NOTICE OF PROPOSED AMENDMENT (NPA) No 13/2004

DRAFT DECISION OF THE EXECUTIVE DIRECTOR OF THE AGENCY,

on certification specifications for large aeroplanes (CS-25)

Miscellaneous Powerplant

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This Notice of Proposed Amendment is bundling the following original JAA NPAs which have followed the JAA consultation process:

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0. GENERAL EXPLANATORY NOTE

General

1. The purpose of this Notice of Proposed Amendment (NPA) is to propose changes to the certifications specifications for large aeroplanes (CS-25). The reason for this proposal is outlined further below. This measure is included in the Agency's 2004 Rulemaking programme.

2. The text of this NPA was developed by the JAA Powerplant Study Group (PPSG). It was adapted to the EASA regulatory context by the Agency. It is now submitted for consultation of all interested parties in accordance with Article 5(3) of the EASA rulemaking procedure[1].
The review of comments will be made by the Agency unless the comments are of such nature that they necessitate the establishment of a group.

Consultation

3. Because the content of this NPA was the subject of a full worldwide consultation, the transitional arrangements of article 15 of the EASA rulemaking procedure apply. They allow for a shorter consultation period of six weeks instead of the standard three months and also exempt from the requirement to produce a full Regulatory Impact Assessment.

4. To achieve optimal consultation, the Agency is publishing the draft decision on its internet site in order to reach its widest audience and collect the related comments.

Comments on this proposal may be forwarded *(preferably by e-mail)*, using the attached comment form and mentioning the NPA number, to:

By e-mail: **NPA@easa.eu.int**

By correspondence: Ms. Inge van Opzeeland
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Comments should be received by the Agency **before 03-01-05** and if received after this deadline they might not be treated. Comments may not be considered if the form provided for this purpose is not used.

Comment response document

5. All comments received will be responded to and incorporated in a Comment Response Document (CRD). This will contain a list of all persons and/or organisations that have provided comments. The CRD will be widely available ultimately before the Agency adopts its final decision.

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[1] Decision of the Management Board concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material ("rulemaking procedure"), EASA MB/7/03, 27.6.2003.

I-A. EXPLANATORY NOTE JAA NPA 25E-337

Originally JAA NPA 25E-337, Safety Assessment of Powerplant Installations

1. The initial issue of CS-25 was based upon JAR-25 at amendment 16. During the transposition of airworthiness JARs into certification specifications the rulemaking activities under the JAA system where not stopped. In order to assure a smooth transition from JAA to EASA the Agency has committed itself to continue as much as possible of the JAA rulemaking activities. Therefore it has included most of it in its own rulemaking programme for 2004 and planning for 2005-2007. This part of present EASA NPA is a result of this commitment and a transposed version of the JAA NPA 25E-337 which was circulated for comments from 1 September 2002 till 1 December 2002, and modified as per the conclusions of the JAA comment response document (see I.D)

This Notice of Proposed Amendment (NPA) introduces a modified CS 25.901(c) requirement and an Acceptable Means of Compliance (AMC) for CS 25.901(c).

The proposed text for the new requirement and advisory material has been developed as a part of the JAA/ FAA Harmonisation Work Program, which has the aim of harmonising "... to the maximum extent possible, the JAR and FAR rules regarding the operation and maintenance of civil aircraft, and the standards, practices, and procedures governing the design, materials, workmanship, and construction of civil aircraft, aircraft engines, and other components." (See Reference 1). The final requirement and advisory material text has been agreed by the Powerplant Installation Harmonisation Working Group (PPIHWG), which was set up under the JAA/FAA Harmonisation Work Program.

Although the proposal includes a new requirement, there will be little practical difference for CS 25.901(c) compliance, compared with existing practice and the intention is to maintain at least the level of safety provided by the current requirement. The PPIHWG agreed to adopt the principle in use by EASA, where the Safety Assessment of powerplant installation systems is to be made using the working methods of CS 25.1309. The main wording difference in the new requirement is an exemption from compliance with CS 25.1309(b) for a number of severe engine and propeller failure conditions - engine case burn through or rupture, uncontained engine rotor failure and propeller debris release. In practice, EASA / JAA have not previously expected compliance with CS 25.901(c) for these failure conditions, but it is considered necessary to clarify this point, within the rule itself.

