NOTICE OF PROPOSED AMENDMENT (NPA) NO 2011-13

DRAFT DECISION OF THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY

amending Decision No 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003

Certification Specifications and Acceptable Means of Compliance, for Large Aeroplanes (CS-25)

'Large Aeroplanes protection against fuel low level and fuel exhaustion'

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

EXECUTIVE SUMMARY

Large Aeroplane incidents and accidents have occurred because of fuel tank low level situations, or fuel starvation situations resulting in one or several engine(s) flame-out.

Based on the analysis and lessons learnt from those events, it is proposed to introduce new CS-25 fuel indication system(s) standards. In addition to the primary function of indicating usable fuel quantity on board, those systems would provide, as early as possible, alerts and information to the flight crew to assist them in the task of managing the fuel quantity on board and managing fuel system condition(s) that, if not corrected, present a risk of engine fuel starvation with potential unsafe condition(s).

An update of CS 25.1305(a)(2) and a new AMC 25.1305(a)(2) are proposed.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

TABLE OF CONTENTS

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

A. Explanatory Note

I. General

1. The purpose of this Notice of Proposed Amendment (NPA) is to envisage amending Decision No. 2003/2/RM[1] of the Executive Director of the European Aviation Safety Agency of 17 October 2003 (Certification Specifications and Acceptable Means of Compliance for large aeroplanes - CS-25). The scope of this rulemaking activity is outlined in Terms of Reference (ToR) 25.055 and is described in more detail below.

2. The European Aviation Safety Agency (hereinafter referred to as the 'Agency') is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation[2] which are adopted as 'Opinions' (Article 19(1)). It also adopts Certification Specifications, Acceptable Means of Compliance and Guidance Material to be used in the certification process (Article 19(2)).

3. When developing rules, the Agency is bound to follow a structured process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'[3].

4. This rulemaking activity is included in the Agency's Rulemaking Programme for 2011-2014. It implements the rulemaking task 25.055.

5. The text of this NPA has been developed by the Agency. It is submitted for consultation of all interested parties in accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

6. The proposed rule has taken into account the development of European Union and International law (ICAO), and the harmonisation with the rules of other authorities of the European Union's main partners as set out in the objectives of Article 2 of the Basic Regulation. The proposed rule is more stringent than the ICAO Standards and Recommended Practices (see chapter 12 below).

II. Consultation

7. To achieve optimal consultation, the Agency is publishing the draft Decision of the Executive Director on its Internet site. Comments should be provided within 3 months in accordance with Article 6 of the Rulemaking Procedure. Comments on this proposal should be submitted by one of the following methods:

CRT:	Send your comments using the Comment-Response Tool (CRT) available at **http://hub.easa.europa.eu/crt/**.
E-mail:	Comments can be sent by e-mail only in case the use of the CRT is prevented by technical problems. The(se) problem(s) should be reported to the CRT webmaster and comments should be sent by e-mail to NPA@easa.europa.eu.

---

[1] Decision No 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003 on Certification Specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes ("CS-25"). Decision as last amended by ED Decision No 2011/004/R of 27 June 2011 (CS-25 Amendment 11).

[2] Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.03.2008, p. 1). Regulation as last amended by Regulation 1108/2009 of the European Parliament and of the Council of 21 October 2009 (OJ L 309, 24.11.2009, p. 51).

[3] Management Board Decision concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material (Rulemaking Procedure), EASA MB 08-2007, 13.6.2007.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Correspondence: If you do not have access to the Internet or e-mail, you can send your comments by mail to:

Process Support
Rulemaking Directorate
EASA
Postfach 10 12 53
D-50452 Cologne
Germany

Comments should be submitted by 24 October 2011. If received after this deadline, they might not be taken into account.

III. Comment response document

8. All comments received in time will be responded to and incorporated in a Comment Response Document (CRD). The CRD will be available on the Agency's website and in the Comment Response Tool (CRT).

IV. Content of the draft Opinion / Decision

9. Summary

Large Aeroplane incidents and accidents have occurred because of fuel tank low level situations or because of fuel starvation situations resulting in one or several engine(s) flame-out. Although the Agency and the industry have already taken actions to mitigate this kind of events, it appears that the Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS-25) need to be updated. This NPA proposes new fuel indication system(s) standards based on the analysis and lessons learnt from those events. The proposal is based on the work performed by an international group[4] including representatives from the industry (Airbus, ATR, Boeing, Embraer, Rolls-Royce) and aviation authorities (FAA, TCCA, EASA).

10. The envisaged changes to CS-25 are:

In Book 1, SUBPART F-EQUIPMENT, amend CS 25.1305(a)(2).

In Book 2, AMC - SUBPART F, create a new AMC 25.1305(a)(2).

11. Review of events and lessons learnt

The working group reviewed and analysed the events and the related safety recommendations, as defined in the objectives of the Terms of Reference.

The type of events taken into account primarily included fuel low level and fuel exhaustion situations (accidents and incidents), and also the related precursor events (incidents) which, if not corrected or not detected, would lead to fuel low level or even fuel exhaustion cases.

The main root causes and factors that have been identified are summarised below.

- Fuel quantity indication system (FQIS) false indications combined with the absence of a low fuel level alert (no fuel low level alerting system or the system existed but was affected by the FQIS failure). FQIS false indications have been caused by failures in the measurement chain (such as gauge failure or incorrect reading) or by maintenance errors (such as installation of a wrong gauge or wrong indicator).
- Adverse weather conditions at the destination airport. When the flight crew is not correctly informed or does not adequately follow up weather changes or does not decide on time to perform a diversion to an airport where weather conditions are adequate for safe landing, this leads to aborted landing(s). Several landing attempts

[4] The group composition is available on the EASA website using the following link: http://www.easa.eu.int/rulemaking/terms-of-reference-and-group-composition.php.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

at the same airport, and no or late decision to divert, have caused fuel low level and fuel exhaustion situations.

- Trapped fuel situations. In this case, sufficient fuel quantity is present on board but one part of this fuel becomes unavailable to feed the engines. Such events are caused by flight crew operational error (like bad selection of a fuel valve or fuel pump, inadequate cross-feed action), maintenance error (like fuel isolation valve closed, aircraft configuration not meeting MMEL procedure(s)), fuel system failures (cross-feed valve failure, fuel system management failure on highly integrated systems).
- Fuel leaks. When a fuel leak occurs and is not detected and, if possible, isolated on time, there is a risk of total fuel exhaustion. In several cases, the pilots detected and managed a perceived fuel imbalance situation but did not identify a fuel leak or identified it too late. Under certain conditions, the effect of a fuel leak not being corrected or isolated can lead to the risk of fire on ground or in flight, for instance fuel spraying on hot parts.
- Insufficient or incorrect monitoring or management of the fuel quantity by the flight crew. Sometimes this was also combined with the preoccupation of the flight crew related to other aircraft system problems (like landing gear malfunction) or the absence of fuel low level alert or the failure to communicate on time an emergency situation to air traffic control. This has resulted in fuel exhaustion before landing.
- Erroneous fuel loading. When such an error happens and if it is combined with other contributor(s) (like fuel gauges failures, inadequate fuel checking in flight, failure to declare an emergency on time, non-availability of air traffic control procedures to assist in distress, adverse weather at destination), this can create a fuel low level or fuel exhaustion.
- Increased fuel consumption. Abnormal aeroplane configuration (such as landing gear or flaps extended) can result in an increase of the fuel consumption. When the flight crew does not react and manage properly this situation (by deciding a diversion or wrongly assessing the impact on the consumption), this may result in fuel exhaustion or fuel low level.
- Navigation errors and failures. In some cases, on old generation aeroplanes, flight crew was not able to complete their navigation following equipments failures, or made navigation errors, which resulted in fuel exhaustion events.

