual. It would describe the indications, controls, and flight crew member procedures.

(d) The applicant may evaluate whether the statement of the intended function(s) and the associated task(s) is sufficiently specific and detailed by using the following questions:

(1) Does each design item have a stated intent?

(2) Are the flight crew member tasks associated with the function(s) described?

(3) What assessments, decisions, and actions is the flight crew expected to make based on the information provided by the system?

(4) What other information are assumed to be used in combination with the system?

(5) Will the installation or use of the system interfere with the ability of the flight crew to operate other flight deck systems?

(6) Are any assumptions made about the operational environment in which the equipment will be used?

(7) What assumptions are made about the attributes or abilities of the flight crew beyond those required in the regulations governing operations, training, or qualification?

(e) The output of this step is a list of design items, with each of the associated intended functions that has been related to the flight crew member tasks.

3.2.3_Determining the level of scrutiny

(a) The depth and extent of the HF investigation to be performed in order to demonstrate compliance with CS 25.1302 is driven by the level of scrutiny.

The level of scrutiny is determined by analysing the design items using the criteria described in the following subparagraphs:

(1) **Integration.** The level of the systems' integration refers to the extent to which there are interdependencies between the systems that affect the operation of the aeroplane by the flight crew. The applicant should describe the integration between systems because it may affect the means of compliance. Paragraph 4.6 also refers to integration. In the context of that paragraph, 'integration' defines how specific systems are integrated into the flight deck and how the level of integration may affect the means of compliance.

(2) **Complexity.** The level of complexity of the system design from the flight crew's perspective is an important factor that may also affect the means of compliance. Complexity has multiple dimensions, for instance:

— the number, the accessibility and the level of integration of information that the flight crew has to use (the number of items of information on a display, the number of colours), alerts, or voice messages may be an indication of the complexity;

— the number, the location and the design of the flight deck controls associated with each system and the logic associated with each of the controls; and

— the number of steps required to perform a task, and the complexity of the workflows.

(3) **Novelty.** The novelty of a design item is an important factor that may also affect the means of compliance. The applicant should characterise the degree of novelty on the basis of the answers to the following questions:

(i) Are any new functions introduced into the flight deck design?

(ii) Does the design introduce a new intended function for an existing or a new design item?

(iii) Are any new technologies introduced that affect the way the flight crew interacts with the systems?

(iv) Are any new design items introduced at aeroplane level that affect flight crew tasks?

(v) Are any unusual procedures needed as a result of the introduction of a new design item?

(vi) Does the design introduce a new way for the flight crew to interact with the system?

While answering the above questions, each negative response should be justified by the applicant identifying the reference product that has been considered. The reference product can be an avionics suite or an entire flight deck previously certified by the same applicant.

The degree of novelty should be proportionate to the number of positive answers to the above questions.

(b) All the affected design items (refer to point 3.2.1) are expected to be scrutinised. If none of the criteria in point (a) above is met, the related design item is candidate for a low level of scrutiny.

The level of scrutiny performed by the applicant should be proportionate to the number of the above criteria which are met by each design item. Applicants should be aware that the impact of a complex design item might also be affected by its novelty and the extent of its integration with other elements of the flight deck. For example, a complex but not novel design item is likely to require a lower level of scrutiny than one that is both complex and novel. On the other hand, a function that is brand new and yet "unknown" might trigger a high level of scrutiny even if the answers to the other questions are "no". In case there is no direct proportionality between the number of criteria and the level of scrutiny, the applicant should provide rationale. The applicant is expected to include in the certification plan all the items that have been analysed with the associated level of scrutiny.

(c) The applicant may use a simpler approach for design items that have been assigned a low level of scrutiny.

3.2.4_Determining the level of scrutiny — EASA's familiarity with the project

The assessment of the classifications of the level of scrutiny proposed by the applicant requires the EASA flight and HF panels to be familiar with the project, making use of the available material and tools.

3.2.5_Applicable HF design requirements

(a) The applicant should identify the HF design requirements applicable to each design item for which compliance must be demonstrated. This may be accomplished by identifying the design characteristics of the design items that could adversely affect the performance of the flight crew, or that pertain to the avoidance and management of flight crew errors. Specific design considerations for the requirements that involve human performance are discussed in paragraph 4.

(b) The expected output of this step is a compliance matrix that links the design items and the HF design requirements that are deemed to be relevant and applicable so that a detailed assessment objective can be derived from each pair of a design item and a HF design requirement. That objective will have then to be verified using the most appropriate means of compliance, or a combination of means of compliance. GM2 25.1302 provides one possible example of this matrix.

3.2.6_Selecting the appropriate means of compliance

(a) The applicant should review paragraph 5.2 for guidance on the selection of the means of compliance, or multiple means of compliance, appropriate to the design. In general, it is expected that the level of scrutiny should increase with higher levels of novelty, complexity or integration of the design. It is also expected that the amount of effort dedicated to the demonstration of compliance should increase with higher levels of scrutiny (e.g. by using multiple means of compliance and/or multiple HF assessments on the same topic).

(b) The output of this step will consist of the list of means of compliance that will be used to verify the HF objectives.

3.2.7_Certification programme

The applicant should document the certification process, outputs and agreements described in the previous paragraphs. This may be done in a separate plan or incorporated into a higher-level certification programme.

3.2.8_Other deliverables

(a) A HF test programme should be produced for each assessment and should describe the experimental protocol (the number of scenarios, the number and profiles of the flight crew members, practical organisation of the assessment, etc.), the HF assessment objectives that are meant to be addressed, the expected crew member behaviours, and the scenarios expected to be run. When required by the LoI, the HF test programme should be provided well in advance to EASA.

(b) A HF assessment report should be produced including at least the following information:

(1) A summary of:

(i) the test vehicle configuration,

(ii) test vehicle limitations/representativeness,

(iii) the detailed HF assessment objectives, and

(iv) the HF assessment protocol, including the number of sessions and flight crew members, type of flight crews (test or operational pilots from the applicant, authority pilots, customer pilots), a description of the scenarios, the organisation of the session (training, briefing, assessment, debriefing), and the observers;

(2) A description of the data gathered with the link to the HF objectives;

(3) In-depth analyses of the observed HF findings;

(4) Conclusions regarding the related HF assessment objectives; and

(5) A description of the proposed way to mitigate the HF findings (by a design modification, improvements in procedures, and/or training actions).

If EASA has retained the review of the assessment report as part of its LoI, then the applicant should deliver it following every HF assessment.

3.3_Certification strategy and methodologies

3.3.1_Certification strategy

(a) The HF assessment should follow an iterative process. Consequently, where appropriate, there may be several iterations of the same system-specific assessment allowing the applicant to reassess the system if the previous campaigns resulted in design modifications.

(b) A HF certification strategy based only on one assessment, aiming to demonstrate that the design assumptions are valid, is generally not sufficient (i.e. one final exercise proposed for compliance demonstration at the very end of the process).

(c) In order to allow a sufficient amount of design and assessment iterations, it is suggested that the applicant initiate the certification process as early as possible starting from the early development phase. The certification process could include familiarisation sessions that would allow EASA to become familiar with the proposed design, but also participate in assessments that would possibly allow early credits to be granted. Potential issues may be identified early on by using this approach, thus reducing the risk of a late redesign of design items that may not be acceptable to EASA. Both parties may have an interest in EASA early involvement, as EASA continuously gains experience and confidence in the HF process and the compliance of the flight deck design. The representativeness of the systems and of the simulation means in the early stages of the development is not a key driver, and will not prevent EASA's involvement as long as the representativeness issues do not compromise the validity of the data to be collected.

(d) If an applicant plans to use data provided by a supplier for compliance demonstration, the approach and the criteria for accepting that data will have to be shared and agreed with EASA as part of the HF certification plan.

3.3.2_Methodological considerations applicable to HF assessments

Various means of compliance may be selected, as described in paragraph 5.
For the highest level of scrutiny, the 'scenario-based' approach is likely to be the most appropriate methodology for some means of compliance.

The purpose of the following points is to provide guidelines on how to implement the scenario-based approach.

(a) The scenario-based approach is intended to substantiate the compliance of human–machine interfaces (HMIs). It is based on a methodology that involves a sample of various flight crew members that are representative of the future users, being exposed to real operational conditions in a test bench or a simulator, or in the aeroplane. The scenarios are designed to show compliance with selected rules and to identify any potential deviations between the expected behaviour of the flight crew and the activities of the flight crew that are actually observed. The scenario designers can make use of triggering events or conditions (e.g. a system failure, an ATC request, weather conditions, etc.) in order to build operational situations that are likely to trigger observable flight crew member errors, difficulties or misunderstandings. The scenarios need to be well consolidated before the test campaign begins. A dry-run session should be performed by the applicant before any HF campaign in order to validate the operational relevance of the scenarios. This approach should be used for both system- and aeroplane-level assessments.

(b) System-level assessments focus on a specific design item and are intended for an in-depth assessment of the related functional and operational aspects, including all the operational procedures. The representativeness of the test article is to be evaluated taking into account the scope of the assessment. Aeroplane-level assessments consider the scope of the full flight deck, and focus on integration and interdependence issues.

(c) The scenarios are expected to cover a subset of the detailed HF assessment objectives. The link between each scenario and the assessment objectives should be substantiated. This rationale should be described in the certification test plan or in any other relevant document.

(d) The criteria used to select the flight crew involved in the HF assessments with certification credit should be adequate to the scope of the tests to be conducted and the selection process of the flight crew should be recorded. The applicant should ensure that the test participants are representative of the end users.

(e) Due to interindividual variability, HF scenario-based assessments performed with a single crew member are not acceptable. The usually accepted number of different flight crew members used for a given campaign varies from three to five, including the EASA crew, if applicable. In the case of a flight crew composed of two members, with HF objectives focused on the duties of only one member, it is fully acceptable for the applicant to use the same pilot flying or monitoring (the one who is not expected to produce any HF data) throughout the campaign.

(f) In addition to the assessment report, and in order to reduce the certification risk, it is recommended that the preliminary analyses resulting from recorded observations and comments should be presented by the applicant to EASA soon after the simulator/flight sessions in order to allow expert discussions to take place.

(g) An initial briefing should be given to the flight crew at the beginning of each session to present the following general information:

(1) A detailed schedule describing the type and duration of the activities (the duration of the session, the organisation of briefings and debriefings, breaks, etc.);

(2) What is expected from the flight crew: it has to be clearly mentioned that the purpose of the assessment is to assess the design of the flight deck, not the performance of the pilot;

(3) The policy for simulator occupancy: how many people should be in the simulator versus the number of people in the control room, and who they should be; and

(4) The roles of the flight crew: if flight crew members from the applicant participate in the assessment, they should be made aware that their role differs significantly from their typical expert pilot role in the development process. For the process to be valid without significant bias, they are expected to react and behave in the flight deck as standard operational pilots.

(5) However, the flight crew that participates in the assessment should neither be:

(i) briefed in advance about the details of the failures and events to be simulated; this is to avoid an obvious risk of experimental bias; nor

(ii) asked before the assessment for their opinion about the scenarios to be flown.

(h) The flight crew need to be properly trained prior to every assessment so that during the analysis, the 'lack of training' factor can be excluded to the maximum extent possible from the set of potential causes of any observed design-related human performance issue. Furthermore, for operational representativeness purposes, realistic flight crew task sharing, from normal to emergency workflows and checklists, should be respected during HF assessments. The applicant should make available any draft or final AFM, procedures and checklists sufficiently in advance for the flight crew to prepare.

(i) When using simulation, the immersion feeling of the flight crew should be maximised in order to increase the validity of the data. This generally leads to recommendations about a sterile environment (with no outside noise or visual perturbation), no intervention by observers, no interruptions in the scenarios unless required by the nature of the objectives, realistic simulation of ATC communications, pilots wearing headsets, etc.

(j) The method used to collect HF data needs to take into account the following principles:

(1) Principles applicable to the collection of HF-related data

(i) In order to substantiate compliance with CS 25.1302, it is necessary to collect both objective and related subjective data.

(A) **Objective data** on flight crew performance and behaviour should be collected through direct observation. The observables should not be limited to human errors, but should also include pilot verbalisations in addition to behavioural indicators such as hesitation, suboptimal or unexpected strategies, catachresis, etc.

(B) **Subjective data** should be collected during the debriefing by the observer through an interactive dialogue with the observed flight crew. The debriefing should be led using a neutral and critical positioning from the observer. This subjective data is typically data that cannot be directly observed (e.g. pilot intention, pilot reasoning, etc.) and facilitate better understanding of the observed objective data from (i).

(ii) Other tools such as questionnaires and rating scales could be used as complementary means. However, it is never sufficient to rely solely on self-administered questionnaires due to the fact that flight crews are not necessarily aware of all their errors, or of deviations with respect to the intended use.

(2) The HF assessment should be systematically video recorded (both ambient camera and displays). Records may be used by the applicant as a complementary observation means, and by the authority for verification purposes, when required.