The new AMC to CS 25.901(c) provides guidance about the safety assessment of powerplant installations. Although the basic methods of CS 25.1309 are to be used, the AMC identifies some specific guidance for the approach to be taken, when assessing powerplant installations.

The text, for the proposed AMC 25.901(c) is a version of the proposed FAA AC 25-901, which was the working document, used during the PPIHWG discussions. The intention is that the technical content is identical, but changes have been made to reflect EASA context.
These changes include:
(i) English spellings.
(ii) References to EASA requirements, documents etc.
(iii) JAA/EASA related Background material.

I-B. PROPOSALS TRANSPOSED JAA NPA 25E-337

The following amendments should be included in Decision No. 2003/2/RM of the Executive Director of the Agency of 17 October 2003:

1. To modify sub-paragraph CS 25.901(c) to read as follows:

" (c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):

(1) Engine case burn through or rupture;

(2) Uncontained engine rotor failure; and

(3) Propeller debris release.

(See AMC 25.901(c).) "

2. To create a new AMC 25.901(c) to read as follows :

AMC 25.901(c)
Safety Assessment Of Powerplant Installations (Acceptable Means of Compliance)

1. PURPOSE.. This Acceptable Means of Compliance (AMC) describes an acceptable means for showing compliance with the requirements of CS 25.901(c). This document describes a method of conducting a "System Safety Assessment" of the powerplant installation as a means for demonstrating compliance. This guidance is intended to supplement the engineering and operational judgement that must form the basis of any compliance findings. The guidance provided in this document is meant for airplane manufacturers, modifiers, foreign regulatory authorities, and EASA Large Aeroplane type certification engineers. Like all AMC material, this AMC is not, in itself, mandatory, and does not constitute a requirement. It is issued to describe an acceptable means, but not the only means, for demonstrating compliance with the powerplant installation requirements for Large Aeroplanes. Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this document is used.

2. RELATED EASA REQUIREMENTS. CS 25.571, 25.901, 25.903, 25.933, 25.1309, and 25.1529; CS E-50 and E-510, CS P-150 and P-230.

3. APPLICABILITY. The guidance provided in this document applies to powerplant installations on Large Aeroplanes that are subject to the requirements of CS 25.901. This guidance specifically concerns demonstrating compliance with the requirements of CS 25.901(c), which states:

> *"(c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):*
>
> *(1) Engine case burn through or rupture;*
>
> *(2) Uncontained engine rotor failure; and*
>
> *(3) Propeller debris release."*

CS 25.901(c) is intended to provide an overall safety assessment of the powerplant installation that is consistent with the requirements of CS 25.1309, while accommodating unique powerplant installation compliance policies. It is intended to augment rather than replace other applicable CS-25 design and performance standards for Large Aeroplanes.

In accommodating unique policies related to powerplant compliance, EASA has determined that specific guidance relative to demonstrating compliance with CS 25.1309(b) is needed; such guidance is contained in this AMC. [No unique compliance requirements for CS 25.1309(a) and (c) are required for powerplant installations.]

Wherever this AMC indicates that compliance with other applicable requirements has been accepted as also meeting the intent of CS 25.901(c) for a specific failure condition, no additional dedicated safety analysis is required. Where this AMC may conflict with AMC 25.1309 ("System Design and Analysis"), this AMC shall take precedence for providing guidance in demonstrating compliance with CS 25.901(c).

When assessing the potential hazards to the aircraft caused by the powerplant installation, the effects of an engine case rupture, uncontained engine rotor failure, engine case burn-through, and propeller debris release are excluded from CS 25.901(c)/CS 25.1309. The effects and rates of these failures are minimised by compliance with CS-E, Engines; CS-P, Propellers; CS 25.903(d)(1), CS 25.905(d), and CS 25.1193.

Furthermore, the effects of encountering environmental threats or other operating conditions more severe than those for which the aircraft is certified (such as volcanic ash or operation above placard speeds) need not be considered in the CS 25.901(c)/CS 25.1309 compliance process. However, if a failure or malfunction can affect the subsequent environmental qualification or other operational capability of the installation, this effect should be accounted for in the CS 25.901(c)/CS 25.1309 assessment.

The terms used in this AMC are intended to be identical to those used in AMC 25.1309.

4. BACKGROUND.

JAR-25 was the Joint Aviation Authorities Airworthiness Code for Large Aeroplanes. It was developed from the U.S. Federal Aviation Regulations Part 25 (FAR 25) during the 1970s. Early versions (Changes) of JAR-25 consisted of only the differences from FAR 25.