In total, 30 accidents and 35 incidents have been identified in this scope of causes, between 1970 and February 2011.

Safety Recommendations received from accident investigation bodies.

These recommendations have focused on the need to better inform flight crew of low fuel level conditions or fuel system discrepancies. Several of them recommend requiring a low fuel level warning which shall be independent of the fuel quantity indication system.

- SR 10 of 2005 from the Irish AAIU final report (ATR42 serious incident, Dublin, 8 August 2003): “*The European Air Safety Agency (EASA) should review the certification criteria for public transport aircraft low fuel contents warning systems, with a view to requiring such systems to be independent of the main contents gauging systems*.”

- Safety recommendation ANSV-13/443-05/3/A/05 from the Italian ANSV final report (ATR72 accident, Sicily, 6 August 2005): “*European Aviation Safety Agency should consider the possibility to change the fuel system certification regulation for public transport aircraft, in order to require that the fuel low level warning be independent from the fuel gauging systems*.”

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

- Safety recommendation AB/2004 from the Portuguese GPIAA final report (A330 accident, Azores, 24 August 2001): "*It is also recommended that the civil aviation authorities of other transport aircraft categories manufacturing States such as Canada, United States of America, and United Kingdom, as well as the European Aviation Safety Authority:*

- *Review the adequacy of aircraft indications and warning systems and procedures to detect fuel-used/fuel-loss discrepancy situations;*
- *Review the capability of these systems to provide clear indications as to the causes of these situations; and*
- *Review the capability of these systems to provide alerts at a level commensurate with the criticality of a fuel-loss situation."*

- Safety recommendation AG/2004 from the Portuguese GPIAA final report (A330 accident, Azores, 24 August 2001): "*It is recommended that the civil aviation authorities of other aircraft manufacturing states, such as Canada, United States of America, and United Kingdom, as well as the European Aviation Safety Authority:*

- *Review the adequacy of the fuel indications and warning systems, as well as procedures associated with fuel imbalance situations to ensure that the possibility of a fuel leak is adequately considered."*

- UK AAIB final report No: 4/2007 (A340-642 incident, Amsterdam, 8 February 2005):

- *"Safety recommendation 2005-108: It is recommended that the European Aviation Safety Agency introduces into CS-25 the requirement for a low fuel warning system for each engine feed fuel tank; this low fuel warning system should be independent of the fuel control and quantity indication system(s).*
- *Safety recommendation 2005-109: It is recommended that the European Aviation Safety Agency should review all aircraft currently certified to EASA CS-25 and JAR-25 to ensure that if an engine fuel feed low warning system is installed, it is independent of the fuel control and quantity indication system(s)."*

12. Current regulatory status

ICAO Annex 8[5]

In the category "*Aeroplanes over 5700 Kg for which application for certification was submitted on or after 2 March 2004*", there is no particular requirement for fuel quantity indication or fuel low level alert. Paragraph 6.1.1 is general and only requires the aeroplane to "*be provided with approved instruments, equipment and systems, including guidance and flight management systems necessary for the safe operation of the aeroplane in the anticipated operating conditions*".

EASA Certification Specifications – CS-25

The following provisions are currently included in CS-25 for fuel tank quantity indications:

SUBPART F-EQUIPMENT

CS 25.1305 Powerplant instruments

The following are required powerplant instruments:

(a) For all aeroplanes

... (2) A fuel quantity indicator for each fuel tank.

[5] Annex 8 to the Convention on International Civil Aviation, "Airworthiness of Aircraft", Eleventh Edition, July 2010.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

CS 25.1337 Powerplant instruments

...

(b) Fuel quantity indicator. There must be means to indicate to the flight-crew members, the quantity, in litres, (gallons), or equivalent units, of usable fuel in each tank during flight. In addition:

> *(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS 25.959;*
>
> *(2) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and*
>
> *(3) Each exposed sight gauge, used as a fuel quantity indicator, must be protected against damage.*

There is no requirement for a low fuel level alert. Nevertheless, many in-service Large Aeroplanes certificated against JAR-25, CS-25 or FAR Part-25 do have a low fuel level warning device installed; however, they are not all independent or fault tolerant from the normal fuel gauging system and the alert level and setting point are not standardised.

In addition, CS 25.1309(c) is relevant to fuel systems unsafe operating conditions:

CS 25.1309 Equipment, systems and installations

...

(c) Information concerning unsafe system operating conditions must be provided to the crew to enable them to take appropriate corrective action. A warning indication must be provided if immediate corrective action is required. Systems and controls, including indications and annunciations must be designed to minimise crew errors, which could create additional hazards.

<u>Operational regulation in the European Union</u>

Commission Regulation (EC) No 859/2008 ("EU-OPS") amending Council Regulation (EEC) No 3922/91 provides the requirements for commercial transportation by aeroplane. Relevant to the scope of this NPA are the fuel policy and the in-flight fuel management requirements specified below.

OPS 1.255 Fuel policy

[...]

(c) An operator shall ensure that the pre-flight calculation of usable fuel required for a flight includes:

1. Taxi fuel; and

2. Trip fuel; and

3. Reserve fuel consisting of:

(i) contingency fuel (see OPS 1.192); and

(ii) alternate fuel, if a destination alternate aerodrome is required. (This does not preclude selection of the departure aerodrome as the destination alternate aerodrome); and

(iii) final reserve fuel; and

(iv) additional fuel, if required by the type of operation (e.g. ETOPS); and

4. extra fuel if required by the commander.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Appendix 1 to OPS 1.255 further explains what is expected in term of final reserve:

1.5. Final reserve fuel, which shall be:

(a) for aeroplanes with reciprocating engines, fuel to fly for 45 minutes; or

(b) for aeroplanes with turbine engines, fuel to fly for 30 minutes at holding speed at 1 500 ft (450 m) above aerodrome elevation in standard conditions, calculated with the estimated mass on arrival at the destination alternate aerodrome or the destination aerodrome, when no destination alternate aerodrome is required.

OPS 1.375 In-flight fuel management

An operator shall establish a procedure to ensure that in-flight fuel checks and fuel management are carried out according to the following criteria:

(a) in-flight fuel checks.

1. a commander must ensure that fuel checks are carried out in-flight at regular intervals. The usable remaining fuel must be recorded and evaluated to:

(i) compare actual consumption with planned consumption;

(ii) check that the usable remaining fuel is sufficient to complete the flight, in accordance with paragraph (b) "In-flight fuel management" below; and

(iii) determine the expected usable fuel remaining on arrival at the destination aerodrome;

2. the relevant fuel data must be recorded.

(b) in-flight fuel management.