(3) It is very important to conduct debriefings after the HF assessments. They allow the applicant's HF observers to gather all the necessary data that has to be used in the subsequent HF analyses.

(4) HF observers should respect the best practices with regard to observation and debriefing techniques.

(5) Debriefings should be based on non-directive or semi-directive interviewing techniques and should avoid the experimental biases that are well described in the literature in the field of social sciences (e.g. the expected answer contained in the question, non-neutral attitude of the interviewer, etc.).

(k) If HF-related concerns are raised that are not directly related to the objective of the assessment, they should nevertheless be recorded, adequately investigated and analysed in the assessment report.

(l) Every design-related human performance issue observed or reported by the flight crew should be analysed following the assessment. In the case of a human error, the analysis should provide information about at least the following:

(1) The type of error;

(2) The observed operational consequences, and any reduction in the safety margins;

(3) The description of the operational context at the time of observation;

(4) Was the error detected? By whom, when and how?

(5) Was the error recovered? By whom, when and how?

(6) Existing means of mitigation;

(7) Possible effects of the representativeness of the test means on the validity of the data; and

(8) The possible causes of the error.

(m) The analysis of design-related human performance issues has to be concluded by detailing the appropriate way forward, which is one of the following:

(1) No action required;

(2) An operational recommendation (for a procedural improvement or a training action);

(3) A recommendation for a design improvement; or

(4) A combination of items (2) and (3).

(n) Workload assessment is considered and addressed in different ways through several requirements within CS-25.

(1) The intent of CS 25.1523 is to evaluate the workload with the objective of demonstrating compliance with the minimum flight crew requirements.

(2) The intent of CS 25.1302 is to identify design-related human performance issues.

(3) As per CS 25.1302, the acceptability of workload levels is one parameter among many to be investigated in order to highlight potential usability problems. The CS 25.1302 evaluations should not be limited to the workload alone. Workload ratings should be complementary to other data from observations of flight crew behaviour or other types.

(4) The techniques used to collect data in the context of the CS 25.1302 evaluations could make use of workload rating scales, but in that case no direct conclusion should be made from the results about the compliance with CS 25.1302.

4)_DESIGN CONSIDERATIONS AND GUIDANCE

4.1_Overview

(a) This material provides the standard which should be applied in order to design a flight deck that is in line with the objectives of CS 25.1302. Not all the criteria can or should be met by all systems. Applicants should use their judgment and experience in determining which design standard should apply to each part of the design in each situation.

(b) The following provide a cross reference between this paragraph and the specifications listed in CS 25.1302:

(1) 'Controls' mainly relates to CS 25.1302(a) and (b);

(2) 'Presentation of information' mainly relates to CS 25.1302(a) and (b);

(3) 'System behaviour' mainly relates to CS 25.1302(c); and

(4) 'Error management' mainly relates to CS 25.1302(d).

Additionally, specific considerations on integration are given in paragraph 4.6.

4.2_Controls

(a) Applicants must show that in the proposed design, as defined in CS 25.777, CS 25.779, CS 25.1543 and CS 25.1555, the controls comply with CS 25.1302(a) and (b).

(b) Each function, method of operating a control, and result of actuating a control must comply with the specifications. Each control must be shown to be:

(1) clear,

(2) unambiguous,

(3) appropriate in resolution and precision,

(4) accessible,

(5) usable, and

(6) able to make the flight crew aware of the effects of their actions, including the provision of adequate feedback.

(c) For each of these design specifications, consideration should be given to the following control characteristics for each control individually and in relation to other controls:

(1) The physical location of the control;

(2) The physical characteristics of the control (e.g. its shape, dimensions, surface texture, range of motion, and colour);

(3) The equipment or system(s) that the control directly affects;

(4) How the control is labelled;

(5) The available settings of the control;

(6) The effect of each possible actuation or setting, as a function of the initial control setting or other conditions;

(7) Whether there are other controls that can produce the same effect (or can affect the same target parameter), and the conditions under which this will happen; and

(8) The location and nature of the feedback that shows the control was actuated.

The following provides additional guidance for the design of controls that comply with CS 25.1302.

(d) The clear and unambiguous presentation of control-related information

(1) Distinguishable and predictable controls (CS 25.1301(a), CS 25.1302)

(i) Each flight crew member should be able to identify and select the current function of the control with the speed and accuracy appropriate to the task. The function of a control should be readily apparent so that little or no familiarisation is required.

(ii) The applicant should evaluate the consequences of actuating each control and show they are predictable and obvious to each flight crew member. This includes the control of multiple displays with a single device, and shared display areas that flight crew may access with individual controls. The use of a single control should also be assessed.

(iii) Controls should be made distinguishable and/or predictable by differences in form, colour, location, motion, effect and/or labelling. For example, the use of colour alone as an identifying feature is usually not sufficient.

(2) Labelling (CS 25.1301(b), CS 25.1302(a) and (b), CS 25.1543(b), CS 25.1555(a))

(i) For the general marking of controls, see CS 25.1555(a).

Labels should be readable from the flight crew's normal seating positions in all lighting and environmental conditions.

Labelling should include all the intended functions unless the function of the control is obvious. Labels of graphical controls accessed by a cursor-control device, such as a trackball, should be included on the graphical display. If menus lead to additional choices (submenus), the menu label should provide a reasonable description of the next submenu.

(ii) The applicant can label the controls with text or icons. The text and the icons should be shown to be distinct and meaningful for the function that they label. The applicant should use standard or unambiguous abbreviations, nomenclature, or icons, consistent within a function and across the flight deck. ICAO Doc 8400 'Procedures for Air Navigation Services (PANS) — ICAO Abbreviations and Codes' provides standard abbreviations, and is an acceptable basis for selecting labels.

(iii) If an icon is used instead of a text label, the applicant should show that the flight crew require only a brief exposure to the icon to determine the function of the control and how it operates. Based on design experience, the following guidelines for icons have been shown to lead to usable designs:

(A) The icon should be analogous to the object it represents;

(B) The icon should be generally used in aviation and well known to crews, or has been validated during a HF assessment; and

(C) The icon should be based on established standards, if they exist, and on conventional meanings.

(3) Interactions of multiple controls (CS 25.1302(b)(3))

If multiple controls for one function are provided to the flight crew, the applicant should show that there is sufficient information to make the flight crew aware of which control is currently functioning. As an example, flight crew need to know which flight crew's input has priority when two cursor-control devices can access the same display. Designers should use caution for dual controls that can affect the same parameter simultaneously.

(e) The accessibility of controls (CS 25.777(a), CS 25.777(b), CS 25.1302)

(1) Any control required for flight crew operation (in normal, abnormal/malfunction and emergency conditions) should be shown to be visible, reachable, and operable by the flight crew with the stature specified in CS 25.777(b), from the seated position with shoulder restraints on. If the shoulder restraints are lockable, the applicant should show that the pilots can reach and actuate high-priority controls needed for the safe operation of the aeroplane with the shoulder harnesses locked.

(2) Layering of information, as with menus or multiple displays, should not hinder the flight crew from identifying the location of the desired control. Evaluating the location and accessibility of a control requires the consideration of more than just the physical aspects of the control. Other location and accessibility considerations include where the control functions may be located within various menu layers, and how the flight crew navigates those layers to access the functions. Accessibility should be shown in conditions of system failures and of a master minimum equipment list (MMEL) dispatch.

(3) The position and direction of motion of a control should be oriented according to CS 25.777.

(f) The use of controls

(1) Environmental factors affecting the controls (CS 25.1301(a) and CS 25.1302)

(i) If the use of gloves is anticipated, the flight deck design should allow their use with adequate precision as per CS 25.1302(b)(2) and (c)(2).

(ii) The sensitivity of the controls should provide sufficient precision (without being overly sensitive) to perform tasks even in adverse environments as defined for the aeroplane's operational envelope per CS 25.1302(c)(2) and (d). The analysis of the environmental factors as a means of compliance is necessary, but not sufficient, for new control types or technologies, or for novel use of the controls that are themselves not new or novel.

(iii) The applicant should show that the controls required to regain control of the aeroplane or system and the controls required to continue operating the aeroplane in a safe manner are usable in conditions with extreme lighting conditions and severe vibration levels and should not prevent the flight crew from performing all their tasks with an acceptable level of performance and workload.

(2) Control display compatibility (CS 25.777 and CS 25.779)

CS 25.779 describes the direction of movement of the flight deck controls.

(i) To ensure that a control is unambiguous per CS 25.1302(b)(1), the relationship and interaction between a control and its associated display or indications should be readily apparent, understandable, and logical. For example, the applicant should specifically assess any rotary knob that has no obvious 'increase' or 'decrease' function with regard to the flight crew' expectations and its consistency with the other controls in the flight deck. The SAE publication ARP4102, Chapter 5, is an acceptable means of compliance for controls used in flight deck equipment.

(ii) CS 25.777(a) requires each flight deck control to be located so that it provides convenient operation and prevents confusion and inadvertent operation. The controls associated with a display should be located so that they do not interfere with the performance of the flight crew' tasks. Controls whose function is specific to a particular display surface should be mounted near the display or the function being controlled. Locating controls immediately below a display is generally preferable, as mounting controls immediately above a display has, in many cases, caused the flight crew's hand to obscure their view of the display when operating the controls. However, controls on the bezel of multifunction displays have been found to be acceptable.

(iii) Spatial separation between a control and its display may be necessary. This is the case with a control of a system that is located with other controls for that same system, or when it is one of several controls on a panel dedicated to controls for that multifunction display. When there is a large spatial separation between a control and its associated display, the applicant should show that the use of the control for the associated task(s) is acceptable in accordance with CS 25.777(a) and CS 25.1302.

(iv) In general, the design and placement of controls should avoid the possibility that the visibility of information could be blocked. If the range of movement of a control temporarily blocks the flight crew' view of information, the applicant should show that this information is either not necessary at that time or is available in another accessible location (CS 25.1302(b)(2) requires the information intended for use by the flight crew to be accessible and useable by the flight crew in a manner appropriate to the urgency, frequency, and duration of the flight crew' tasks).

(v) Annunciations/labels on electronic displays should be identical to the labels on the related switches and buttons located elsewhere on the flight deck. If display labels are not identical to those on the related controls, the applicant should show that flight crew can quickly, easily, and accurately identify the associated controls so they can safely perform all the tasks associated with the intended function of the systems and equipment (CS 25.1302).

(3) Control display design

(i) Controls of a variable nature that use a rotary motion should move clockwise from the OFF position, through an increasing range, to the full ON position.

(g) Adequacy of feedback (CS 25.771(a), CS 25.1301(a), CS 25.1302)

(1) Feedback for the operation of the controls is necessary to give the flight crew awareness of the effects of their actions. The meaning of the feedback should be clear and unambiguous. For example, if the intent of the feedback is to indicate a commanded event versus system state. Additionally, provide feedback when a flight crew's input is not accepted or not followed by the system (CS 25.1302(b)(1)). This feedback can be visual, auditory, or tactile.

(2) To meet the objectives of CS 25.1302, the applicant should show that feedback in all forms is obvious and unambiguous to the flight crew when performing their tasks associated with the intended function of the equipment. Feedback, in an appropriate form, should be provided to inform the flight crew that:

(i) a control has been activated (commanded state/value);

(ii) the function is in process (given an extended processing time);

(iii) the action associated with the control has been initiated (actual state/value if different from the commanded state); or

(iv) when a control is used to move an actuator through its range of travel, the equipment should provide, if needed (for example, fly-by-wire system), within the time required for the relevant task, operationally significant feedback of the actuator's position within its range. Examples of information that could appear relative to an actuator's range of travel include the target speed, and the state of the valves of various systems.

(3) The type, duration and appropriateness of the feedback will depend upon the flight crew's task and the specific information required for successful operation. As an example, the switch position alone is insufficient feedback if awareness of the actual system response or the state of the system as a result of an action is required in accordance with CS 25.1302(b)(3).

(4) Controls that may be used while the user is looking outside or at unrelated displays should provide tactile feedback. Keypads should provide tactile feedback for any key depression. In cases when this is omitted, it should be replaced with appropriate visual or other feedback indicating that the system has received the inputs and is responding as expected.

(5) The equipment should provide appropriate visual feedback, not only for knob, switch, and push-button positions, but also for graphical control methods such as pull-down menus and pop-up windows. The user interacting with a graphical control should receive a positive indication that a hierarchical menu item has been selected, a graphical button has been activated, or another input has been accepted.

4.3_The presentation of information

(a) Introduction

(1) The presentation of information to the flight crew can be visual (for instance, on a display), auditory (a 'talking' checklist), or tactile (for example, control feel). The presentation of information in the integrated flight deck, regardless of the medium used, should meet all of the requirements bulleted above. For visual displays, this AMC addresses mainly display format issues and not display hardware characteristics. The following provides design considerations for the requirements found in CS 25.1301(a), CS 25.1301(b), CS 25.1302, and CS 25.1543(b).

(2) Applicants should show that, in the proposed design, as defined in CS 25.1301, CS 25.771(a) and CS 25.771(b), the presented information is:

— clear,

— unambiguous,

— appropriate in resolution and precision,

— accessible,

— usable, and

— able to provide adequate feedback for flight crew awareness.