In 1976, JAR-25 Change 3 was published and introduced, for the first time, requirement JAR 25.1309 and ACJ Nos. 1 to 7 to JAR 25.1309. Requirement JAR 25.1309 was almost the same as the (then) existing FAR regulation (Amdt. 25-37), but the advisory material given in the ACJ provided interpretation of and acceptable means of compliance with, the requirement. Specific advice was given on how to show that the inverse relationship existed between the criticality of the Failure Condition and its probability of occurrence.

JAR-25, Change 3, did not include any specific JAR-25 requirement for powerplant installation safety assessment and so FAR 25.901(c) was also valid for JAR-25. FAR 25.901(c) text (Amdt. 25-23, Effective 8 May 1970) stated:

> *"25.901 Installation*
> *(c) The powerplant installation must comply with § 25.1309"*.

At Change 4 of JAR-25, effective 19 July 1978, JAR 25.901(c) was introduced using the same FAR 25 words as shown above (viz.):

"JAR 25.901 Installation
(c) The power-plant installation must comply with JAR 25.1309."

However, at about that time, the FAA had been reviewing a proposal to revise FAR 25.901(c), to introduce the wording "… no single failure or probable combination …". This revised text was introduced at Amdt. 25-40, effective 2 May 1977.

The revisions introduced by Amdt. 25-40 were reviewed by the JAR-25 Study Groups and in two letters (Refs.: JAR/JET/2416/BT dated 21 July 1977 and JAR/JET/2467/BT dated 21 October 1977), the JAR-25 Powerplant Study Group recommended that, for JAR 25.901(c), the text should remain the same as the pre-Amdt. 25-40 version of FAR 25.901(c).

Since that time, JAR 25.901(c) and CS 25.901(c) have continued to refer to JAR / CS 25.1309 and for EASA/JAA, powerplant installations have been treated in the same way as for other aircraft systems when assessing the effects of failures and malfunctions.

One traditional exception to this has been the assessment of hazards resulting from an engine rotor failure. Previous ACJ No. 1 to JAR 25.1309 allowed for an explicit exception to the quantitative objective for a given catastrophic failure condition, for cases where the state of the art does not permit it to be achieved. This is the case for engine rotor failure and the 'minimisation of hazard' requirement of CS 25.903(d)(1) has been used instead of CS 25.1309 to cover this risk.

5. GENERAL SYSTEM SAFETY ASSESSMENT GUIDANCE. Compliance with CS 25.901(c)/CS 25.1309 may be shown by a System Safety Assessment (SSA) substantiated by appropriate testing and/or comparable service experience. Such an assessment may range from a simple report that offers descriptive details associated with a failure condition, interprets test results, compares two similar systems, or offers other qualitative information; to a detailed failure analysis that may include estimated numerical probabilities.

The depth and scope of an acceptable SSA depend on:

- the complexity and criticality of the functions performed by the system(s) under consideration,
- the severity of related failure conditions,
- the uniqueness of the design and extent of relevant service experience,
- the number and complexity of the identified causal failure scenarios, and
- the detectability of contributing failures.

The SSA criteria, process, analysis methods, validation and documentation should be consistent with the guidance material contained in AMC 25.1309. Wherever there is unique guidance specifically for powerplant installations, this is delineated in Section 6, below.

In carrying out the SSA for the powerplant installation for CS 25.901(c)/CS 25.1309, the results of the engine (and propeller) failure analyses (reference CS P-150 and CS E-510) should be used as inputs for those powerplant failure effects that can have an impact on the aircraft. However, the SSA undertaken in response to CS-E and CS-P may not address all the potential effects that an engine and propeller as installed may have on the aircraft.

For those failure conditions covered by analysis under CS-E and CS-P, and for which the installation has no effect on the conclusions derived from these analyses, no additional analyses will be required to demonstrate compliance to CS 25.901(c)/CS 25.1309.

The effects of structural failures on the powerplant installation, and vice versa, should be carefully considered when conducting system safety assessments:

a. <u>Effects of structural failures on powerplant installation.</u> The powerplant installation must be shown to comply with CS 25.901(c) following structural failures that are anticipated to occur within the fleet life of the airplane type. This should be part of the assessment of powerplant installation failure condition causes.

Examples of structural failures that have been of concern in previous powerplant installations are:

(1) Thrust reverser restraining load path failure that may cause a catastrophic inadvertent deployment.