1. the flight must be conducted so that the expected usable fuel remaining on arrival at the destination aerodrome is not less than:

(i) the required alternate fuel plus final reserve fuel, or

(ii) the final reserve fuel if no alternate aerodrome is required;

2. however, if, as a result of an in-flight fuel check, the expected usable fuel remaining on arrival at the destination aerodrome is less than:

(i) the required alternate fuel plus final reserve fuel, the commander must take into account the traffic and the operational conditions prevailing at the destination aerodrome, at the destination alternate aerodrome and at any other adequate aerodrome, in deciding whether to proceed to the destination aerodrome or to divert so as to perform a safe landing with not less than final reserve fuel, or

(ii) the final reserve fuel if no alternate aerodrome is required, the commander must take appropriate action and proceed to an adequate aerodrome so as to perform a safe landing with not less than final reserve fuel;

3. the commander shall declare an emergency when calculated usable fuel on landing, at the nearest adequate aerodrome where a safe landing can be performed, is less than final reserve fuel.

[...]

13. EASA mitigation actions

The Agency has issued a Certification Review Item (CRI) providing a Special Condition (SC) on Fuel Quantity Indication System for new Large Aeroplane Type projects (or Fuel System major change on an already certificated Type). It includes the requirement for a low fuel level warning which is not affected by any single failure of the fuel gauging system, and fuel system information or alerts that consider abnormal fuel management or transfer between tanks, and possible fuel leaks in the tanks, the fuel lines and other fuel system components and the engines. This SC has been applicable since 30 September 2008.

For already certificated Types, the Agency has issued in March 2009 a Continuing Airworthiness Review Item on Fuel Low Level Awareness (CARI 25-01). The objective was to review the in-service experience with regard to fuel exhaustion and identify the causes; the Agency would use the outcome of this investigation to decide if any mandatory action is required. Type Certificate Holders were requested to review the fuel system design and identify fuel leaks scenarios, the cockpit indications available to identify the fuel leaks, and the associated existing operational procedures. Based on this review, a safety assessment of fuel leaks scenarios was performed and any found weakness could be improved through hardware modifications or operational procedures improvements. Most procedural improvements were at the level of fuel transfer and fuel cross-feed procedures where steps could be added to verify the absence of fuel leak before initiating a transfer or a cross-feed. Finally, some analysis revealed that non-isolated fuel leaks could cause a hazard during some flight phases, for instance fuel spillage on the brakes when applying reverse thrust during landing.

14. Proposed new fuel indication system(s) standards

The objective is to propose new standards for type certification of large aeroplanes which provide the optimal protection against the fuel low level/fuel exhaustion events scenarios found when analysing accidents and incidents.

The proposed standards would introduce new fuel indication system(s) requirements. In addition to the primary function of indicating usable fuel quantity on board, those systems would provide, as early as possible, alerts and information to the flight crew to assist them in the task of managing the fuel quantity on board and managing fuel system condition(s) that, if not corrected, present a risk of engine fuel starvation with potential unsafe condition(s).

An update of CS 25.1305(a)(2) and a new AMC 25.1305(a)(2) are proposed.

Note: For ETOPS operation approval, additional requirements may be applicable. Refer to AMC 20-6 (currently at revision 2) and operational regulation (e.g. Council Regulation (EEC) No 3922/91 “EU-OPS” as last amended in the European Union (EU)).

Fuel quantity indications

The primary function of the system(s) is providing usable fuel quantity indications. This includes the total usable fuel quantity which shall be permanently displayed and be easily and directly readable by the pilots; indeed, this is considered as essential information which shall be regularly checked by the pilots per operational regulation. The usable quantities of each individual tank must be available as well but it is acceptable that they are displayed only when required (on demand or automatically).

Other information and alerts

Service experience indicates that scenarios leading to impending fuel starvation of one or more engines have many times developed into an unsafe system operating condition.

It is therefore expected that applicants will identify such scenarios when doing the system safety assessment and that flight crew is appropriately informed so that they can take appropriate corrective action.

As a minimum, the proposed rule would require to inform the flight crew of the existence of a fuel leak, a trapped fuel situation, any abnormal fuel transfer between tanks, and a low fuel level situation.

For each alert, operational procedures with corrective actions shall be available to the flight crew; these procedures would give instructions on how to identify and/or correct the problem, and, if necessary, direct them to perform a diversion or land as soon as possible. In addition, any required procedure will be available to avoid additional hazard such as fuel coming into contact with wheel brakes during landing when a fuel leak is not isolated, or exceeding centre of gravity or fuel imbalance limits.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Fuel leaks

Alert and information shall be provided to the flight crew enabling them to identify a fuel leak. Fuel leaks are typically generated by the loss of integrity of the fuel system and result in fuel being drained overboard the aircraft. The fuel leak scenarios shall include leaks in the engine, both upstream and downstream the fuel flow meter up to the fuel nozzles.

Trapped fuel

Alert and information shall permit the flight crew to identify a trapped fuel situation. A trapped fuel is a quantity of fuel which is gauged by the fuel quantity indication system but which is not any more available to feed the engine(s). This can be caused either by a failure in the fuel system (such as a pump or pipe failure) or by an inappropriate selection by the flight crew.

Abnormal fuel transfer between tanks

Alert and information shall permit the flight crew to identify and, if possible, correct an abnormal fuel transfer between fuel tanks. The abnormal transfer may result from a fuel management system failure or from an inappropriate action of the flight crew. If not corrected, this can lead to engine(s) fuel starvation although the total quantity of fuel on-board is as expected.

Low fuel level alert

The objective is to get the attention of the pilots and inform them that the fuel quantity situation requires to land rapidly. Other fuel system alerts may be triggered before the low fuel level alert; if this does not happen or if the pilots did not correctly manage or check their fuel quantity (as required per operational regulation, such as EU-OPS 1.375 in the EU), it is the last safety net to avoid fuel exhaustion.

The low fuel level alert is applicable to any tank or collector cell that is not expected to be depleted in flight because otherwise this situation would lead to an engine fuel starvation. The alert shall be triggered when the quantity of usable fuel in the tank concerned reaches the quantity required to operate an engine for 30 minutes with the aircraft operated in optimum cruise conditions.

This setting would allow performing a safe diversion without generating nuisance alerts on normal flights. It would also be triggered before reaching the final reserve required by operational regulations (EU-OPS 1.255, Appendix 1: 30 minutes at holding speed at 1 500 ft (450 m) above aerodrome elevation in standard conditions, calculated with the estimated mass on arrival at the destination alternate aerodrome or the destination aerodrome, when no destination alternate aerodrome is required).

Incidents and accidents have also demonstrated that it is important that this fuel low level alert is not adversely affected by any failure of the fuel quantity indication. Therefore, the alert shall be designed such that no failure of the FQIS (including total loss of FQIS power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert not being correctly triggered.

15. Other consideration reviewed by the rulemaking group – minority position

The rulemaking group considered and analysed an option of requiring an additional function which continuously and automatically verifies that the fuel on board remains sufficient to perform the intended mission. This would include appropriate indication whenever the fuel available for engine feed is below that required to safely complete the flight with the required fuel reserves, and early enough to assure a safe diversion with the required fuel reserves. The computation should also take into account the actual aircraft configuration (e.g. excessive fuel consumption caused by abnormal aircraft configuration).

This function would assist the pilots in doing their in-flight fuel check and fuel management duty which is part of the basic airmanship and required per operational regulation.