(b) The clear and unambiguous presentation of information

Qualitative and quantitative display formats (CS 25.1301(a) and CS 25.1302)

(1) Applicants should show, as per CS 25.1302(b), that display formats include the type of information the flight crew needs for the task, specifically with regard to the required speed and precision of reading. For example, the information could be in the form of a text message, numerical value, or a graphical representation of state or rate information. State information identifies the specific value of a parameter at a particular time. Rate information indicates the rate of change of that parameter.

(2) If the flight crew's sole means of detecting abnormal values is by monitoring the values presented on the display, the equipment should offer qualitative display formats. Analogue displays of data are best for conveying rate and trend information. If this is not practical, the applicant should show that the flight crew can perform the tasks for which the information is used. Digital presentations of information are better for tasks requiring precise values. Refer to CS 25.1322 when an abnormal value is associated with a crew alert.

(c) Display readability (CS 25.1301(b) and CS 25.1543(b))

Flight crew, seated at their stations and using normal head movement, should be able to see and read display format features such as fonts, symbols, icons and markings. In some cases, cross-flight deck readability may be required to meet the intended function that both pilots must be able to access and read the display. Examples of situations where this might be needed are cases of display failures or when cross-checking flight instruments. Readability must be maintained in sunlight viewing conditions (as per CS 25.773(a)) and under other adverse conditions such as vibration. Figures and letters should subtend not less than the visual angles defined in SAE ARP4102-7 at the design eye position of the flight crew that normally uses the information.

(d) Colour (CS 25.1302)

(1) The use of many different colours to convey meaning on displays should be avoided. However, if thoughtfully used, colour can be very effective in minimising the workload and response time associated with display interpretation. Colour can be used to group functions or data types in a logical way. A common colour philosophy across the flight deck is desirable.

(2) Applicants should show that the chosen colour set is not susceptible to confusion or misinterpretation due to differences in colour coordinates between the displays.

(3) Improper colour-coding increases the response times for display item recognition and selection, and increases the likelihood of errors, which is particularly true in situations where the speed of performing a task is more important than the accuracy, so the compatibility of colours with the background should be verified in all the foreseeable lighting conditions. The use of the red and amber colours for other than alerting functions

or potentially unsafe conditions is discouraged. Such use diminishes the attention-getting characteristics of true warnings and cautions.

(4) The use of colour as the sole means of characterising an item of information is also discouraged. It may be acceptable, however, to indicate the criticality of the information in relation to the task. Colour, as a graphical attribute of an essential item of information, should be used in addition to other coding characteristics such as texture or differences in luminance. AMC 25-11 contains recommended colour sets for specific display features.

(5) Applicants should show that the layering of information on a display does not add to confusion or clutter as a result of the colour standards and symbols used. Designs that require flight crew to manually declutter such displays should also be avoided.

(e) Symbology, text, and auditory messages (CS 25.1302)

(1) Designs can base many elements of electronic display formats on established standards and conventional meanings. For example, ICAO Doc 8400 'Procedures for Air Navigation Services (PANS) — ICAO Abbreviations and Codes' provides abbreviations, and is one standard that could be applied to the textual material used in the flight deck.

SAE ARP4102-7, Appendices A to C, and SAE ARP5289A are acceptable standards for avionics display symbols.

(2) The position of a message or symbol within a display also conveys meaning to the flight crew. Without the consistent or repeatable location of a symbol in a specific area of the electronic display, interpretation errors and response times may increase.

(3) Applicants should give careful attention to symbol priority (the priority of displaying one symbol overlaying another symbol by editing out the secondary symbol) to ensure that higher-priority symbols remain viewable.

(4) New symbols (a new design or a new symbol for a function which historically had an associated symbol) should be assessed for their distinguishability and for flight crew understanding and retention.

(5) Applicants should show that displayed text and auditory messages are distinct and meaningful for the information presented. CS 25.1302 requires the information intended for use by the flight crew to be provided in a clear and unambiguous format in a resolution and precision appropriate to the task, and the information to convey the intended meaning. The equipment should display standard and/or unambiguous abbreviations and nomenclature, consistent within a function and across the flight deck.

(f) The accessibility and usability of information

(1) The accessibility of information (CS 25.1302)

(i) Information intended for the flight crew must be accessible and usable by the flight crew in a manner appropriate to the urgency, frequency, and duration of their tasks, as per CS 25.1302(b)(2). The flight crew may, at certain times, need some information immediately, while other information may not be necessary during all phases of flight. The applicant should show that the flight crew can access and manage (configure) all the necessary information on the dedicated and multifunction displays for the given phase of flight. The applicant should show that any information required for continued safe flight and landing is accessible in the relevant degraded display modes following failures as defined by CS 25.1309. The applicant should specifically assess what information is necessary in those conditions, and how such information will be simultaneously displayed. The applicant should also show that supplemental information does not displace or otherwise interfere with the required information.

(ii) Analysis as the sole means of compliance is not sufficient for new or novel display management schemes. The applicant should use simulation of typical operational scenarios to validate the flight crew's ability to manage the available information.

(2) Clutter (CS 25.1302)

(i) Visual or auditory clutter is undesirable. To reduce the flight crew's interpretation time, the equipment should present information simply and in a well-ordered way. Applicants should show that an information delivery method (whether visual or auditory) presents the information that the flight crew actually requires to perform the task at hand. Flight crew can use their own discretion to limit the amount of information that needs to be presented at any point in time. For instance, a design might allow the flight crew to program a system so that it displays the most important information all the time, and less important information on request. When a design allows the flight crew to select additional information, the basic display modes should remain uncluttered.

(ii) Display options that automatically hide information for the purpose of reducing visual clutter may hide needed information from the flight crew. If the equipment uses automatic deselection of data to enhance the flight crew's performance in certain emergency conditions, the applicant must show, as per CS 25.1302(a), that it provides the information the flight crew needs. The use of part-time displays depends not only on the removal of clutter from the information, but also on the availability and criticality of the display. Therefore, when designing such design items, the applicant should follow the guidance in AMC 25-11.

(iii) Because of the transient nature of the auditory information presentation, designers should be careful to avoid the potential for competing auditory presentations that may conflict with each other and hinder their interpretation. Prioritisation and timing may be useful to avoid this potential problem.

(iv) Information should be prioritised according to the criticality of the task. Lower-priority information should not mask higher-priority information, and higher-priority information should be available, readily detectable, easily distinguishable and usable.

(3) System response time.

Long or variable response times between a control input and the system response can adversely affect the usability of the system. The applicant should show that the response to a control input, such as setting values, displaying parameters, or moving a cursor symbol on a graphical display, is fast enough to allow the flight crew to complete the task at an acceptable level of performance. For actions that require a noticeable system processing time, the equipment should indicate that the system response is pending.

4.4_System behaviour

(a) Introduction

The demands of the flight crew' tasks vary depending on the characteristics of the system design. Systems differ in their responses to relevant flight crew inputs. The response can be direct and unique, as in mechanical systems, or it can vary as a function of an intervening subsystem (such as hydraulics or electrics). Some systems even automatically vary their responses to capture or maintain a desired aeroplane or system state.

(1) CS 25.1302(c) states that the installed equipment must be designed so that the behaviour of the equipment that is operationally relevant to the flight crew' tasks is: (1) predictable and unambiguous, and (2) designed to enable the flight crew to intervene in a manner appropriate to the task (and intended function).

(2) The requirement for operationally relevant system behaviour to be predictable and unambiguous will enable the flight crew to know what the system is doing and what they did to enable/disable the behaviour. This distinguishes the system behaviour from the functional logic within the system design, much of which the flight crew do not know or do not need to know.

(3) If flight crew intervention is part of the intended function, or part of the abnormal/malfunction or emergency procedures for the system, the flight crew may need to take some action, or change an input to the system. The system must be designed accordingly. The requirement for flight crew intervention capabilities recognises this reality.

(4) Improved technologies, which have increased safety and performance, have also introduced the need to ensure proper cooperation between the flight crew and the integrated, complex information and control systems. If the system behaviour is not understood or expected by the flight crew, confusion may result.

(5) Some automated systems involve tasks that require flight crew' attention for effective and safe performance. Examples include flight management systems (FMSs) or flight guidance systems. Alternatively, systems designed to operate autonomously, in the sense that they require very limited or no human interaction, are referred to as 'automatic systems'. Such systems are switched 'ON' or 'OFF' or run automatically, and, when operating in normal conditions, the guidance material of this paragraph is not applicable to them. Examples include full authority digital engine controls (FADECs). Detailed specific guidance for automatic systems can be found in the relevant parts of CS-25.

(b) The allocation of functions between flight crew and automation.

The applicant should show that the allocation of functions is conducted in such a way that:

(1) the flight crew are able to perform all the tasks allocated to them, considering normal, abnormal/malfunction and emergency operating conditions, within the bounds of an acceptable workload and without requiring undue concentration or causing undue fatigue (see CS 25.1523 and CS-25 Appendix D for workload evaluation); and

(2) the system enables the flight crew to understand the situation, and enables timely failure detection and flight crew intervention when appropriate.

(c) The functional behaviour of a system

(1) The functional behaviour of an automated system results from the interaction between the flight crew and the automated system, and is determined by:

(i) the functions of the system and the logic that governs its operation; and

(ii) the user interface, which consists of the controls that communicate the flight crew' inputs to the system, and the information that provides feedback to the flight crew on the behaviour of the system.

(2) The design should consider both the functions of the system and the user interface together. This will avoid a design in which the functional logic governing the behaviour of the system can have an unacceptable effect on the performance of the flight crew. Examples of system functional logic and behavioural issues that may be associated with errors and other difficulties for the flight crew are the following:

(i) The complexity of the flight crew' interface for both control actuation and data entry, and the complexity of the corresponding system indications provided to the flight crew;

(ii) The flight crew having inadequate understanding and incorrect expectations of the behaviour of the system following mode selections and transitions; and

(iii) The flight crew having inadequate understanding and incorrect expectations of what the system is preparing to do next, and how it is behaving.

(3) Predictable and unambiguous system behaviour (CS 25.1302(c)(1))

Applicants should detail how they will show that the behaviour of the system or the system mode in the proposed design is predictable and unambiguous to the flight crew.

(i) System or system mode behaviour that is ambiguous or unpredictable to the flight crew has been found to cause or contribute to crew errors. It can also potentially degrade the crew's ability to perform their tasks in normal, abnormal/malfunction and emergency conditions. Certain design characteristics have been found to minimise flight crew errors and other flight crew performance problems.

(ii) The following design considerations are applicable to operationally relevant systems and to the modes of operation of the systems:

(A) The system behaviour should be simple (for example, the number of modes, or mode transitions).

(B) Mode annunciation should be clear and unambiguous. For example, a mode engagement or arming selection by the flight crew should result in annunciation, indication or display feedback that is adequate to provide awareness of the effect of their action. Additionally, any change in the mode as a result of the aeroplane changing from one operational mode (for instance, on an approach) to another should be clearly and unambiguously annunciated and fed back to the flight crew.

(C) Methods of mode arming, engagement and deselection should be accessible and usable. For example, the control action necessary to arm, engage, disarm or disengage a mode should not depend on the mode that is currently armed or engaged, on the setting of one or more other controls, or on the state or status of that or another system.

(D) Uncommanded mode changes and reversions should have sufficient annunciation, indication, or display information to provide awareness of any uncommanded changes of the engaged or armed mode of a system. 'Uncommanded' could refer both to a mode change not commanded by the pilot but by the automation as part of its normal operation, or to a mode change resulting from a malfunction.

(E) The current mode should remain identified and displayed at all times.

(4) Flight crew intervention (CS 25.1302(c)(2))

(i) Applicants should propose the means that they will use to show that the behaviour of the systems in the proposed design allows the flight crew to intervene in the operation of the systems without compromising safety. This should include descriptions of how they will determine that the functions and conditions in which intervention should be possible have been addressed.

(ii) The methods proposed by the applicants should describe how they would determine that each means of intervention is appropriate to the task.

(5) Controls for automated systems

Automated systems can perform various tasks selected by and under the supervision of the flight crew. Controls should be provided for managing the functionality of such a system or set of systems. The design of such 'automation-specific' controls should enable the flight crew to:

(i) safely prepare the system for the immediate task to be executed or the subsequent task to be executed; preparation of a new task (for example, a new flight trajectory) should not interfere, or be confused, with the task being executed by the automated system;

(ii) activate the appropriate system function and clearly understand what is being controlled; for example, the flight crew must clearly understand that they can set either the vertical speed or the flight path angle when they operate a vertical speed indicator;

(iii) manually intervene in any system function, as required by the operational conditions, or revert to manual control; for example, manual intervention might be necessary if a system loses functions, operates abnormally, or fails.