(2) Throttle quadrant framing or mounting failure that causes loss of control of multiple engines.

(3) Structural failures in an avionics rack or related mounting that cause loss of multiple, otherwise independent, powerplant functions/components/systems.

b. <u>Effects of powerplant installation failures on structural elements.</u> Any effect of powerplant installation failures that could influence the suitability of affected structures, should be identified during the CS 25.901(c) assessment and accounted for when demonstrating compliance with the requirements of CS-25, Subpart C (“Structure”) and D (“Design and Construction”). This should be part of the assessment of powerplant installation failure condition effects.

Some examples of historical interdependencies between powerplant installations and structures include:

(1) Fuel system failures that cause excessive fuel load imbalance.

(2) Fuel vent, refuelling, or feed system failures that cause abnormal internal fuel tank pressures.

(3) Engine failures that cause excessive loads/vibration.

(4) Powerplant installation failures that expose structures to extreme temperatures or corrosive material.

6. <u>SPECIFIC CS 25.901(c) SYSTEM SAFETY ASSESSMENT GUIDANCE.</u> This section provides compliance guidance unique to powerplant installations.

a. <u>Undetected Thrust Loss</u>. The SSA discussed in Section 5 should consider undetected thrust loss and its effect on aircraft safety. The assessment should include an evaluation of the failure of components and systems that could cause an undetected thrust loss, except those already accounted for by the approved average-to-minimum engine assessment.

(1) In determining the criticality of undetected thrust losses from a system design and installation perspective, the following should be considered:

(a) Magnitude of the thrust loss,*

(b) Direction of thrust,

(c) Phase of flight, and

(d) Impact of the thrust loss on aircraft safety.

(*Although it is common for safety analyses to consider the total loss of one engine's thrust, a small undetected thrust loss that persists from the point of takeoff power set could have a more significant impact on the accelerate/stop distances and takeoff flight path/obstacle clearance capability than a detectable single engine total loss of thrust failure condition at V_1)

(2) In addition, the level at which any thrust loss becomes detectable should be validated. This validation is typically influenced by:

(a) Impact on aircraft performance and handling,

(b) Resultant changes in powerplant indications,

(c) Instrument accuracy and visibility,

(d) Environmental and operating conditions,

(e) Relevant crew procedures and capabilities, etc.

(3) Reserved.

b. <u>Detected Thrust Loss</u>**.** While detectable engine thrust losses can range in magnitude from 3% to 100% of total aircraft thrust, the total loss of useful thrust (inflight shutdown/IFSD) of one or more engines usually has the largest impact on aircraft capabilities and engine-dependent systems. Furthermore, single and multiple engine IFSD’s tend to be the dominant thrust loss-related failure conditions for most powerplant installations. In light of this, the guidance in this AMC focuses on the IFSD failure conditions. The applicant must consider other engine thrust loss failure conditions, as well, if they are anticipated to occur more often than the IFSD failure condition, or if they are more severe than the related IFSD failure condition.

(1) **Single Engine IFSD**. The effects of any single engine thrust loss failure condition, including IFSD, on aircraft performance, controllability, manoeuvrability, and crew workload are accepted as meeting the intent of CS 25.901(c) if compliance is also demonstrated with:

- CS 25.111 (“Takeoff path”),
- CS 25.121 (“Climb: one-engine-inoperative”), and
- CS 25.143 (“Controllability and Manoeuvrability -- General”).

(a) Nevertheless, the effects of an IFSD on other aircraft systems or in combination with other conditions also must be assessed as part of showing compliance with CS 25.901(c)/CS 25.1309. In this case, it should be noted that a single engine IFSD can result from any number of single failures, and that the rate of IFSD's range from approximately $1x10^{-4}$ to $1x10^{-5}$ per engine flight hour. This rate includes all failures within a typical powerplant installation that affect one -- and only one -- engine. Those failures within a typical powerplant that can affect more than one engine are described in Section 6.b.(2), below.

(b) If an estimate of the IFSD rate is required for a specific turbine engine installation, any one of the following methods is suitable for the purposes of complying with CS 25.901(c)/CS 25.1309(b):

(i) Estimate the IFSD rate based on service experience of similar powerplant installations;

(ii) Perform a bottom-up reliability analysis using service, test, and any other relevant experience with similar components and/or technologies to predict component failure modes and rates; or

(iii) Use a conservative value of $1x10^{-4}$ per flight hour.