It could be implemented on aeroplanes designed with highly integrated fuel management systems and also equipped with a flight management system.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Today some aeroplanes equipped with a flight management system (FMS) or equivalent system offer this kind of functions with limited capabilities. They indeed use theoretical performance data bases to determine the expected fuel consumption, which may not reflect the actual aircraft fuel consumption and do not account for all failures or abnormal aircraft configurations. This function is not available on aircraft that are not equipped with an FMS, which is currently not required for CS-25 certification.

A step-change in the capabilities and complexity of the existing state-of-the-art systems would be required in order to be able to quantify the predicted fuel consumption for possible abnormal configurations of the aircraft and then calculate if the destination can still be reached with the remaining usable fuel, and also taking into account the numerous variables of the mission profile and the uncertainties on calculating performance degradation based on actual aircraft status information available in flight. Furthermore, in some cases, like for instance fuel leaks, fuel gauges indications failures, fuel system failures making fuel suddenly unavailable to the engine, the prediction of such systems would nevertheless not be reliable enough to ensure a safe diversion; for instance, it is not possible to predict how a fuel leak can evolve over time, and the prediction would be affected by false fuel gauges indications. Moreover, FMS prediction functions are currently DO178-DAL C certified. Therefore, the integrity of such automated fuel check function is limited.

Furthermore, based on the in-service events analysis, the safety benefit of this function was considered to be low by the majority of the rulemaking group. Assuming this function would be precise and reliable enough to predict accurate fuel consumption, in seven accidents and one incident it may have triggered an alert in addition to the other alerts triggered in compliance with the standard proposed in chapter 14 above (in those cases a fuel low level alert or a fuel leak alert). However, in all cases, the other alerts would already provide a means to avoid the event.

The group considers that it is paramount for the safety of flight to detect and alert as early as possible on fuel system failures (e.g. fuel leak, trapped fuel…) so that corrective actions and diversion can be made before reaching a situation where anyway a fuel starvation will not be avoided. The low fuel level alert is the last safety net to make the pilots aware of the urgency and consider landing as soon as possible.

Finally, considering the low safety benefit and the complex technical issues limiting the integrity, capability and the reliability of an automated fuel check function, the majority of the group decided not to require this function in the proposed certification specifications.

FAA maintains its minority position and would have required this additional function. FAA proposed the argument that the 30 minutes low fuel level alert would not necessarily be sufficient even for non-ETOPS twin-engined aeroplanes, because the operational rule authorises the aircraft flying up to 60 minutes away from an airport (at the one engine inoperative cruise speed). Nevertheless, the events analysed and the available information did not identify any event where the fuel low level alert would have been correctly triggered in a location where the aeroplane would have been too far away from a suitable place to land.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

V. Regulatory Impact Assessment

1. Process and consultation

The content of this RIA is based on the recommendations of the task 25.055 working group. This working group included representatives from the industry (Airbus, ATR, Boeing, Embraer, Rolls-Royce) and aviation authorities (FAA, TCCA, EASA). However, FAA has maintained a minority position as explained in chapter 15 above.

2. Issue analysis and risk assessment

2.1. What is the issue?

Fuel low level and fuel exhaustion situations have caused accidents and incidents.

The analysis of events revealed several root causes and factors which are detailed in chapter 11 of this NPA. The main subjects are: Fuel quantity indication system (FQIS) false indications combined with the absence of a low fuel level alert; Adverse weather conditions at the destination airport; Trapped fuel situations; Fuel leaks; Bad monitoring or management of the fuel quantity by the flight crew; Erroneous fuel loading; Increased fuel consumption; Navigation error.

The current regulatory status is provided in chapter 12 of this NPA.

Some actions have already been taken in order to investigate and mitigate this issue by the industry and the Agency, as explained in chapter 13 of this NPA. As a continuation of those efforts, it is necessary to update CS-25 based on the best available and harmonised standards using the lessons learnt and available technologies.

2.2. Who is affected?

Primary affected stakeholders: Large aeroplane manufacturers.

Secondary affected stakeholders: Operators of Large aeroplanes.

2.3. What are the risks (probability and severity)?

The worst foreseeable event is a complete fuel exhaustion leading to loss of power or thrust on all engines. If the aeroplane is then not able to reach a suitable runway on time, the risk is to have to perform an emergency landing or ditching with potential catastrophic consequences.

A total of 30 accidents and 35 incidents have been identified worldwide between 1970 and February 2011. In 16 of the accidents fatalities were involved. The list of events is available in chapter V.6.1 below. This risk has been classified as a “high significance” safety issue (likelihood “improbable” and severity “catastrophic”). See Table 1 and Annex A below for more details.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Table 1: Risk index matrix

Probability of occurrence		Severity of occurrence				
		Negligible	**Minor**	**Major**	**Hazardous**	**Catastrophic**
		1	2	3	5	8
Extremely improbable	1					
Improbable	2					**16**
Remote	3					
Occasional	4					
Frequent	5					

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

3. Objectives

The overall objectives of the Agency are defined in Article 2 of Regulation (EC) No 216/2008 (the Basic Regulation). This proposal will contribute to the overall objectives by addressing the issues outlined in chapter V.2 above.

The specific objective of this proposal is to update CS-25 for better protection against the risk of fuel exhaustions or fuel low level events.

New fuel indication system(s) standards would be introduced. In addition to the primary function of indicating usable fuel quantity, those systems would provide information and alerts to the flight crew to assist them in the task of managing the fuel quantity on board and managing fuel system condition(s) that, if not corrected, present a risk of engine fuel starvation.

4. Options identified

Table 2: Selected policy options

Option No	Description
0	Baseline option: No change to CS-25; the Agency would nevertheless continue to use the Certification Review Item (CRI) process for issuing a Special Condition (SC) on Fuel Quantity Indication System for new Large Aeroplane Type projects (or Fuel System major change on an already certificated Type).
1	Update CS-25 to provide for new fuel indication system(s) standards that will protect against fuel low level and fuel exhaustion.

5. Methodology and data requirements

N/A

6. Analysis of the impacts

6.1. Safety impacts

A total of 30 accidents and 35 incidents have been identified between 1970 and February 2011. A total of 322 fatalities were caused by 16 of these accidents.