(6) Displays for automated systems

Automated systems can perform various tasks with minimal flight crew intervention, but under the supervision of the flight crew. To ensure effective supervision and maintain flight crew awareness of the system state and system 'intention' (future states), displays should provide recognisable feedback on:

(i) the entries made by the flight crew into the system so that the flight crew can detect and correct errors;

(ii) the present state of the automated system or its mode of operation (*What is it doing?*);

(iii) the actions taken by the system to achieve or maintain a desired state (*What is it trying to do?*);

(iv) future states scheduled by the automation (*What is it going to do next?*); and

(v) transitions between system states.

(7) The applicant should consider the following aspects of automated system designs:

(i) Indications of the commanded and actual values should enable the flight crew to determine whether the automated systems will perform according to the flight crew' expectations;

(ii) If the automated system nears its operational authority or is operating abnormally for the given conditions, or is unable to perform at the selected level, it should inform the flight crew, as appropriate for the task;

(iii) The automated system should support crew coordination and cooperation by ensuring that there is shared awareness of the system status and the flight crew' inputs to the system; and

(iv) The automated system should enable the crew to review and confirm the accuracy of the commands before they are activated. This is particularly important for automated systems because they can require complex input tasks.

4.5_Flight crew error management

(a) Meeting the objective of CS 25.1302(d)

(1) CS 25.1302(d) addresses the fact that crews will make errors, even when they are well trained, experienced, rested, and use well-designed systems.

CS 25.1302(d) addresses errors that are design related only. It is not intended to require consideration of errors resulting from acts of violence, sabotage or threats of violence.

(2) To meet the objective of CS 25.1302(d), the applicant should consider the following:

(i) enable the flight crew to detect (see 4.5(b)) and recover from errors (see 4.5(c));

(ii) ensure that the effects of crew errors on the aeroplane functions or capabilities are evident to the flight crew, and continued safe flight and landing is possible (see 4.5(d));

(iii) prevent crew errors by using switch guards, interlocks, confirmation actions, or similar means;

(iv) preclude the effects of errors through system logic and/or redundant, robust, or fault-tolerant system designs (see 4.5(e)).

(3) The strategies described in (2) above:

(i) recognise and assume that flight crew errors cannot be entirely prevented, and that no validated methods exist to reliably predict either their probability or all the sequences of events with which they may be associated;

(ii) call for means of compliance that are methodical and complementary to, and separate and distinct from, aeroplane system analysis methods such as system safety assessments.

(4) When demonstrating compliance, the applicant should consider the flight crew' tasks in all operating conditions, considering that many of the same design characteristics are relevant in each case. For example, under abnormal/malfunction or emergency conditions, the flying tasks (navigation, communication and monitoring) are generally still present, although they may be more difficult. So, the tasks associated with the abnormal/malfunction or emergency conditions should be considered as additive. The applicant should not expect the errors considered to be different from those in normal conditions, but any assessment should account for the change in the expected tasks.

(5) To demonstrate compliance with CS 25.1302(d), the applicant may employ any of the general types of methods of compliance discussed in paragraph 5, individually or in combination. These methods must be consistent with an approved certification plan as discussed in paragraph 3, and account for the objectives above and the considerations described below. When using some of these methods, it may be helpful for some applicants to refer to other references related to understanding the occurrence of errors. Here is a brief summary of those methods and how they can be applied to address flight crew error considerations:

(i) Statement of similarity (paragraph 5.3): A statement of similarity may be used to substantiate that the design has sufficient certification precedent to conclude that the ability of the flight crew to manage errors has not significantly changed. Applicants may also use in-service data to identify errors known to commonly occur for similar flight crew interfaces or system behaviour. As part of compliance demonstration, the applicant should identify the steps taken in the new design to avoid or mitigate similar errors. However, the absence of in-service events related to a particular design item cannot be considered to be an acceptable means of demonstrating compliance with CS 25.1302.

(ii) Design descriptions (paragraph 5.3): Applicants may structure design descriptions and rationales to show how various types of errors are considered in the design and addressed, mitigated or managed. Applicants can also use a description of how the design adheres to an established and valid design philosophy to substantiate that the design enables crews to manage errors.

(iii) Calculation and engineering analysis (paragraph 5.3): As one possible means of demonstrating compliance with CS 25.1302(d), an applicant may document the means of error management through the analysis of controls, indications, system behaviour, and related flight crew tasks. This would need to be done in conjunction with an understanding of the potential error opportunities and the means available for the flight crew to manage those errors. In most cases, it is not considered feasible to predict the probability of flight crew errors with sufficient validity or precision to support a means of compliance. If an applicant chooses to use a quantitative approach, the validity of the approach should be established.

(iv) Assessments (paragraph 5.3): For compliance purposes, assessments are intended to identify error possibilities that may be considered for mitigation in design or training. In any case, scenario objectives and assumptions should be clearly stated before running the evaluations or tests. In that way, any discrepancy in those expectations can be discussed and explained in the analysis of the results.

(6) As discussed further in paragraph 5, these evaluations or tests should use appropriate scenarios that reflect the intended functions and tasks, including the use of the equipment in normal, abnormal/malfunction and emergency conditions. Scenarios should be designed to consider flight crew errors. If inappropriate scenarios are used or important conditions are not considered, incorrect conclusions can result. For example, if no errors occur during an assessment, it may only mean that the scenarios are too simple, incomplete, or not fully representative. On the other hand, if some errors do occur, it may mean any of the following:

(i) The design, procedures, or training should be modified;

(ii) The scenarios are unrealistically challenging; or

(iii) Insufficient training was delivered prior to the assessment.

(7) In such assessments, it is not considered feasible to establish criteria for the frequency of errors.

(b) Error detection

(1) Applicants should design equipment to provide information to the flight crew so that they can become aware of an error. Applicants should show that this information is available to the flight crew, is adequately detectable, and it shows a clear relationship between the flight crew action and the error so a recovery can be made in a timely manner.

(2) The information for error detection may take three basic forms:

(i) Indications provided to the flight crew during normal monitoring tasks.

(A) As an example, if an incorrect knob was used, resulting in an unintended heading change, the change would be detected through the display of target values. The presentation of a temporary flight plan for crew review before accepting it would be another way of providing crew awareness of errors.

(B) Indications on instruments in the primary field of view that are used during normal operations may be adequate if the indications themselves contain information used on a regular basis and are provided in a readily accessible form. These may include mode annunciations and normal aeroplane state information such as the altitude or heading. Other locations for the information may be appropriate depending on the crew's tasks and the importance of the information, such as on the control display unit when the task involves dealing with a flight plan. Paragraph 5.4 'Presentation of information' contains additional guidance to determine whether the information is adequately detectable.

(ii) Indications to the flight crew that provide information of an error or a resulting aeroplane system condition.

(A) An alert that activates following a flight crew error may be sufficient to show an error is detectable and provides sufficient information. The alert should directly relate to the error or be easily assessed by the flight crew as related to the error. Alerts should not be confusing leading the flight crew to believe there may be non-error causes for the annunciated condition.

(B) If a flight crew error is only one of several possible causes for an alert about a system, then the information that the alert provides is insufficient. If, on the other hand, additional information is available that would allow the crew to identify and correct the error, then the alert, in combination with the additional information, would be sufficient to comply with CS 25.1302(d) for that error.

(C) An error that is detectable by the system should provide an alert and provide sufficient information that a flight crew error has occurred, such as in the case of a take-off configuration warning. On the other hand, an alert about the system state resulting from accidentally shutting down a hydraulic pump, for example, may not provide sufficient information to the flight crew to enable them to distinguish an error from a system fault. In this case, flight manual procedures may provide the error detection means as the crew performs the 'loss of hydraulic system' procedures.

(D) If the system can detect pilot error, the system could be designed to prevent pilot errors. For example, if the system can detect an incorrect frequency entry by the pilot, then the system should be able to disallow that entry and provide appropriate feedback to the pilot. Examples are automated error checking and filters that prevent the entry of unallowable or illogical entries.

(iii) 'Global' alerts cover a multitude of possible errors by annunciating external hazards, the envelope of the aeroplane, or operational conditions. Examples include monitoring systems such as a terrain awareness and warning system (TAWS) and a traffic alert and collision avoidance system (TCAS). An example would be a TAWS alert resulting from turning in the wrong direction in a holding pattern in mountainous terrain.

(3) The applicant should consider the following when establishing whether the level or type of information available to the flight crew is adequately detectable and clearly related to the error:

(i) The effects of some errors are easily and reliably determined by the system because of its design, and some are not. For those that cannot be sensed by the system, the design and arrangement of the information monitored and scanned by the flight crew can facilitate error detection.

An example would be the alignment of engine speed indicator needles in the same direction during normal operations. In the event of an engine asymmetrical thrust linked to flight crew error, which manifested itself in a change in the rpm on one engine, the spatial misalignment of the needles could assist the pilots in diagnosing the issue and identifying asymmetrical thrust-lever position.

(ii) Aeroplane alerting and indication systems may not detect whether an action is erroneous because the systems cannot know the intent of the crew in many operational circumstances. For flight crew errors of this nature, error detection depends on the crew's interpretation of the available information. Training, crew resource management (CRM), and monitoring systems (such as TAWS and TCAS) are examples of ways to provide a redundant level of safety.

(4) The applicant may establish that information is available and clearly related to the error by using a design description when a precedent exists or when a reasonable case may be made that the content of the information is clearly related to the error that caused it. In some cases, a flight crew assessment (see 5.3) may be needed to assess whether the information provided is adequately available and detectable.

(c) Error recovery

(1) When an error or its effects are detected, the next logical step is to ensure that the error can be reversed, or that the effect of the error can be mitigated in some way so that the aeroplane is returned to a safe state.

(2) An acceptable means to establish that an error is recoverable is to show that:

(i) controls and indications exist that can be used either to reverse an erroneous action directly so that the aeroplane or system is returned to the original state, or to mitigate the effect so that the aeroplane or system is returned to a safe state; and

(ii) those controls and indications can be expected to be used by the flight crew to accomplish the corrective actions in a timely manner.

(3) For simple or familiar types of system interfaces, or systems that are not novel, even if they are complex, a statement of similarity or a description of the design of the flight crew interfaces and the procedures associated with the indications may be an acceptable means of compliance.

(4) To establish that the flight crew can be expected to use those controls and indications to accomplish corrective actions in a timely manner, an assessment of the flight crew procedures in a simulated flight deck environment can be highly effective. This assessment should include an examination of the nomenclature used in alert messages, controls, and other indications. It should also include the logical flow of procedural steps and the effects that executing the procedures have on other systems.

(d) Error effects

(1) Another means of satisfying the objective of error mitigation is to ensure that the effects of the error or the relevant effects on the state of the aeroplane:

(i) are evident to the crew; and

(ii) do not adversely impact on safety.

(2) Piloted assessments in the aeroplane or in simulation may be relevant if flight crew performance issues are in question for determining whether a state following an error permits continued safe flight and landing. Assessments and/or analyses may be used to show that, following an error, the flight crew has the information in an effective form and has the aeroplane capability required for continued safe flight and landing.

(e) Precluding errors or their effects

(1) For irreversible errors that have potential safety implications, means to prevent errors are recommended. Acceptable ways to prevent errors include switch guards, interlocks, or confirmation actions. For example, generator drive controls on many aeroplane have guards over the switches to prevent their inadvertent actuation, because once disengaged, the drives cannot be re-engaged while in flight or with the engine running. An example of confirmation action would be the presentation of a flight plan modification in a temporary flight plan, where the flight crew will activate the flight plan through a confirmation action.

(2) Another way of avoiding flight crew error is to design systems to remove misleading or inaccurate information (e.g. sensor failures) from displays. An example would be a system that removes the flight director bars from a primary flight display or removes the 'own-ship' position from an airport surface map display when the data driving the symbols is incorrect.

(3) The applicant should avoid applying an excessive number of protections for a given error. The excessive use of protections could have unintended safety consequences. They might hamper the flight crew's ability to use judgment and take action in the best interest of safety in situations that were not predicted by the applicant. If protections become a nuisance in daily operation, crews may use well-intentioned and inventive means to circumvent them. This could have further effects that were not anticipated by the operator or the designer.

4.6_Integration

(a) Introduction

(1) Many systems, such as flight management systems (FMS), are integrated physically and functionally into the flight deck and may interact with other flight deck systems. It is important to consider a design not just in isolation, but in the context of the overall flight deck. Integration issues include where a display or control is installed, how it interacts with other systems, and whether there is internal consistency across functions within a multi-function display, as well as consistency with the rest of the flight deck equipment.

(2) Analyses, evaluations, tests and other data developed to establish compliance with each of the specific requirements in CS 25.1302(a) to (d) should address the integration of new design items. It should include consideration of the following integration factors:

(i) consistency (see 4.6(b)),

(ii) consistency trade-offs (see 4.6(c)),

(iii) the flight deck environment (see 4.6(d)), and

(iv) integration-related workload and error (see 4.6(e)).

(b) Consistency

(1) If similar information is presented in multiple locations or modes (both visual and auditory, for example), the consistent presentation of the information is desirable. If information cannot be presented consistently within the flight deck, the applicant should show that the differences do not increase the error rates or task times, which would lead to a significant reduction in the safety margins or an increase in the flight crew' workload, and do not cause confusion to flight crew.