(c) If an estimate of the percentage of these IFSD's for which the engine is restartable is required, the estimate should be based on relevant service experience.

(d) The use of the default value delineated in paragraph 6.b.(1)(b)(iii) is limited to traditional turbine engine installations. However, the other methods [listed in 6.b.(1)(b)(i) and (ii), above] are acceptable for estimating the IFSD rates and restartability for other types of engines, such as some totally new type of engine or unusual powerplant installation with features such as a novel fuel feed system. In the case of new or novel components, significant non-service experience may be required to validate the reliability predictions. This is typically attained through test and/or technology transfer analysis.

(e) Related issues that should be noted here are:

(i) CS 25.901(b)(2) sets an additional standard for installed engine reliability. This requirement is intended to ensure that all technologically feasible and economically practical means are used to assure the continued safe operation of the powerplant installation between inspections and overhauls.

(ii) The effectiveness of compliance with CS 25.111, CS 25.121 and CS 25.143 in meeting the intent of CS 25.901(c) for single engine thrust loss is dependent on the accuracy of the human factors assessment of the crew's ability to take appropriate corrective action. For the purposes of compliance with CS 25.901(c) in this area, it may be assumed that the crew will take the corrective actions called for in the airplane flight manual procedures and associated approved training.

(2) **Multiple Engine IFSD**. The guidance in AMC 25.1309 provides for a catastrophic failure condition to exceed 1×10^{-9} per hour under certain conditions (i.e., well-proven design and construction techniques, and a predicted overall airplane level rate of catastrophic failures within historically-accepted service experience). Typical engine IFSD rates have been part of this historically-accepted service experience, and these IFSD rates are continuously improving.

However, typical engine IFSD rates may not meet the AMC 25.1309 condition that calls for 1×10^{-9} per hour for a catastrophic multiple engine IFSD.

(a) Current typical turbine engine IFSD rates, and the resulting possibility of multiple independent IFSD's leading to a critical power loss, are considered acceptable for compliance with CS 25.901(c) without quantitative assessment. Therefore, there is no need to calculate the overall airplane level risk of catastrophic failure, even though the probability of a catastrophic failure condition due to multiple engine IFSD's may exceed 1×10^{-9}.

(b) Nevertheless, some combinations of failures within aircraft systems common to multiple engines may cause a catastrophic multiple engine thrust loss. These should be assessed to ensure that they meet the *extremely improbable* criteria. Systems to be considered include:

- fuel system,
- air data system,
- electrical power system,
- throttle assembly,
- engine indication systems, etc.

(c) The means of compliance described above is only valid for turbine engines, and for engines that can demonstrate equivalent reliability to turbine engines, using the means outlined in Section 6.a. of this AMC. The approach to demonstrating equivalent reliability should be discussed early in the program with the Agency on a case-by-case basis.

c. Automatic Takeoff Thrust Control System. CS-25, Appendix I ["Automatic Takeoff Thrust Control System (ATTCS)"], specifies the minimum reliability levels for these automatic systems. In addition to showing compliance with these reliability levels for certain combinations of failures, other failure conditions that can arise as a result of introducing such a system must be shown to comply with CS 25.901(c)/CS 25.1309.

d. Thrust Management Systems. A System Safety Assessment is essential for any airplane system that aids the crew in managing engine thrust (i.e., computing target engine ratings, commanding engine thrust levels, etc.). As a minimum, the criticality and failure hazard classification must be assessed. The system criticality will depend on:

- the range of thrust management errors it could cause,
- the likelihood that the crew will detect these errors and take appropriate corrective action, and
- the severity of the effects of these errors with and without crew intervention.

The hazard classification will depend on the most severe effects anticipated from any system. The need for more in-depth analysis will depend upon the systems complexity, novelty, initial failure hazard classification, relationship to other aircraft systems, etc.

(1) Automated thrust management features, such as autothrottles and target rating displays, traditionally have been certified on the basis that they are only conveniences to reduce

crew workload and do not relieve the crew of any responsibility for assuring proper thrust management. In some cases, malfunctions of these systems can be considered to be minor, at most. However, for this to be valid, even when the crew is no longer directly involved in performing a given thrust management function, the crew must be provided with information concerning unsafe system operating conditions to enable them to take appropriate corrective action.