The list of the relevant accidents and incidents is provided below.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Accidents

Date	A/C Type	Operator	Place of event	Category of event	Outcome of the event	Could the event have been prevented by the proposed Option 1 rule?
02 May 1970	DC-9-33F	Antillian Airlines	St. Croix, Virgin Islands	Accident	Fuel exhaustion and ditching which resulted from continued unsuccessful attempts (3) to land at St. Maarten. 23 fatalities.	Yes
17 August 1971	F27 MK 500	M.P.C.E.P.S.A.	Poitiers-Biard, France	Accident	Trapped fuel caused by pilot's mistake (fuel valve closure during landing base leg). Landing with the undercarriage retracted, no fire. No mentioned fatality.	Yes
25 October 1973	DC-6B	Guyana Airways Corporation	Biscayne Bay, USA	Accident	Fuel leak and fuel exhaustion. Ditching in Biscayne Bay. No fatality.	Yes
24 July 1975	DC-3 DAKOTA/C-47	ST.FELICIEN AS	Lake Mistassini, Canada	Accident	Radio and navigation equipments failures. Fuel low level and ditching in Lake Mistassinini. No fatality.	No
02 December 1977	TU-154	Balkan-Bulgarian Airlines	Near Benghazi, Libya	Accident	Heavy fog prevented landing at destination, and the flight crew was unable to locate the alternate airport. Forced landing because of fuel exhaustion. 59 fatalities.	No
28 December 1978	DC-8	United Airlines	Portland, USA	Accident	Landing gear malfunction and long holding period, late	Yes

					reaction of the flight crew in a low fuel situation. Crash in a wooded area. 10 fatalities.	
23 July 1983	B767	Air Canada	Gimli, Canada	Accident	Erroneous fuel loading combined with fuel gauges failures. Fuel starvation and diversion landing on runway with no engine power and NLG up. No fatality.	Yes
28 October 1987	Convair CV-640	SMB Stage Line	Bartlesville, USA	Accident	Erroneous crossfeed leading to fuel starvation on both engines. Emergency belly landing on a SOD runway, collision with trees. No fatality.	Yes
13 December 1988	B707-351C	GAS Air Nigeria	Karm, Egypt	Accident	2 missed approaches because of bad weather at destination, followed by a diversion. The aircraft crashed into a residential area after running out of fuel. 9 fatalities (including 1 on ground).	Yes
03 September 1989	B737-200	Varig	Sao Jose Do Xingu, Brazil	Accident	Navigation error causing fuel exhaustion. Forced landing in the jungle. 13 fatalities.	Yes
25 January 1990	B707-321B	Avianca Airlines	Cove Neck, NY, USA	Accident	Flight crew failure to manage fuel load and adequately communicate an emergency fuel situation to air traffic control. Loss of all engines power and crash in a wooded residential area.	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

					73 fatalities	
26 June 1991	BAC-111-402AP	Okada Air	Sokoto, Nigeria	Accident	Navigation errors. Forced landing due to fuel shortage. 4 fatalities.	No
15 November 1993	A300B2-101	Indian Airlines	Tirupati, India	Accident	Missed approach at destination (low visibility) followed by holding, and inadequate diversion with regard to the available fuel quantity. Forced landing in a field 14 NM from Tirupati airport. No fatality, no injury.	Yes
18 September 1994	BAC-111-515FB	Oriental Airlines	Tamanrasset airport, Algeria	Accident	The aircraft circled and aborted 4 approaches at destination (bad weather). It then ran out of fuel, struck a light pole and crashed onto the airport in bad visibility. 34 fatalities.	Yes
19 December 1995	Jet Commander 1121	American Air Network Inc.	Guatemala City, Guatemala	Accident	After 2 missed approaches, the aircraft ran out of fuel and crashed 10 miles north of Guatemala city. 2 fatalities.	Yes
01 February 1997	HS-748-SRS 2A	Air Senegal	Tambacounda, Senegal	Accident	Crash during take-off after loss of power on one engine (trapped fuel caused by fuel isolation valve set in closed position by a mechanic). 23 fatalities.	Yes
24 May 1998	DC-3 DAKOTA/C-47	GALAXY AIR CARGO INC.	8 Km from Anchorage, USA	Accident	Inadequate in-flight planning/decision which resulted in fuel exhaustion and subsequent loss of engine	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

					power. Forced landing in a marsh. No reported fatality.	
24 March 2000	AN-12	SKY CAB (PVT) LTD	2,2 Km from Colombo-Bandaranaike airport, Sri Lanka	Accident	Inadequate fuel planning, missed approach (adverse weather), not enough fuel to make a diversion. Crash due to fuel starvation during the third approach. 6 Fatalities.	Yes
12 July 2000	A310-304	Hapag-Lloyd	Vienna, Austria	Accident	Increased fuel consumption due to flight with landing gear down. Inappropriate reaction of the crew to a low fuel level warning. Diversion landing on the grass before reaching runway threshold with engines stopped. No fatality.	No
24 August 2001	A330	Air Transat	Azores, Portugal	Accident	Fuel leak on one engine not identified by the pilots (conducted the “fuel imbalance” procedure). Diversion Landing on runway with no engine power. No fatality.	Yes
06 December 2001	Convair CV 580	TRANS AIR LINK CORP	Sunny Isles Beach, USA	Accident	Inaccurate fuel quantity gauges, inadequate dispatch of the aeroplane, inadequate pre-flight check by the captain leading to fuel starvation. The aeroplane was ditched east of a buoy and remained floating after the ditching. No reported	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

					fatality.	
04 July 2002	B707-120B	New Gomair	Bangui, Central African Republic	Accident	Landing gear could not be retracted after take-off. Excessive fuel dump before approach leading to fuel starvation and loss of engine power. Crash during diversion approach to Bangui 4 km short of the runway. 23 fatalities.	Yes
10 July 2002	Saab 2000	SWISS INTERNATIONAL AIR LINES LTD	Werneuchen, Germany	Accident	Adverse weather prevented landing at destination and at the subsequent several alternate airports. Landing on a former Soviet military airfield and collision with an earth embankment across the runway. No fatality.	No
30 August 2002	Fokker 100	TAM	Birigui, Brazil	Accident	Fuel leak on engine 2 and fuel exhaustion caused by inappropriate fuel management. Loss of all engines power and landing in a farm field. One cow was killed.	Yes
11 November 2002	Fokker 27	Laoag International Airways	Manila Bay, Philippines	Accident	The fuel isolation valves of the collector tanks were not selected to the Open position prior to engines start. Left engine lost power rapidly after take-off, followed by a crash on water. 19 fatalities.	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

17 January 2003	AN-24	Aerocom	Near Ndjolé, Gabon	Accident	Total electrical failure while en-route. Pilots unable to locate an airport. Fuel exhaustion after circling and crash against a low hill. 7 fatalities.	No
08 April 2003	FALCON 20	Grand Aire Express	Mississippi river, USA	Accident	Improper pilots in-flight decision not to divert to an alternate destination resulting in fuel exhaustion, and failure to relay the low fuel state to air traffic control in a timely manner. Ditching on the Mississippi river. Pilots seriously injured.	Yes
13 August 2004	Convair CV 580	Air Tahoma	1 Km from Cincinnati, USA	Accident	Fuel starvation resulting from the flight crew decision not to follow approved fuel crossfeed procedures. Other contributors: inadequate pre-flight planning, distraction during the flight, late initiation of the in-range checklist, failure to monitor the fuel gauges and to recognise that the airplane's changing handling characteristics were caused by a fuel imbalance. The aircraft crashed south of the airport and broke up. 1 fatality.	Yes
06 August 2005	ATR-72	Tuninter	Off the coast of Capo Galo, Sicily	Accident	Fuel starvation caused by wrong fuel quantity indicator installation and non-independent	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

					fuel low level alert. This resulted in both engines' loss of power. Ditching into the sea with both engines stopped. 16 fatalities.	
01 February 2008	B727-200	LLOYD AEREO BOLIVIANO	Near Trinidad airport, Bolivia	Accident	After 3 attempts to land at Cobija in bad weather, the aeroplane diverted to the alternate airport but finally ran out of fuel. Forced landing in a jungle clearing near Trinidad Airport. Minor injuries although the aircraft suffered major damage.	Yes