(2) Consistency needs to be considered within a given system and across the flight deck. Inconsistencies may result in vulnerabilities that may lead to human performance issues, such as increased workload and errors, especially during stressful situations. For example, in some FMS, the format for entering the latitude and longitude differs between the display pages. This may induce flight crew errors, or at least increase the crew's workload. Additionally, errors may result if the latitude and longitude are displayed in a format that differs from the formats used on the most commonly used paper charts. Because of this, it is desirable to use formats that are consistent with other media whenever possible. One way in which the applicant can achieve consistency within a given system, as well as within the overall flight deck, is to adhere to a comprehensive flight deck design philosophy. The following are design attributes to consider for their consistency within and across systems:

(i) Symbology, data entry conventions, formatting, the colour philosophy, terminology, and labelling.

(ii) Function and logic. For example, when two or more systems are active and perform the same function, they should operate consistently and use an interface in the same style.

(iii) Information presented with other information of the same type that is used in the flight deck. It is important that functions that convey the same information be consistent. One example is symbol sets. Traffic or terrain awareness systems should display consistent symbol sets if generated by separate installed systems.

(3) Another way to demonstrate consistency is to show that certain aspects of the design are consistent with accepted, published standards such as the labels and abbreviations recommended in ICAO Doc 8400 'Procedures for Air Navigation Services (PANS) - ICAO Abbreviations and Codes' or in SAE ARP4105C 'Abbreviations, Acronyms, and Terms for Use on the Flight Deck'. The applicant might standardise the symbols used to depict navigation aids (very high frequency omnidirectional range (VOR), for example), by following the conventions recommended in SAE ARP5289A 'Electronic Aeronautical Symbols'. However, inappropriate standardisation, rigidly applied, can be a barrier to

innovation and product improvement. Thus, the guidance in this paragraph promotes consistency rather than rigid standardisation.

(c) Consistency trade-offs

It is recognised that it is not always possible or desirable to provide a consistent flight crew interface. Despite conformance with the flight deck design philosophy, principles of consistency, etc., it is possible to negatively impact on the crew's workload. For example, all the auditory alerts may adhere to a flight deck alerting philosophy, but the number of alerts may be unacceptable. The use of a consistent format across the flight deck may not work when individual task requirements necessitate the presentation of data in two significantly different formats. An example is a weather radar display formatted to show a sector of the environment, while a moving-map display shows a 360-degree view. In such cases, it should be demonstrated that the design of the interface is compatible with the requirements of the piloting task, and that it can be used individually and in combination with other interfaces without interference with either the system or the function.

Additionally:

(1) The applicant should provide an analysis identifying each piece of information or data presented in multiple locations, and show that the data is presented in a consistent manner or, where that is not true, justify why that is not appropriate.

(2) Where information is inconsistent, that inconsistency should be obvious or annunciated, and should not contribute to errors in the interpretation of information.

(3) There should be a rationale for instances where the design of a system diverges from the flight deck design philosophy. Applicants should consider any impact on the workload and on errors as a result of such divergences.

(4) The applicant should describe what conclusion the flight crew are expected to draw and what action should be taken when information on the display conflicts with other information in the flight deck (either with or without a failure).

(d) Flight deck environment

(1) The flight deck system is influenced by the physical characteristics of the aeroplane into which a system is integrated, as well as by the characteristics of the operational environment. The system is subject to such influences on the flight deck as turbulence, noise, ambient light, smoke, and vibrations (such as those that may result from ice or the loss of a fan blade). The design of the system should recognise the effect of such influences on usability, workload, and flight crew task performance. Turbulence and ambient light, for example, may affect the readability of a display. Flight deck noise may affect the audibility of aural alerts. The applicant should also consider the impact of the flight deck environment for abnormal situations, such as recovery from an unusual attitude or regaining control of the aeroplane or system.

(2) The flight deck environment includes the layout, or the physical arrangement of the controls and information displays. Layouts should take into account the flight crew requirements in terms of:

(i) access and reach (to the controls);

(ii) visibility and readability of the displays and labels; and

(iii) the task-oriented location and grouping of HMI elements.

An example of poor physical integration would be a required piece of information that is obscured by a control in its normal operating position.

(e) Integration-related workload and error

(1) When integrating functions and/or equipment, designers should be aware of the potential effects, both positive and negative, that integration can have on the workload of the flight crew and its subsequent impact on error management. Systems must be designed and assessed, both in isolation and in combination with other flight deck systems, to ensure that the flight crew are able to detect, reverse, or recover from errors. This may be more challenging when integrating systems that employ higher levels of automation or have a high degree of interaction and dependency on other flight deck systems.

(2) Applicants should show that the integrated design does not adversely impact on the workload or errors in the context of the entire flight regime. Examples of such impacts would be taking more time to:

(i) interpret a function;

(ii) make a decision; or

(iii) take appropriate action.

(3) Controls, particularly multi-function controls and/or novel types of control, may present the potential for misidentification and increased response times. Designs should generally avoid multi-function controls with hidden functions, because they increase both the workload of the flight crew and the potential for error.

(4) Two examples of integrated design items that may or may not impact on errors and the workload are as follows:

(i) Presenting the same information in two different formats. This may increase the workload, such as when altitude information is presented concurrently in both tape and round-dial formats. However, different formats may be suitable, depending on the design and the crew task. For example, an analogue display of engine revolutions per minute (rpm) can facilitate a quick scan, whereas a digital numeric display can facilitate precise inputs. The applicant is responsible for demonstrating compliance with CS 25.1523 and showing that the differences in the formats do not result in unacceptable levels of workload.

(ii) Presenting conflicting information. Increases in workload and error may result from two displays depicting conflicting altitude information on the flight deck concurrently, regardless of the formats. Systems may exhibit minor differences between each flight crew station, but all such differences should be assessed specifically to ensure that the potential for interpretation error is minimised, or that a method exists for the flight crew to detect any incorrect information, or that the effects of these errors can be precluded.

(iii) The applicant should show that the proposed function will not inappropriately draw attention away from other flight deck information and tasks in a way that degrades the performance of the flight crew and decreases the overall level of safety. There are some cases in which it may be acceptable for the system design to increase the workload. For example, adding a display into the flight deck may increase the workload by virtue of the additional time flight crew spend looking at it, but the safety benefit that the additional information provides may make it an acceptable trade-off.

(iv) Since each new system integrated into the flight deck may have a positive or negative effect on the workload, each must be assessed in isolation and in combination with the other systems for compliance with CS 25.1523. This is to ensure that the overall workload is acceptable, i.e. that the performance of flight tasks is not adversely impacted, and that the crew's detection and interpretation of information does not lead to unacceptable response times. Special attention should be paid to items that are workload factors. They include the 'accessibility, ease, and simplicity of operation of all necessary flight, power, and equipment controls'.

5)_MEANS OF COMPLIANCE

5.1_Overview

This paragraph provides considerations the applicant should use when selecting the means of compliance. It discusses seven types of means of compliance and provides specific HF considerations for their use.

The applicant should determine the means of compliance to be used on a given project on a case-by-case basis, taking into account the specific compliance issues. In any case, the nature of the HF objective to be assessed should drive the selection of the appropriate means of compliance.

Some certification projects may necessitate more than one means of demonstrating compliance with a particular CS. For example, when flight testing in a conforming aeroplane is not possible, a combination of a design review and a part-task evaluation may be proposed. In this context, part-task evaluation focuses only on specific sub-functions of the design item.

The uses and limitations of each type of means of compliance are provided in paragraph 5.3.

5.2_List of the means of compliance

The most common means of compliance that are used to demonstrate compliance with HF certification specifications are discussed in this paragraph and include:

(a) MC0: Compliance statements,

(b) MC1: Design review,

(c) MC2: Calculations and analyses,

(d) MC4: Laboratory tests,

(e) MC5: Ground tests,

(f) MC6: Flight tests,

(g) MC8: Simulation.

When the 'scenario-based' methodology is used as part of the above-listed means of compliance, additional guidance can be found in paragraph 3.3.2.

5.3_Selecting the means of compliance

5.3.1_Credit from previous compliance certification processes

When determining the level of scrutiny applicable to each design item, the applicant should identify a reference product.

The reference product can also play a role in the compliance demonstration process if data from previous certification exercises is used. However, the following two dimensions should be taken into account when assessing the extent to which certification credits can be granted:

— The reference product from which the applicant intends to claim compliance;

— The certification basis that was used to certify that reference product.

The applicant is then expected to gain more certification credits from the equipment installed on one of its aeroplane already certified under CS 25.1302.

Fewer certification credits can be requested when the equipment installed on an aeroplane was certified by the applicant under a HF regulatory material different from CS 25.1302. The acceptability of this approach will be evaluated on a case-by-case basis by assessing the compatibility of the reference regulatory material and the methods used at the time of the initial certification.

As a general principle, no certification credit can be claimed when the design item installed on an aeroplane was certified by another design organisation or when it was not certified by EASA.

5.3.2_ Representativeness of the test article

Means of compliance MC4, MC5, MC6 and MC8 require the use of a test article (benches, mock-ups, the actual aeroplane, or a simulator).

As explained in paragraph 3.3.1, in order the achieve its objectives, the HF assessment should be started in the early stage of the project and follow an iterative process. This iterative nature of the process may require the applicant to perform assessments in the early stage of the project when the design is still likely to change. On the other hand, test articles that are not fully representative of the final design can be available later on during the certification process and may be the only available ones to actually perform some assessments (for example, a bench or a simulator may be the only means to assess the behaviour for failures that cannot be simulated in flight).

Therefore, the verification of the test article's representativeness, with its deviations from the intended final standard, is a step of paramount importance for the HF assessment. These deviations should be evaluated taking into account the objectives of the assessment.

For example:

— If a ground test is carried out to assess the controls reachability, specific attention should be paid at the flight deck geometry being representative of the design under certification while the conformity of the avionics is not required.

— If a simulator is used, the required functional and physical representativeness of the simulation (or degree of realism) will typically depend on the configurations, design items, and crew tasks to be assessed.

As a general principle, as long as the deviations from the intended final standard are known and monitored and do not compromise the validity of the data to be collected, the lack of full representativeness should not prevent the use of a test article. In such cases, partial certification credits may still be granted, provided that the applicant can show that the deviations do not affect the test results.

5.3.3_Presentation of the means of compliance

(a) MC0 Compliance statement based on similarity

Description
A statement of similarity is a declaration of (full or partial) compliance based on a description of the system to be approved compared to a description of a previously approved system, detailing the physical, logical, and operational similarities relevant for the regulation the applicant wishes to demonstrate compliance with.
Use
A statement of similarity can be sufficient or used in combination with other means of compliance.
Limitations
A statement of similarity, for the purpose of compliance demonstration, should be used with care. The flight deck should be assessed as a whole, not merely as a set of individual functions or systems. Two design items previously approved on separate programmes may be incompatible when combined in a single flight deck. Also, changing one feature in the flight deck may necessitate corresponding changes in other features, to maintain consistency and prevent confusion.
Example
If the window design in a new aeroplane is identical to that in an existing aeroplane, a statement of similarity may be an acceptable means of compliance to meet CS 25.773.

(b) MC1 Design review

The applicant may elect to substantiate that the design meets the objectives of a specific paragraph by describing the design. The applicant has traditionally used drawings, configuration descriptions, and/or design philosophies to demonstrate compliance.

(1) Drawings

Description
Drawings depicting the physical arrangement of hardware or display graphics.
Use

Applicants can use drawings for very simple certification programmes when the change to the flight deck is very simple and straightforward. Drawings can also be used to support compliance findings for more complex interfaces.
Limitations
The use of drawings is limited to physical arrangements and graphical concerns.

(2) Configuration description

Description
A configuration description is a description of the layout, general arrangement, direction of movement, etc., of a design item. It can also be a reference to documentation that provides such a description. It could be used to show the relative locations of flight instruments, groupings of control functions, the allocation of colour codes to displays and alerts, etc.
Use
Configuration descriptions are generally less formalised than engineering drawings. They are developed to point out features of the design that support a finding of compliance. In some cases, such configuration descriptions may provide sufficient information for a finding of compliance. More often, however, they provide important background information, while the final confirmation of compliance is found through other means, such as demonstrations or tests. The background information provided by configuration descriptions may significantly reduce the risk associated with demonstrations or tests. The applicant will have already communicated how a system works with the configuration description, and any discussions or assumptions may have already been coordinated.
Limitations
Configuration descriptions may provide sufficient information for a finding of compliance only with a specific requirement.

(3) Design philosophy

Description
A design philosophy approach can be used to demonstrate that an overall safety-centred philosophy, as detailed in the design specifications for the product/system or flight deck, has been applied.
Use
It documents that the design qualifies to meet the objectives of a specific paragraph.
Limitations
In most cases, this means of compliance will be insufficient as the sole means to demonstrate compliance.

Example
The design philosophy may be used as a means of compliance when a new alert is added to the flight deck provided the new alert is consistent with the acceptable, existing alerting philosophy.