(2) Consequently, when demonstrating compliance with CS 25.901(c)/CS 25.1309, failures within any automated thrust management feature which, if not detected and properly accommodated by crew action, could create a catastrophe should be either:

(a) considered a catastrophic failure condition when demonstrating compliance with CS 25.901(c)/ CS 25.1309(b); or

(b) considered an unsafe system operating condition when demonstrating compliance with the warning requirements of CS 25.1309(c).

e. <u>Thrust Reverser.</u> Compliance with CS 25.933(a) ("Reversing systems") provides demonstration of compliance with CS 25.901(c)/CS 25.1309 for the thrust reverser inflight deployment failure conditions. A standard CS 25.901(c)/CS 25.1309 System Safety Assessment should be performed for any other thrust reverser-related failure conditions.

7. <u>TYPICAL FAILURE CONDITIONS FOR POWERPLANT SYSTEM INSTALLATIONS</u>.
The purpose of this section is to provide a list of typical failure conditions that ***may*** be applicable to a powerplant system installation. This list is by no means all-encompassing, but it captures some failure conditions that have been of concern in previous powerplant system installations. The specific failure conditions identified during the preliminary SSA for the installation should be reviewed against this list to assist in ensuring that all failure conditions have been identified and properly addressed.

As stated previously in this AMC, the assessment of these failure conditions may range from a simple report that offers descriptive details associated with a failure condition, interprets test results, compares two similar systems, or offers other qualitative information; to a detailed failure analysis that may include estimated numerical probabilities. The assessment criteria, process, analysis methods, validation, and documentation should be consistent with the guidance material contained in AMC 25.1309.

a. <u>Fire Protection System -- Failure Conditions</u>:

(1) Loss of detection in the presence of a fire.

(2) Loss of extinguishing in the presence of a fire.

(3) Loss of fire zone integrity in the presence of a fire.

(4) Loss of flammable fluid shut-off or drainage capability in the presence of a fire.

(5) Creation of an ignition source outside a fire zone but in the presence of flammable fluids.

b. <u>Fuel System -- Failure Conditions</u>:

(1) Loss of fuel feed/fuel supply.

(2) Inability to control lateral and longitudinal balance.

(3) Hazardously misleading fuel indications.

(4) Loss of fuel tank integrity.

(5) Loss of fuel jettison.

(6) Uncommanded fuel jettison.

c. Powerplant Ice Protection -- Failure Conditions:

(1) Loss of propeller, inlet, engine, or other powerplant ice protection on multiple powerplants when required.

(2) Loss of engine/powerplant ice detection.

(3) Activation of engine inlet ice protection above limit temperatures.

d. Propeller Control -- Failure Conditions:

(1) Inadvertent fine pitch (overspeed, excessive drag).

(2) Inadvertent coarse pitch (over-torque, thrust asymmetry)

(3) Uncommanded propeller feathering.

(4) Failure to feather.

(5) Inadvertent application of propeller brake in flight.

(6) Unwanted reverse thrust (pitch).

e. Engine Control and Indication -- Failure Conditions:

(1) Loss of thrust.

(2) Loss of thrust control, including asymmetric thrust, thrust increases, thrust decreases, thrust fail fixed, and unpredictable engine operation.

(3) Hazardously misleading display of powerplant parameter(s).

f. Thrust Reverser -- Failure Conditions:

(1) Inadvertent deployment of one or more reversers.

(2) Failure of one or more reversers to deploy when commanded.

(3) Failure of reverser component restraints (i.e., opening of D-ducts in flight, release of cascades during reverser operation , etc.).

I-C. ORIGINAL JAA NPA 25E-337 proposals justification

This proposal results from the Harmonisation initiative set up by the FAA and JAA. The intention is to create a single, Harmonised requirement for assessing the safety of powerplant installations, together with common advisory material.

Since this NPA arises from Harmonisation discussions, at which there has been considerable involvement of FAA, JAA and Transport Canada, as well as the opportunity for Industry to participate and comment on the drafts which led to this proposal, no detailed Justification is offered. However, mention is made below of the principle elements of this proposal.

The use of JAR 25.1309 Safety Assessment principles for complying with JAR 25.901(c) will continue with the new Harmonised proposal. The basic requirement remains unchanged. A reference to the new ACJ is given.

The new requirement also now includes some additional information about the scope of the Powerplant Installation and it specifies that no safety assessment is needed for a number of severe engine and propeller failure conditions. Although these conditions have not previously been analysed during compliance with JAR 25.901(c), it was considered necessary for a Harmonised text to make the scope of the assessment to be quite clear. Note: The frequency and effects of these severe failure conditions are controlled by other engine, propeller and aeroplane requirements.