Incidents

Date	A/C Type	Operator	Place of event	Category of event	Outcome of the event	Could the event have been prevented by the proposed Option 1 rule?
02 May 1988	B747-123	United Airlines	Tokyo, Japan	Incident	Trapped fuel caused by number 2 crossfeed valve failure in closed position, not recognised by the pilots. Emergency descent to destination with 3 engines flamed out. 3 tyres blew on landing. No injury.	Yes
24 August 1997	A320	Air France	N/A	Incident	Fuel leak on left engine which stopped shortly before arrival. Safe landing at destination with one engine running. No injury.	Yes

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

08 August 2003	ATR-42	Aer Arann	Near Dublin, Ireland	Incident	Absence of fuel in the RH tank caused by inadvertent transfer of fuel to the LH tank (on ground) by the Captain leading to RH engine loss of power. Diversion Landing on runway with only one engine powered. No fatality.	Yes
06 November 2003	A330-300	Air Canada	Vancouver, Canada	Incident	Engine 2 fuel leak during take-off detected by the airport tower (visible vapour coming out). Uneventful turn back and landing with a fuel leakage.	No
10 June 2004	B777-200	British Airways	London, UK	Incident	Fuel leak detected during take-off (vapour trail) from an open purge door inside the left main landing gear bay (maintenance error). Uneventful landing with a fuel leakage.	No
17 July 2004	A320	Martinair Holland N.V.	Bremen, Germany	Incident	Adverse weather prevented landing at destination and alternates airports. Diversion to Bremen with fuel planned below the required final reserves. Uneventful landing.	No
02 January 2005	B767-300	Air Canada	Santiago, Chile	Incident	In Cruise, low fuel pressure output from both boost pumps in the left main fuel tank followed by left engine flame out. Left engine could be restarted later after crossfeed valve opening.	Yes

					Left tank fuel quantity indication was found erroneous on ground. Normal landing.	
08 February 2005	A340-600	Virgin Atlantic Airways	Amsterdam, Netherlands	Incident	The automatic transfer function stopped due to a FCMC discrete output failure. No fuel system warnings were triggered following this failure. There was no fuel leak and sufficient fuel quantity on-board, but fuel was not anymore available to feed engines 1 and 4. The selection of the fuel cross feed valves prevented the complete rundown engine 4. Diversion to Amsterdam and safe landing on three engines.	Yes
05 August 2005	ATR 42-300	Aer Arann	Near Cork, Ireland	Incident	Fuel leak on engine 1; the engine progressively lost power. Uneventful landing with fuel leaking from engine 1.	Yes
09 August 2005	MD90-30	Saudi Arabian Airlines	Cairo, Egypt	Incident	Fuel leak on the right engine, lateral fuel imbalance. Landing with fuel leaking from the right engine. Right engine fire at the end of the landing.	Yes
18 March 2006	ATR 72	N/A	Dusselforf, Germany	Incident	Fuel quantity indication (FQI) inconsistency noted by flight crew on ground in Dusseldorf, when comparing	No

					remaining fuel from last flight with the FQI indication. An ATR 42 FQI was installed instead of an ATR 72 FQI.	
06 September 2006	B737-300	JET CONNECT LTD	Auckland, New Zealand	Incident	Fuel leak from engine 1 noted at the arrival into Auckland. Uneventful landing.	Yes
21 November 2006	CL-600-2B19	Air Canada Jazz	Fort St John, British Columbia, Canada	Incident	Flaps failure in extended position resulting in increased fuel consumption and fuel low level during a diversion after a missed approach (adverse weather). The aircraft landed with about 500 pounds of remaining fuel level.	No
05 February 2007	B747-300	Qantas Airways Limited	Melbourne, Australia	Incident	An 'over-read' malfunction in the number 3 tank fuel quantity indicator (FQI), the crew believed there was a greater quantity of fuel remaining in the tank than was actually present. Tank number 3 became empty at top of descent and engine 3 was shut down. Uneventful landing in Melbourne.	Yes
08 March 2007	ATR 72-200	Aer Arann	Dublin, Ireland	Incident	Engine 2 lost power and shut down approx 15 nm before landing. The aeroplane landed safely. The engine was found to have suffered an internal fuel leak.	Yes

14 June 2007	B747-400	Cathay Pacific Airways Ltd.	Rome, Italy	Incident	The aircraft could not perform the required CAT III landing and performed 2 go-arounds. Diversion in an emergency fuel condition. Uneventful landing with fuel low level.	Yes
26 June 2007	EMB-120ER	Skippers Aviation Pty Ltd	Jundee Airstrip, Australia	Incident	Left engine fuel starvation during landing. The flight crew performed a go-around and diversion because of the left drift on final approach. Uneventful one-engine landing in Wiluna. On ground a fault was found in the outboard-most fuel quantity measurement probe from the left tank.	Yes
11 August 2007	B737-400	Qantas Airways Limited	Sydney, Australia	Incident	Trapped fuel because of centre fuel tank pump switches were inadequately selected to the Off position. Low pressure on main tank fuel pumps. After selection of centre fuel tank pump switches to On, the aircraft landed safely but with less than the required fuel in the wing tanks.	Yes
13 August 2007	B737-700	VIRGIN BLUE	Rockhampton, Australia	Incident	Engine 2 fuel leak induced a fuel imbalance situation, and the engine was shut down by the crew. The aircraft was diverted to Rockhampton where a single-engine approach and landing was completed without further	Yes

					incident.	
05 May 2008	MD 83	Meridiana Spa	Cagliari Elmas, Italy	Incident	Dangerous bird activity at destination required the crew performing two go-arounds which created a fuel shortage situation. Uneventful landing.	Yes
20 June 2008	A340-600	IBERIA	Cordoba, Argentina	Incident	The aircraft landed at SACO in a low fuel level situation after two consecutive diversions caused by unfavourable meteorological conditions.	No
2002-2009	B777 with Rolls-Royce engines	-	-	6 Incidents	Engine fuel leak resulting in a fuel imbalance situation. Diversion with all engines operating. At least two of the landings were performed with fuel leakage, presenting a fire hazard.	Yes
10 February 2009	A321	Deutsche Lufthansa	Stuttgart, Germany	Incident	Diversion after two missed approaches (strong crosswind) and landing with fuel level less than the minimum required reserves.	No
22 June 2009	B757-236	First Choice Airways	En-route from Boa Vista, Cape Verde, to Manchester	Incident	Fuel leak on the right engine resulting in an excessive fuel consumption and a fuel imbalance situation detected by the flight crew during normal fuel check. Diversion after right engine shut down. Normal landing.	No