(c) MC2 Calculations/analyses

Description
Calculations or engineering analyses ('paper and pencil' assessments) that do not require direct participant interaction with a physical representation of the equipment.
Use
Provides a systematic analysis of specific or overall aspects of the human interface part of the product/system/flight deck.
Limitations
The applicant should carefully consider the validity of the assessment technique if the analyses are not based on recognised industry standard methods. The applicant may be asked to validate any computational tools used in such analyses. If the analysis involves comparing measured characteristics with recommendations derived from pre-existing research (internal or public domain), the applicant may be asked to justify the applicability of the data to the project. While analyses are useful to start investigating the potential for design-related human errors, as well as the theoretical efficiency of the available means of protection, this demonstration should be complemented by observations through other means of compliance when required. Analysis cannot be used to assess complex cognitive issues.
Example
An applicant may conduct a vision analysis to demonstrate that the flight crew has a clear and undistorted view out of the windshield. Similarly, an analysis may also demonstrate that flight, navigation and power plant instruments are plainly visible from the flight crew stations. The applicant may need to validate the results of the analysis in a ground or flight test, or by using a means of simulation that is geometrically representative. An applicant may also conduct an analysis based on evidence collected during similar previous HF assessments.

(d) MC4 Laboratory tests

Description
An assessment made using a bench test representing the HMI. This can be conducted on an avionics bench when the purpose is to assess the information, or on a mock-up when the purpose is to assess the flight deck geometry.

Bench or laboratory assessment
The applicant can conduct an assessment using devices emulating flight crew interfaces for a single system or a group of related systems. The applicant can use flight hardware, simulated systems, or combinations of these.
Example of a bench or laboratory assessment
A bench assessment for an integrated system could be conducted using an avionics suite installed in a mock-up of a flight deck, with the main displays and autopilot controls included. Such a tool may be valuable during development and for making EASA familiar with the system. However, in a highly integrated architecture, it may be difficult or impossible to assess how well the avionics system will fit into the overall flight deck without more complete simulation or use of the actual aeroplane.
Mock-up evaluation
A mock-up is a full-scale, static representation of the physical configuration (form and fit). It does not include functional aspects of the flight deck and its installed equipment. Mock-ups can be used as representations of the design, allowing participants to physically interact with the design. Three-dimensional representations of the design in a CAD system, in conjunction with three-dimensional models of the flight deck occupants, have also been used as 'virtual' mock-ups for certain limited types of evaluations. Reachability, for example, can be addressed using either type of mock-up.
Example of a mock-up evaluation
An analysis to demonstrate that the controls are arranged so that flight crew from 1.58 m (5 ft 2 in) to 1.91 m (6 ft 3 in) in height can reach all controls. This analysis may use computer-generated data based on engineering drawings. The applicant may demonstrate the results of the analysis in the actual aeroplane.
Limitations
Bench tests or mock-ups cannot be used to assess complex cognitive issues.

(e) MC5 Ground tests

Description
An assessment conducted on a flight test article on ground.
Limitations
Ground tests cannot be used to assess complex cognitive issues.
Example
An example of a ground test is the assessment of the displays' potential for reflections on the windshield and on the windows. Such an assessment involves covering the flight deck windows to simulate darkness and setting the flight deck lighting to the desired levels. This particular

assessment may not be possible in a simulator because of differences in the light sources, display hardware, and/or construction of the windows.

(f) MC6 Flight tests and MC8 Simulation

The applicant may use a wide variety of part-task to full-installation representations of the product/system or flight deck for assessment purposes. The representation of the HMI does not necessarily conform to the final design. The paragraphs below address both system- and aeroplane-level evaluations that typically make up this group of means of compliance.

Description
As soon as the maturity of the design allows pilots to take part in the compliance demonstration, HF assessments are conducted in a dynamic operational context. Depending on the HF objectives to be addressed, and according to the HF test programme, those assessments can be either conducted at the system level or the aeroplane level. Both simulators and real aeroplane can be used, but the selection of the MoC depends on the nature of the test objectives.
Use
Traditionally, these types of activities are part of the design process. They allow applicants to continuously improve their designs thanks to the application of an iterative approach.

(f)(i) MC8 Simulation

Simulator assessment
A simulator assessment uses devices that present an integrated emulation (using flight hardware, simulated systems, or combinations of these) of the flight deck and the operational environment. These devices can also be 'flown' with response characteristics that replicate, to some extent, the responses of the aeroplane.

(f)(ii) MC6 Flight tests

In-flight assessment
Flight testing during certification is the final compliance demonstration of the design, and is conducted in a conforming aeroplane during flight. The aeroplane and its components (flight deck) are the most representative of the type design to be certified and will be the closest to real operations of the equipment. In-flight testing is the most realistic testing environment, although it is limited to those tests that can be conducted safely. Flight testing can be used to validate and verify other assessments previously conducted during the development and certification programme. It is often best to use flight testing as the final confirmation of data collected using other means of compliance, including analyses and assessments. Flights tests carried out for areas of investigation outside the HF scope can be given partial credit for demonstrating compliance with 25.1302. The acceptability of this approach has, however, to

be assessed by EASA on a case-by-case basis. A prerequisite for acceptance by EASA is the respect of the basic HF methodical principles for data collection and processing. These flight tests should only be used as a complementary approach to dedicated HF assessments.

(f)(iii) MC6 versus MC8

MC6 versus MC8:
The selection of the flight test as a means of assessment should not be exclusively motivated by the absence of any other available means, but should be duly justified, taking into account its inherent limitations: — Due to safety reasons, the actual testing on an aeroplane may be inappropriate for the malfunction assessment. — Flight test does not normally allow the manipulation of the operational environment which may be needed to apply the scenario-based approach. — HF in-flight scenarios may be challenging to replicate due to the difficulty in reproducing the operational context. For example, events like ATC communications, weather, etc., which are expected to trigger a crew reaction to be tested may not be repeatable. This may hamper the collection of homogeneous data and may adversely affect its validity. However, flight test is deemed adequate when the operational and/or system representativeness is a key driver for the validity of HF data. For example, an in-flight assessment is typically more adequate when dealing with workload determination.

AMC 25.1302 APPENDIX 1: Related regulatory material and documents

The following is a list of requirements, acceptable means of compliance and other documents relevant to flight deck design and flight crew interfaces which may be useful when reviewing this AMC.

Related EASA Certification Specifications:

CS 25 BOOK 1 Requirements	General topic	CS 25 BOOK 2 Acceptable Means of Compliance
CS 25.785 (g)	Seats, berths, safety belts and harnesses	AMC 25.785 (g)
CS 25.1309(c)	Minimising flight crew errors that could create additional hazards	AMC 25.1309
CS 25.1523	Minimum flight crew and workload	AMC 25.1523
CS 25.1321	Arrangement and visibility	

CS 25.1322	Crew alerting design principles	AMC 25.1322
CS 25.1329	Autopilot, flight director, autothrust	AMC No.1 to CS 25.1329, AMC No.2 to CS 25.1329
	Electronic displays	AMC 25-11
CS 25.1543	Instrument markings - general	AMC 25.1543

Other documents:

The following is a list of other documents relevant to flight deck design and flight crew interfaces that may be useful when applying this AMC. Some are not aviation specific, such as International Standard ISO 9241-4, which, however, provides useful guidance. When using that document, applicants should consider environmental factors such as the intended operational environment, turbulence, and lighting, as well as cross-side reach.

— PS-ANM100-01-03A, *Factors to Consider When Reviewing an Applicant's Proposed Human Factors Methods for Compliance for Flight Deck Certification*

— Policy Memo ANM-99-2, *Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks*

— SAE ARP4033, *Pilot-System Integration*, August 1995

— SAE ARP5289A, *Electronic Aeronautical Symbols*

— SAE ARP4102/7, *Electronic Displays*

— SAE ARP4105C, *Abbreviations, Acronyms, and Terms for Use on the Flight Deck*

— ICAO Doc 8400, *Procedures for Air Navigation Services — ICAO Abbreviations and Codes*, Ninth Edition, 2016

— ICAO Doc 9683 – AN/950, *Human Factors Training Manual*, First Edition, 1998

— International Standards ISO 9241-4, *Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs)*

— FAA Human Factors Team report on: *The Interfaces Between Flight crews and Modern Flight Deck Systems*, 1996

— DOT/FAA/RD–93/5: *Human Factors for Flight Deck Certification Personnel*, 1993

— FAA AC 20-175 *Controls for Flight Deck Systems*, 2011

— FAA AC 00-74 *Avionics Human Factors Considerations for Design and Evaluation*, 2019

— DOT/FAA/TC-13/44 *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls*, 2016

Create GM1 25.1302 as follows:

GM1 25.1302 Explanatory material

1_Introduction

(a) Accidents most often result from a sequence or combination of different errors and safety-related events (e.g. equipment failures and weather conditions). Analyses show that the design of the flight deck and other systems can influence the flight crew's task performance and the occurrence and effects of some flight crew errors.

(b) Flight crew make a positive contribution to the safety of the aviation system because of their ability to continuously assess changing conditions and situations, analyse potential actions, and make reasoned decisions. However, even well-trained, qualified, healthy, alert flight crew make errors. Some of these errors may be induced or influenced by the designs of the systems and their flight crew interfaces, even with those that are carefully designed. Most of these errors have no significant safety effects, or are detected and mitigated in the normal course of events. However, some of them may lead or contribute to the occurrence of unsafe conditions. Accident analyses have identified flight crew performance and errors as recurrent factors in the majority of accidents involving large aeroplanes.

(c) Some current requirements are intended to improve safety by requiring the flight deck and its equipment to be designed with certain capabilities and characteristics. The approval of flight deck systems with respect to design-related flight crew error has typically been addressed by referring to system-specific or general applicability requirements, such as CS 25.1301(a), CS 25.771(a), and CS 25.1523. However, little or no guidance exists to show how the applicant may address potential flight crew limitations and errors. That is why CS 25.1302 and this guidance material have been developed.

(d) CS 25.1302 was developed to provide a basis for addressing the design-related aspects of the avoidance and management of flight crew errors by taking the following approach.

(i) Firstly, by providing means to address the design characteristics that are known to reduce or avoid flight crew error and that address flight crew capabilities and limitations. CS 25.1302(a) to (c) are intended to reduce the design contribution to such errors by ensuring that the information and controls needed by the flight crew to perform the tasks associated with the intended function of installed equipment are provided, and that they are provided in a usable form.

In addition, operationally relevant system behaviour must be understandable, predictable, and supportive of the crew's tasks. Guidance is provided in this paragraph on the avoidance of design-induced flight crew errors.

(ii) Secondly, CS 25.1302(d) addresses the fact that since flight crew errors will occur, even with a well-trained and proficient crew operating well-designed systems, the design must support the management of those errors to avoid any safety consequences. Paragraph 5.7 below on flight crew error management provides the relevant guidance.

(e) EASA would like to bring the applicants' attention to the fact that the implementation of the process used to show compliance with CS 25.1302 may require up to several years, depending on the characteristics of the project. However, STCs may require much less time.

2_CS 25.1302: applicability and explanatory material

(a) CS-25 contains certification specifications for the design of flight deck equipment that is system specific (refer to AMC 25.1302, Table 1, in paragraph 2), generally applicable (e.g. CS 25.1301(a), CS 25.1309(c), CS 25.771(a)), and establishes minimum crew requirements (e.g. CS 25.1523). CS 25.1302 complements the generally applicable requirements by adding more explicit objectives for the design attributes related to the avoidance and management of flight crew errors. Other ways to avoid and manage flight crew errors are regulated through the requirements governing the licensing and qualifications of flight crew and aeroplane operations. Taken together, these complementary approaches provide an adequate level of safety.

(b) The complementary approach is important. It is based upon the recognition that equipment design, training/licensing/qualifications and operations/procedures each provide safety contributions to risk mitigation. An appropriate balance is needed between them. There have been cases in the past where design characteristics known to contribute to flight crew errors were accepted based upon the rationale that training or procedures would mitigate that risk. We now know that this can often be an inappropriate approach. Similarly, due to unintended consequences, it would not be appropriate to require equipment design to provide total risk mitigation.

(c) A proper balance is needed between certification specifications in CS-25 and the requirements for training/licensing/qualifications and operations/procedures. CS 25.1302 and this GM were developed with the intent of achieving that appropriate balance.

(1) Introduction. The introductory sentence of CS 25.1302 states that 'this paragraph applies to installed systems and equipment intended to be used by the flight crew when operating the aeroplane from their normal seating positions in the flight deck'.

(i) 'Intended to be used by the flight crew when operating the aeroplane from their normal seating positions in the flight deck' means that the intended function of the installed system or equipment includes its use by the flight crew when operating the aeroplane. An example of such installed equipment would be a display that provides information enabling the flight crew to navigate. The term 'flight crew' is intended to include any or all individuals comprising the minimum crew as determined for compliance with CS 25.1523. The phrase 'from their normal seating positions on the flight deck' means that the flight crew members are seated at their normal duty stations for operating the aeroplane.

(ii) The phrase 'from their normal seating positions on the flight deck' means that the flight crew members are positioned at their normal duty stations on the flight deck. These phrases are intended to limit the scope of this requirement so that it does not address the systems or equipment that are/is not used by the flight crew while performing their duties in operating the aeroplane in normal, abnormal/malfunction and emergency conditions. For example, this paragraph is not intended to apply to design items such as certain circuit breakers or maintenance controls intended for use by the maintenance crew (or by the flight crew when not operating the aeroplane).

(iii) The phrase 'Those installed systems and equipment must be shown […]' in the first paragraph means that the applicant must provide sufficient evidence to support compliance determinations for each of the CS 25.1302 objectives. This is not intended to require a demonstration of compliance beyond that required by point 21.A.21(a) of Part 21. Accordingly, for simple design items or items similar to previously approved equipment and installations, the demonstrations, assessments or data needed to demonstrate compliance with CS 25.1302 are not expected to entail more extensive or onerous efforts than are necessary to demonstrate compliance with the previous requirements.

(iv) The phrase 'individually and in combination with other such systems and equipment' means that the objectives of this paragraph must be met when a systems or equipment is installed in the flight deck with other system or equipment. The installed system or equipment must not prevent other system or equipment from complying with these objectives. For example, applicants must not design a display so that the information it provides is inconsistent or is in conflict with information provided from other installed equipment.

(v) In addition, this paragraph presumes a qualified flight crew that is trained to use the installed system or equipment. This means that the design must meet these objectives for flight crew who are allowed to fly the aeroplane by meeting the qualification requirements of the operating rules. If the applicant seeks a type design or supplemental type design approval before a training programme is accepted, the applicant should document any novel, complex or highly integrated design items and assumptions made during the design phase that have the potential to affect the training time or the flight crew procedures. The certification specification and associated material are written assuming that either these design items and assumptions or the knowledge of a training programme (proposed or in the process of being developed) will be coordinated with the appropriate operational approval organisation when assessing the adequacy of the design.

(vi) The objective for the system or equipment to be designed so that the flight crew can safely perform their tasks associated with the intended function of the system or equipment applies in normal, abnormal/malfunction and emergency conditions. The tasks intended to be performed under all the above conditions are generally those prescribed by the flight crew procedures. The phrase 'safely perform their tasks' is intended to describe one of the safety objectives of this certification specification. The objective is for the system or equipment design to enable the flight crew to perform their tasks with sufficient accuracy and in a timely manner, without unduly interfering with their other required tasks. The phrase 'tasks associated with the intended function of the systems and equipment' is intended to characterise either the tasks required to operate the system or equipment or the tasks for which the intended function of the system or equipment provides support.

(2) **CS 25.1302(a)** requires the applicant to install the appropriate controls and provide the necessary information for any flight deck system or equipment identified in the first

paragraph of CS 25.1302. The controls and the information displays must be sufficient to allow the flight crew to accomplish their tasks. Although this may seem obvious, this objective is included because a review of CS-25 on the subject of HF revealed that a specific objective for flight deck controls and information to meet the flight crew needs is necessary. This objective is not reflected in other parts of CS-25, so it is important to be explicit.

(3) **CS 25.1302(b)** addresses the objective for flight deck controls and information that are/is necessary and appropriate for the flight crew to accomplish their tasks, as determined in (a) above. The intent is to ensure that the design of the controls and information devices makes them usable by the flight crew. This subparagraph seeks to reduce design-induced flight crew errors by imposing design objectives for flight deck information presentation and controls. Subparagraphs (1) through (3) specify these design objectives. The design objectives for information and controls are necessary to:

(i) properly support the flight crew in planning their tasks;

(ii) make available to the flight crew appropriate, effective means to carry out planned actions; and

(iii) enable the flight crew to have appropriate feedback information about the effects of their actions on the aeroplane.

(4) **CS 25.1302(b)(1)** specifically requires controls and information to be designed in a clear and unambiguous form, at a resolution and precision appropriate to the task.

(i) As applied to information, 'clear and unambiguous' means that it can be perceived correctly (is legible) and can be comprehended in the context of the flight crew tasks associated with the intended functions of the equipment, such that the flight crew can perform all the associated tasks.

(ii) For controls, the objective for 'clear and unambiguous' presentation means that the flight crew must be able to use them appropriately to achieve the intended functions of the equipment. The general intent is to foster the design of equipment controls whose operation is intuitive, consistent with the effects on the parameters or states that they affect, and compatible with the operation of the other controls in the flight deck.

(iii) CS 25.1302(b)(1) also requires the information or control to be provided, or to operate, at a level of detail and accuracy appropriate for accomplishing the task. Insufficient resolution or precision would mean the flight crew could not perform the task adequately. Conversely, excessive resolution has the potential to make a task too difficult because of poor readability or the implication that the task should be accomplished more precisely than is actually necessary.

(5) **CS 25.1302(b)(2)** requires controls and information to be accessible and usable by the flight crew in a manner appropriate to the urgency, frequency, and duration of their tasks. For example, controls that are used more frequently or urgently must be readily accessible, or require fewer steps or actions to perform the task. Less accessible controls may be acceptable if they are needed less frequently or less urgently. Controls that are

used less frequently or less urgently should not interfere with those used more urgently or more frequently. Similarly, tasks requiring a longer time for interaction should not interfere with the accessibility to information required for urgent or frequent tasks.

(6) **CS 25.1302(b)(3)** requires equipment to present information that makes the flight crew aware of the effects of their actions on the aeroplane or systems, if that awareness is required for the safe operation of the aeroplane. The intent is for the flight crew to be aware of the system or aeroplane states resulting from crew actions, permitting them to detect and correct their own errors. This subparagraph is included because new technology enables new kinds of flight crew interfaces that previous objectives did not address. Specific deficiencies of existing objectives in addressing HF are described below:

(i) CS 25.771(a) addresses this topic for controls, but does not include criteria for the presentation of information;

(ii) CS 25.777(a) addresses controls, but only their location;

(iii) CS 25.777(b) and CS 25.779 address the direction of motion and actuation but do not encompass new types of controls, such as cursor-control devices. These requirements also do not encompass types of control interfaces that can be incorporated into displays via menus, for example, thus affecting their accessibility;

(iv) CS 25.1523 has a different context and purpose (determining the minimum crew), so it does not address these requirements in a sufficiently general way.

(7) **CS 25.1302(c)** requires installed equipment to be designed so that its behaviour that is operationally relevant to flight crew tasks is:

(i) predictable and unambiguous, and

(ii) designed to enable the flight crew to intervene in a manner appropriate to the task (and intended function).

Other related considerations are the following:

(iii) Improved flight deck technologies involving integrated and complex information and control systems have increased safety and performance. However, they have also introduced the need to ensure proper interactions between the crew and those systems. In-service experience has shown that some equipment behaviour (especially from automated systems) is excessively complex or dependent upon logical states or mode transitions that are not well understood or expected by the flight crew. Such design characteristics can confuse the flight crew and have been determined to contribute to incidents and accidents.

(8) **CS 25.1302(c)(1)** requires the behaviour of a system to be such that a qualified flight crew knows what the system is doing and why it is doing it. It requires operationally relevant system behaviour to be 'predictable and unambiguous'. This means that a crew can retain enough information about what their action or a changing situation will cause the system to do under foreseeable circumstances, so they can operate the system safely.

The behaviour of a system must be unambiguous because the actions of the crew may have different effects on the aeroplane, depending on its current state or operational circumstances.

(9) **CS 25.1302(c)(2)** requires the design to be such that the flight crew will be able to take some action, or change or alter an input to the system, in a manner appropriate to the task.

(10) **CS 25.1302(d)** addresses the reality that even well-trained, proficient crews using well-designed systems will make errors. It requires the equipment to be designed such in order to enable the flight crew to manage such errors. For the purpose of this CS, errors 'resulting from crew interaction with the systems and equipment' are those errors that are in some way attributable, or related, to the design of the controls, the behaviour of the systems and equipment, or the information presented. Examples of designs or information that could cause errors are indications and controls that are complex and inconsistent with each other or with other systems on the flight deck. Another example is a procedure that is inconsistent with the design of the equipment. Such errors are considered to be within the scope of this CS and the related AMC.

(i) What is meant by a design which enables the flight crew to 'manage errors' is that:

(A) the flight crew must be able to detect and/or recover from errors resulting from their interaction with the equipment; or

(B) the effects of such flight crew errors on the aeroplane functions or capabilities must be evident to the flight crew, and continued safe flight and landing must be possible; or

(C) flight crew errors must be prevented by switch guards, interlocks, confirmation actions, or other effective means; or

(D) the effects of errors must be precluded by system logic or redundant, robust, or fault-tolerant system design.

(ii) The objective to manage errors applies to those errors that can be reasonably expected in service from qualified and trained crews. The term 'reasonably expected in service' means errors that have occurred in service with similar or comparable equipment. It also means errors that can be predicted to occur based on general experience and knowledge of human performance capabilities and limitations related to the use of the type of controls, information, or system logic being assessed.

(iii) CS 25.1302(d) includes the following statement: 'This subparagraph (d) does not apply to skill-related errors associated with the manual control of the aeroplane.' That statement is intended to exclude errors resulting from the flight crew's proficiency in the control of the flight path and attitude with the primary roll, pitch, yaw and thrust controls, and which are related to the design of the flight control systems. These issues are considered to be adequately addressed by the existing certification specifications, such as CS-25 Subpart B and CS 25.671(a). It is not intended that the design should be required to compensate for deficiencies in flight crew training or experience. This assumes at least the minimum flight crew requirements for the intended operation, as discussed at the beginning of paragraph 5.1 above.

(iv) This objective is intended to exclude the management of errors resulting from flight crew decisions, acts or omissions that are not in good faith. It is intended to avoid imposing requirements on the design to accommodate errors committed with malicious or purely contrary intent. CS 25.1302 is not intended to require applicants to consider errors resulting from acts of violence or threats of violence.

This 'good faith' exclusion is also intended to avoid imposing requirements on designs to accommodate errors due to a flight crew's obvious disregard for safety. However, it is recognised that errors committed intentionally may still be in good faith, but could be influenced by the characteristics of the design under certain circumstances. An example would be a poorly designed procedure that is not compatible with the controls or information provided to the flight crew.

Imposing requirements without considering their economic feasibility or the commensurate safety benefits should be avoided. Operational practicability should also be addressed, such as the need to avoid introducing error management features into the design that would inappropriately impede crew actions or decisions in normal, abnormal/malfunction and emergency conditions. For example, it is not intended to require so many guards or interlocks on the means to shut down an engine that the flight crew would be unable to do this reliably within the available time. Similarly, it is not intended to reduce the authority or means for the flight crew to intervene or carry out an action when it is their responsibility to do so using their best judgment in good faith.

This subparagraph is included because managing errors (which can be reasonably expected in service) that result from flight crew interactions with the equipment is an important safety objective. Even though the scope of applicability of this material is limited to errors for which there is a contribution from or a relationship to the design, CS 25.1302(d) is expected to result in design changes that will contribute to safety. One example, among others, would be the use of 'undo' functions in certain designs.

Create GM2 25.1302 as follows:

GM2 25.1302 Examples of compliance matrices

The compliance matrix developed by the applicant should provide the essential information in order to understand the relationship between the following elements:

— the design items,

— the applicable certification specifications,

— the test objectives,

— the means of compliance, and

— the deliverables.

The two matrices below are provided as examples only. The applicant might present the necessary information through any format that meets the above objectives.