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

10 July 2009	Fokker 100	Air Niugini	Cairns, Australia	Incident	Fuel leak (fuel venting off both wings) detected during take-off by air traffic control. Uneventful turn back and landing.	No
15 July 2009	A319	Air Canada	Toronto, Canada	Incident	A fuel shortage was detected by the flight crew while en route. The aircraft returned to Toronto. Uneventful landing but with an engine fuel leakage.	Yes
19 August 2009	A340-300	Virgin Atlantic Airways Ltd	Hong Kong, China	Incident	Fuel loss detected by the flight crew while en route, turn back, overweight landing, and several tyres bursts. Fuel leak on one of the engine was found on ground.	Yes
10 May 2010	EMB 145	American Eagle, Inc. (Dallas/Ft. Worth, Tx)	Montreal, Canada	Incident	Aborted approach (due to wind) followed by the declaration of an emergency fuel situation 2 minutes later. Uneventful landing performed after a second approach on another runway.	Yes
12 June 2010	B757-28A	Thomas Cook Airlines	Near London, UK	Incident-Investigation on going	Fuel leak on left engine during Cruise. Pilots identified the leak but transferred fuel to correct the fuel imbalance. Landing to destination with left engine fuel leaking, no damage, no injury.	Yes
05 July 2010	ATR-72	Finnish Commuter Airlines	Flight between Kuopio and Helsinky	Incident	Dispatch with left tank electrical pump inoperative. The crossfeed valve	No

					was kept in the open position during the first flight from Helsinki to Kuopio and during the flight back to Helsinki. In this configuration, the majority of the fuel fed to both engines came from the right tank. This should not have been the case per MMEL procedure (cross feed valve to be closed after engine start). Landing with right tank very low level and excessive fuel tanks imbalance. Right fuel tank level reached 0 when arriving at the gate.	

Option 1 would provide new standards for protection of new Large Aeroplanes Types against scenarios of fuel exhaustion or fuel low level.

The majority of the events identified above, 24 accidents and 25 incidents, would benefit from this new standard; 252 fatalities were caused by these events.

Some of the events (6 accidents and 10 incidents) would nevertheless not be avoided; these events include:

- Accidents caused by loss of situational awareness without external help (radio and navigation failure; complete electrical failure); inability to find the alternate airport because of adverse weather (like heavy fog, storm conditions) or navigation error; flight crew inappropriate reaction to a low fuel level warning although alternate airports are easily accessible.
- Incidents where the flight crew has already reacted adequately (e.g. fuel leak detected on time (and eventually isolated) and diversion/turn back performed, diversion decided before the fuel low level setting is reached); several changes in the alternate airport diversion caused by adverse weather; inadequate FQIS configuration detected on ground before departure; aeroplane abnormal configuration (like flaps failed extended) appearing after a missed approach and followed by a diversion; dispatch without following MMEL procedure.

For fuel leak incidents, the new standard would require fuel leak being not only identified but also isolated and/or special procedure available to avoid additional hazard (like fuel coming into contact with wheel brakes during landing).

If option 0 is retained, a similar safety benefit would nevertheless be reached by the Agency using the CRI (Certification Review Item) process; refer to chapter 13 “EASA mitigation actions”.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

6.2. Social impacts

No impact identified.

6.3. Economic impacts

Although the development of the functions required by Option 1 has a cost, it has already been anticipated by at least the majority of the manufacturers; this was the case for the manufacturers represented in the task 25.055 rulemaking group (Boeing, Airbus, ATR, Embraer).

As a consequence, the proposed update of CS-25 would not impose additional costs on the main aircraft manufacturers. There may be some manufacturers not yet fully prepared to comply with Option 1 proposed standard because they have not applied for a new Type Certificate (TC) or a major change to a TC since the EASA CRI has been created. In this case, a cost impact may be incurred. Any manufacturers concerned may comment on this point and provide the results of their impact evaluation as a comment to this NPA.

6.4. Environmental impacts

There may be weight increase associated with compliance with Option 1. However, the manufacturers represented in the task 25.055 rulemaking group considered this impact as negligible; therefore, no quantifiable impact on the fuel consumption is foreseen.

A benefit for the environment can be expected from the implementation of fuel leak isolation procedures which would limit the amount of fuel released in the atmosphere in case of fuel leak event.

Option 0 would indirectly have the same effect because of the CRI process.

6.5. Proportionality issues

No impact identified.

6.6. Impact on regulatory coordination and harmonisation

FAA and TCCA participated in the rulemaking group and will use the outcome of the project to prepare amendments of their regulation. Harmonisation is a common objective shared by FAA, TCCA and EASA. However, at this stage FAA maintains a minority position which is not harmonised with this NPA proposal (see explanations in chapter 15 above).

7. Conclusion and preferred option

Considering the service experience including various accidents and incidents where unsafe conditions have been caused by fuel low level and fuel exhaustion situations, it appears that improvements are required for certification of Large Aeroplanes. Actions and efforts have already been made by the Agency and a CRI has been developed in the meantime before the regulation is updated through the rulemaking process.

The Agency concludes that there are sufficient elements to take action and update CS-25 as proposed under Option 1. Compared to Option 0, Option 1 would provide applicants with an upgraded standard required for certification of new Types (or major changes to already certificated Types). The applicants would then benefit from prior awareness of EASA expectations by having the corresponding material directly available in the CS-25. This may prevent the development of unacceptable designs in the early stage of projects; finally, the current CRI item would be removed and, in the end, both applicants and EASA would save the

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.

Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

time which could be spent managing the CRI process or discussing and correcting the unacceptable designs.

Annex A: Risk assessment

ICAO **defines** safety as the state in which the risk of harm to persons or property damage is reduced to, and maintained at or below, an acceptable level through a continuous process of hazard identification and risk management.

Thus, risk assessment is a key element for managing safety. **Risk is expressed in terms of predicted probability and severity of the consequences of a hazard taking as a reference the worst foreseeable situation.**

In order to define the elements 'probability' and 'severity', the following tables were developed based on the ICAO framework.

Table 3: Probability of occurrence[6]

Definition	Value	Description
Frequent	5	Likely to occur many times (has occurred frequently). Failure conditions are anticipated to occur one or more times during the entire operational life to each aircraft within a category.
Occasional	4	Likely to occur sometimes (has occurred infrequently). Failure conditions are anticipated to occur one or more times during the entire operational life to many different aircraft types within a category.
Remote	3	Unlikely, but possible to occur (has occurred rarely). Those failure conditions that are unlikely to occur to each aircraft within a category during its total life but that may occur several times when considering a specific type of operation.
Improbable	2	Very unlikely to occur. Those failure conditions not anticipated to occur to each aircraft during its total life but which may occur a few times when considering the total operational life of all aircraft within a category.
Extremely improbable	1	Almost inconceivable that the event will occur. For rulemaking proposals aimed at CS-25, CS-29 or CS-23 (commuter) aircraft, the failure conditions are so unlikely to occur that they are not anticipated to occur during the entire operational life of the entire fleet. For other categories of aircraft, the likelihood of occurrence may be greater.[7]

[6] These categories need to be applicable to a wide range of safety issues and are taken from the ICAO Safety Management Manual. The description is harmonised with CS-25. Note that these descriptions are indicative only and may have to be adjusted to different rulemaking tasks depending on subsector of aviation.

[7] The category 'extremely improbable' here can also include cases where the probability cannot be quantified as 10^{-9}.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Table 4: Severity of occurrences

Definition	Value	Description
Catastrophic[8]	8	Multiple deaths (three and more) and equipment destroyed (hull loss).
Hazardous	5	A large reduction of safety margins. Maximum two fatalities. Serious injury. Major equipment damage.
Major	3	A significant reduction of safety margins. Serious incident. Injury of persons.
Minor	2	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.
Negligible	1	Little consequences.