An example with a *design item* entry:

Function	Sub-function	Focus	CS reference	CS description	Assessed dimension	MoC	Reference to the related deliverable
Electronic checklist (ECL) function	Display electronic checklist (ECL)	Electronic checklist quick access keys (ECL QAKs)	CS 25.777(a)	Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation	Assess the ECL QAKs location for convenient operation and prevention of inadvertent operation.	MoC8 HF campaign #2 Scenario #4	HF Test Report XXX123

Function	Sub-function	Focus	CS reference	CS description	Assessed dimension	MoC	Reference to the related deliverable
			CS25.777(c)	The controls must be located and arranged, with respect to the pilots' seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flight crew (established under CS 25.1523) when any member of this flight crew from 1.58 m (5ft 2 inches) to 1·91 m (6ft 3 inches) in height, is seated with the seat belt and shoulder harness (if provided) fastened.	Assess accessibility to control the ECL QAKs.	MoC4 HF Reachability Analysis MoC5 HF Reachability and Accessibility Campaign	HF Reachability and Accessibility Assessment Report XXX123
			[…]	[…]	[…]	[…]	[…]
			CS 25.1302(a)	(a) The controls and information necessary for the accomplishment of the tasks must be provided.	Assess that appropriate controls are provided in order to display ECL.	MoC1 ECL implementation description for XXXX	ECL implementation description document for XXXX

Function	**Sub-function**	**Focus**	**CS reference**	**CS description**	**Assessed dimension**	**MoC**	**Reference to the related deliverable**
			CS 25.1302(b)(1)	(b)The controls and information required by paragraph (a), which are intended for use by the flight crew, must: (1) Be presented in a clear and unambiguous form, at resolution and with a precision appropriate to the flight crew task.	Assess the appropriateness of the ECL QAKs labels.	MoC8 HF campaign #4 Scenario #1	HF Test Report XXX345

Another example with a *certification specification* entry:

CS reference	CS description	Focus	Assessed dimension	MoC	Reference to the related deliverable
CS 25.777(a)	(a) Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.	All flight deck controls	Assess the locations of all flight deck controls for convenient operation and prevention of inadvertent operation.	MoC8 All HF simulator evaluations	HF Test Reports XXX123 XXX456 XXX789
		ECL QAKs	Assess the location of the ECL QAKs for convenient operation and prevention of inadvertent operation.	MoC8 HF campaign #2 Scenario #4	HF Test Report XXX123
CS 25.777(c)	(c) The controls must be located and arranged, with respect to the pilots' seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flight crew (established under CS 25.1523) when any member of this flight crew from 1.58 m (5ft 2 inches) to 1·91 m (6ft 3 inches) in height, is seated with the seat belt and shoulder harness (if provided) fastened.	All flight deck controls	Assess the accessibility of all flight deck controls.	MoC4 HF Reachability Analysis MoC5 HF Reachability and Accessibility Campaign	HF Reachability and Accessibility Assessment Report XXX123
		ECL QAKs	Assess the accessibility to control the ECL QAKs.	MoC4 HF Reachability Analysis MoC5 HF Reachability and Accessibility Campaign	HF Reachability and Accessibility Assessment Report XXX123
[…]	[…]				
CS 25.1302(a)	(a)The controls and information necessary for the accomplishment of				

CS reference	CS description	Focus	Assessed dimension	MoC	Reference to the related deliverable
	the tasks must be provided.				
CS 25.1302(b)(1)	(b)The controls and information required by paragraph (a), which are intended for use by the flight crew, must: (1) Be presented in a clear and unambiguous form, at resolution and with a precision appropriate to the flight crew task.				

Item 4: Performance and handling characteristics in icing conditions

Amend AMC 25.21(g) as follows:

AMC 25.21(g) Performance and handling characteristics in icing conditions

(…)

4.6 Failure Conditions (CS 25.1309).

(…)

4.6.5 For failure conditions that are remote or extremely remote ~~but not extremely improbable~~, the analysis and substantiation of continued safe flight and landing, in accordance with CS 25.1309, should take into consideration whether annunciation of the failure is provided and the associated operating procedures and speeds to be usedfollowing the failure condition.

(…)

Item 5: Brakes and Braking Systems Certification Tests and Analysis

Amend AMC 25.735 as follows:

AMC 25.735 Brakes and Braking Systems Certification Tests and Analysis

(…)

4. DISCUSSION

a. Ref. CS 25.735(a) Approval

(1) CS 25.735(a) states that each assembly consisting of a wheel(s) and brake(s) must be approved. Each wheel and brake assembly fitted with each designated and approved tyre type and size, where appropriate, should be shown to be capable of meeting the minimum standards and capabilities detailed in the applicable European Technical Standard Order (E)TSO, in conjunction with the type certification procedure for the aeroplane, or by any other means approved by the Agency. This applies equally to replacement, modified, and refurbished wheel and brake assemblies or components, whether the changes are made by the Original Equipment Manufacturer (OEM) or others. Following initial aeroplane certification, any additional wheel and brake assemblies should meet the applicable airworthiness requirements specified in 21.A.101(a) and (b) to eliminate situations that may have adverse consequences on aeroplane braking control and performance. This includes the possibility of the use of modified brakes either alone (i.e., as a ship set) or alongside the OEM's brakes and the mixing of separately approved assemblies. ~~Additionally,~~

~~t~~The components of the wheels, brakes, and braking systems should be designed to:

(a) Withstand all pressures and loads, applied separately and in conjunction, to which they may be subjected in all operating conditions for which the aeroplane is certificated.

(b) Withstand simultaneous applications of normal and emergency braking functions, unless adequate design measures have been taken to prevent such a contingency.

(c) Meet the energy absorption requirements without auxiliary cooling devices (such as cooling fans).

(d) Not induce unacceptable vibrations at any likely ground speed and condition or any operating condition (such as retraction or extension).

(e) Protect against the ingress or effects of foreign bodies or materials (water, mud, oil, and other products) that may adversely affect their satisfactory performance. ~~Following initial aeroplane certification, any additional wheel and brake assemblies should meet the applicable airworthiness requirements specified in 21A.101(a) and (b) to eliminate situations that may have adverse consequences on aeroplane braking control and performance. This includes the possibility of the use of modified brakes either alone (i.e., as a ship set) or alongside the OEM's brakes and the mixing of separately approved assemblies.~~

(2) Respecting brake energy qualification limits (…)

(3) Refurbished and Overhauled Equipment. (…)

(4) Replacement and Modified Equipment. Replacement and modified equipment includes changes to any approved wheel and brake assemblies not addressed under paragraph 4a(~~2~~ 3) of this AMC. (…)

(5) The following apply to both Refurbished and Overhauled Equipment as well as Replacement and Modified Equipment:

(a) Minor Changes. (…)

(b) Major Changes. Changes to a wheel or brake assembly outside the limits allowed by the OEM's CMM should be considered a major change due to potential airworthiness issues.

(c) (…)

(d) (…)

(…)

Item 6: Oxygen equipment and supply

Amend AMC 25.1441(b) as follows:

AMC 25.1441(b) Risk assessment related to oxygen fire hazards in gaseous oxygen systems

(…)

3.3. Ventilation

The compartments in which oxygen system components are installed should be ventilated in such a way that, if a leak occurred or oxygen was discharged directly into the compartment (not overboard) from any protective device or pressure-limiting device, the likelihood of ignition of the oxygen-enriched environment would be minimised. ~~The applicant should substantiate that the ventilation rate of the compartment is adequate. Analytically determined ventilation rates should be validated by flight test results or their equivalent.~~

In order to support the demonstration of compliance with CS 25.869(c)(3), potential oxygen system leakage locations should be identified, and the ventilation in the area surrounding the oxygen installation should be sufficient so that oxygen concentrations would not reach unsafe levels. If there is any area of potential high oxygen concentrations, it should be shown that this area is void of potential ignition sources, such as electrical equipment or sources of heat.

CS 25.1453(f) provides additional specifications related to ventilation.

This paragraph does not apply to portable oxygen systems, such as systems used to provide first-aid oxygen to passengers or supplemental oxygen for cabin crew mobility, usually stowed in overhead bins, provided that it is confirmed that the shut-off means mounted on the oxygen container is always closed when the system is stowed and not used.

(…)

Item 7: Air conditioning 'off' – maximum time period

Amend AMC 25.831(a) as follows:

AMC 25.831(a) Ventilation

(…)
3. Operations with the air conditioning system 'off'
The following provisions should be considered for the limited time periods, such as during takeoff, during which the air conditioning system is 'off':
(…)
e. Finally, the period during which the aeroplane is operated with the air conditioning system 'off' is intended to be of short duration. Therefore, the maximum ~~time~~ period allowed ~~for the operation of an aeroplane~~ in this configuration should be defined by the applicant and specified in the appropriate operating manuals, along with any related operating procedures that are necessary to ensure that the above items are addressed.

Item 8: Cabin crew portable oxygen equipment

Amend CS 25.1443 as follows:

CS 25.1443 Minimum mass flow of supplemental oxygen

(…)

(e) If portable oxygen equipment is installed for use by crew members, the minimum mass flow of supplemental oxygen is the same as specified in sub-paragraph (a) or (b) of this paragraph, whichever is applicable (See AMC 25.1443(e)).

Create AMC 25.1443(e) as follows:

AMC 25.1443(e) Minimum mass flow of portable oxygen equipment

Cabin crews are part of the 'crew members'. Therefore, CS 25.1443 (e) is applicable to portable oxygen equipment (POE) used by cabin crews. This means that the POE must comply with the minimum mass flow specified by CS 25.1443(a) or (b), as applicable.

Consequently, even if ETSO C64 masks are used as part of the POE, the compliance with CS 25.1443 (a) or (b) will have to be demonstrated for the complete POE up to:

- the maximum cabin altitude after a depressurisation event, when the POE is used as a primary means to provide hypoxia protection for the cabin crew, or
- the maximum possible level-off altitude after a depressurisation of the aeroplane, but not exceeding 7620 m (25 000 ft), when the POE is installed to allow cabin crew mobility in

aeroplanes where the passenger oxygen system design allows to level off at altitudes between 3048 m (10 000 ft) and 7620 m (25 000 ft) after a depressurisation event (typically passenger oxygen gaseous system or long duration chemical oxygen generators).

Amend AMC 25.1447(c)(4) as follows:

AMC 25.1447(c)(4) Equipment standards for portable oxygen equipment ~~dispensing units~~

When the portable oxygen equipment (POE) is the primary means to protect cabin crew members in case of depressurisation, when seated at their station, the following applies:

1 The equipment should be so located as to be within reach of the cabin crew members while seated and restrained at their seat stations.

2 The mask/hose assembly should be already connected to the supply source, and oxygen should be delivered with no action being required except turning ~~it~~ the system on and donning the mask.

3 Where a cabin crewmember's work area is not within easy reach of the equipment provided at his seat station, an additional unit should be provided at the work area.

When the POE is installed to allow cabin crew mobility in aeroplanes where the passenger oxygen system design allows to level off at altitudes between 3048 m (10 000 ft) and 7620 m (25 000 ft) after a depressurisation event (typically passenger gaseous oxygen system or long duration chemical oxgen generator), the following applies:

1. The POE should be, to the degree practicable, uniformly distributed throughout the cabin. The distribution of the POE should be such that cabin crew transfer from any possible location to the nearest POE is safe. It should be assumed that cabin crew members will move around in the cabin only when they are notified by the flight crew that a safe flight level has been reached (designated as 'level-off altitude'). Consequently, the safe transfer to POE should be demonstrated at the maximum possible level-off altitude after a depressurisation of the aeroplane. Considering potential operational scenarios, the maximum level-off altitude should be 7620 m (25 000 ft). Any other lower value should be justified by the applicant and operational limitations should be provided in the Aeroplane Flight Manual (AFM). It can be assumed that cabin crew members will not leave their seats during an emergency descent or during temporary level-off at altitudes above 7620 m (25 000 ft). The applicant should provide appropriate information to support cabin crew training for depressurisation events, including the recommendation that cabin crew members should not move around in the cabin until an altitude of 7620 m (25 000 ft) or lower has been reached. The reaching of such safe altitude should be announced by the flight crew, unless other appropriate means of information exist.

2. The POE should be immediately available to each cabin crew member. The immediate availability is acceptable if:
   - the mask is always connected to the supply source,
   - oxygen can be delivered with no action being required except turning the system on and donning the mask,
   - easy and unobstructed access is ensured by design.

3. A minimum of one POE should be provided for each required cabin crew member, with even distribution throughout the passenger cabin.

Amend CS 25.1449 as follows:

CS 25.1449 Means for determining use of oxygen

(see AMC 25.1449)

(…)

Create a new AMC 25.1449 as follows:

AMC 25.1449 Means for determining use of oxygen

CS 25.1449 is also applicable to portable oxygen equipment (POE).

A flow indicator should be provided, unless it can be shown that the inflation of the economiser system, or another appropriate means, provides an effective indication. A system using a simple re-breathing bag would not be considered as an acceptable means of indication.

4. Impact assessment (IA)

There is no need to develop a detailed regulatory impact assessment as the topics addressed in this NPA are considered as non-complex and non-controversial.

5. Proposed actions to support implementation

N/A

6. References

6.1. Related EU regulations

N/A

6.2. Related EASA decisions

Decision No. 2003/2/RM of the Executive Director of the Agency of 17 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes («CS-25»)

6.3. Other references

- Transport Aircraft Crashworthiness and Ditching Working Group Report to FAA, rev. A dated 10 May 2018
- National Transportation Safety Board (NTSB) accident report NTSB/AAR-10/03, Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River -US Airways Flight 1549, Airbus A320-214, N106US - Weehawken, New Jersey, on 15 January 2009

7. Appendix

N/A

8. Quality of the NPA

To continuously improve the quality of its documents, EASA welcomes your feedback on the quality of this NPA with regard to the following aspects:

8.1. The regulatory proposal is of technically good/high quality

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.2. The text is clear, readable and understandable

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.3. The regulatory proposal is well justified

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.4. The regulatory proposal is fit for purpose (capable of achieving the objectives set)

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.5. The impact assessment (IA), as well as its qualitative and quantitative data, is of high quality

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.6. The regulatory proposal applies the 'better regulation' principles[1]

[Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.]
Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.7. Any other comments on the quality of this NPA (please specify)

Note: Your comments on this Section will be considered for internal quality assurance and management purposes only and will not be published in the related CRD.

[1] For information and guidance, see:
- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en
- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en