Table 5: Risk index matrix

Probability of occurrence		Severity of occurrence				
		Negligible	Minor	Major	Hazardous	Catastrophic
		1	2	3	5	8
Extremely improbable	1	1	2	3	5	8
Improbable	2	2	4	6	10	16
Remote	3	3	6	9	15	24
Occasional	4	4	8	12	20	32
Frequent	5	5	10	15	25	40

8 Note that severity category 'Catastrophic' was attributed the value of 8. This has been done in order to distinguish a 'Catastrophic/Extremely improbable' case from a 'Negligible/Frequent' case and give a higher weight to catastrophic events. The former is considered to be of medium significance whereas the latter is of low significance as the potential outcome is limited.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Table 6: Description of the different risk indices

Risk index		Description[9]
15-40	High significance	Unacceptable under the existing circumstances.
15	Medium or High significance	For non-complex aircraft this would result in a medium significance issue. For CAT with complex motor-powered aircraft this would result in a high significance issue.
7-14	Medium significance	Tolerable based on risk mitigation by the stakeholders and/or rulemaking action.
1-6	Low significance	Acceptable, but monitoring or non-rulemaking action required.

9 The descriptions are based on the ICAO Safety Management Systems Handbook. However, as the SMS system is geared towards operators and not regulators, the descriptions were adjusted to better reflect EASA's needs.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

B. Draft CS-25 Decision

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

1. deleted text is shown with a strike through: ~~deleted~~
2. new text is highlighted with grey shading: new
3. ...

   indicates that remaining text is unchanged in front of or following the reflected amendment.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

CS-25 Book 1

SUBPART F - EQUIPMENT

Amend CS 25.1305(a)(2) as follows:

CS 25.1305 Powerplant instruments

...

(2) ~~A fuel quantity indicator for each fuel tank~~ Fuel indication system(s) which:

(i) Permanently display(s) to the flight crew the total quantity of usable fuel on board,

(ii) Is(are) capable of indicating to the flight crew the quantity of usable fuel in each tank in accordance with CS 25.1337(b),

(iii) Provide(s) a low fuel level cockpit alert for any tank and/or collector cell that should not become depleted of fuel.

Each alert must be such that:

(1) It is provided to the flight crew when the usable quantity of fuel in the tank concerned reaches the quantity required to operate the engine(s) for 30 minutes at cruise conditions,

(2) The alert and the fuel quantity indication for that tank may not be adversely affected by the same failure.

(iv) Provide(s) fuel quantity and availability information to the flight crew, including alerts, to indicate any fuel system condition (e.g. misconfiguration or failure) that, if uncorrected, would result in no fuel supplied to one or more engine(s). This includes:

(1) Abnormal fuel transfer between tanks,

(2) Trapped fuel,

(3) Fuel leaks including in the engines.

...

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

CS-25 Book 2

AMC - SUBPART F

Create a new AMC 25.1305(a)(2) as follows:

AMC 25.1305(a)(2)

Fuel indication system(s)

1. Purpose

This AMC provides guidance for the design of fuel indication system(s) and the associated functions for compliance with CS 25.1305(a)(2).

2. General objective

a. The primary function of fuel indication system(s) is indicating the usable fuel quantity on board an aircraft. Additionally, it is expected that the fuel indication system(s) provide any alert and information to the flight crew to assist them in the task of managing the fuel quantity on board.

b. Service experience indicates that scenarios leading to impending fuel starvation of one or more engines have developed into an unsafe system operating condition. Therefore, such scenarios must be identified and, as required per CS 25.1309(c), appropriate information must be provided to the flight crew to enable them taking appropriate corrective action.

This information, including alerts, must be provided in a timely manner so that any unsafe fuel starvation situation can be avoided.

c. The generated fuel indication system(s) alerts shall as a minimum inform the flight crew of:

- a low fuel level situation,
- any abnormal fuel transfer,
- a trapped fuel situation,
- the existence of a fuel leak.

For each alert, corrective actions shall be available to the flight crew. This should include for instance:

- procedure(s) to identify and isolate the fuel leak,
- procedure(s) to correct the abnormal fuel transfer and/or to manage the trapped fuel situation,
- diversion procedure or the instruction to land as soon as possible,
- any required procedure to avoid additional hazard (for instance: fuel coming into contact with wheel brakes during landing when a fuel leak is not isolated; exceeding centre of gravity or fuel imbalance limits).

3. Usable fuel quantity

a. The total usable fuel quantity is considered essential information. Operational regulations require the flight crew to regularly check the remaining total usable fuel quantity. This quantity is then evaluated when comparing the actual quantity of fuel used to the planned fuel consumption, and to ensure that sufficient fuel is available to complete the flight with the required fuel reserve. The total usable fuel quantity shall therefore be permanently displayed and it shall be easily and directly readable by the flight crew.

b. As required per CS 25.1337(b), there must also be means to indicate to the flight crew the usable fuel quantity in each fuel tank. It is considered acceptable that these individual tank quantities be only displayed when required. This may be displayed either at pilot discretion (on

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

demand) or automatically as determined to support operational procedures associated to fuel system alerts.

4. Low fuel level alert

a. The fuel indication system(s) shall trigger an alert in case of low fuel level. The low fuel level cockpit alert is applicable to any tank or collector cell that is not expected to be depleted in flight because otherwise this situation would lead to an engine fuel starvation. Fuel tanks that may normally be depleted during flight do not require a low fuel level alert.

b. The alert shall be triggered when the quantity of usable fuel in the tank concerned reaches the quantity required to operate an engine for 30 minutes with the aircraft operated in optimum Cruise conditions specified for the design of the aircraft.

c. The safety analysis in accordance with CS 25.1309 (b) and (c) should at least include the following failure scenarios:

- Erroneous high fuel quantity indication system (FQIS) readings,

- Loss of FQIS gauging information.

It should be demonstrated that no failure of the FQIS system (including total loss of FQIS system power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert not being correctly triggered.

5. Abnormal fuel transfer between tanks

The fuel indication system(s) shall provide any alert and information enabling to identify abnormal fuel transfer between tanks.

Abnormal fuel transfer between tanks is a fuel transfer that - if no corrective action is taken - can lead to fuel becoming unavailable to an engine and/or fuel imbalance causing aeroplane control difficulties. It may result either from a fuel management system failure or from inappropriate flight crew action.

6. Trapped fuel

The fuel indication system(s) shall provide any alert and information enabling to identify trapped fuel situations.

Trapped fuel means any fuel quantity (above the unusable fuel quantity) gauged by the FQIS that cannot be supplied to the engine.

For instance, failure of an isolation valve in an auxiliary tank, failure of a transfer pump, fuel pipe failure inside a tank could result in trapped fuel. Also, inappropriate selection of fuel system configuration by the flight crew shall be considered.

7. Fuel leaks

The fuel indication system(s) shall provide any alert and information enabling the crew to identify a fuel leak.

Fuel leaks may be generated by a loss of integrity of the fuel system (for instance, fuel pipes failures, leakage of connections) and result in fuel being drained overboard the aircraft.

The fuel leaks analysis shall identify all foreseeable leakage sources from the aircraft fuel tank(s) to the engine fuel nozzles. For the engines, it means that the effects of leaks upstream and downstream of the engine fuel flow meter shall be considered.

TE.RPRO.00034-002© European Aviation Safety Agency. All rights reserved.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.