The new ACJ (written in FAA Advisory Circular format) provides the background to the JAA use of safety assessments for powerplant installations, gives general guidance to the safety assessment process and discusses some specific powerplant installation issues as they relate to safety assessments. The content of some of this material has been included to give guidance to those, who may not previously have been required to comply with the '25.1309' type of assessment for powerplant installations. It also includes JAA policy, which had not been available in written form before.

Section 6 b.(2)(c) of the ACJ includes a reference to 'turbine' engines. Although JAR-25 only relates to turbine engines, it is proposed to retain this reference for Harmonisation with FAR 25 and because this Section would be applicable to novel engine concepts.

I-D. JAA NPA 25E-337 COMMENT-RESPONSE DOCUMENT

Note : the comments are not included in the text of below responses. Should you wish to get the content of a specific comment, please contact

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This document provides responses to comments on the above NPA, provided in JAA letter, dated 9 December 2002. The responses, given in the table below, use the same numbering, as in the JAA letter. As this has been a Harmonisation project, no commitment will be made here about revisions to the text, but where appropriate, recommendations will be made. There were no comments from the FAA on this NPA.

Comment	Response
019	This comment concerns the ACJ section, which deals with the probability and effects of multiple engine shut downs. In simple terms, this section explains how the probability of 'total loss of thrust' will be considered to meet the $1x10^{-9}$ Safety Objective of JAR 25.901(c) and JAR 25.1309, for a twin-engined aircraft. The same approach will also be accepted for the loss of two engines on a multi-engined aircraft. The commentor is correct in saying that modern turbine engines can comfortably meet the required shut down rate, but the reliability of new engines is not generally known at the time of aircraft Type Certification. The intent of the sentence in question is to make this point and deletion of the sentence may not be an improvement. Conclusion: No revisions are required.
018	1. This comment applies to the reliability estimation for ANY component or piece of equipment. The final selection an IFSD rate will need to be justified to the Authorities. In any doubt, the conservative IFSD rate of $1x10^{-4}$ may be used. 2. The IFSD rate is influenced by a number of factors e.g. the basic engine failure rate and the failure rates of a number of (generally) airframe systems, which can result in the shut down of an engine. For a new aircraft, an assessment could be made of the overall powerplant IFSD rate, based upon a similar engine basic IFSD rate, plus the appropriate rates for the relevant aircraft systems. Safety Assessments for aircraft normally assume that the pilot follows the AFM procedures. So the pilot is expected to shut the engine down in the event of the proper indication of low oil pressure (say). It is not expected that pilot errors, which create an erroneous IFSD would materially influence the total IFSD rate, but if there was such evidence and it is possible to show that these errors are not relevant to the current Certification, the erroneous evidence may be discounted. Where IFSD rates are known for twin and four engined aircraft, the appropriate data should be used. 3. The ACJ proposal states that the number is conservative. The intention is that the rate is expressed as 'per engine flight hour'. 'Traditional' equals 'conventional'. Conclusion: No revisions are required.
017	3.1 The Task Group responsible for this proposal included several engine manufacturers. The commentor should remember that, when Certificating a new aircraft, we cannot always assume that the highest reliability will be achieved by every installation. It would be quite wrong to arbitrarily assume optimistic values. 3.2 The relevant sentence is provided to exclude from consideration in this section any event, which may affect both or all engines e.g. fuel exhaustion.

	Conclusion: No revisions are required.
016	The 4th sub-paragraph says: When doing the aircraft Powerplant SSA, consider the effects of the failures considered in the engine and propeller analyses, but there may be other engine and propeller effects to be considered. It is considered that the Commentor's remarks support the intention of the 4th sub-paragraph, but the proposed text is not considered to be any clearer. The proposed change to the 5th sub-paragraph is not accurate, not needed and is not 'Self explanatory'. Conclusion: No revisions are required.
015	1. Comment agreed. A recommendation will be made to include the appropriate propeller requirement references. 2. There is no clear definition of how the 'Related Requirements' should be chosen. This ACJ was produced by a Harmonisation Task Group and the format is similar to that of the equivalent AC proposal (yet to be formally introduced). JAR-E 50(a)(4) (Amendment 12) refers to the engine Failure Analysis. Conclusion: A recommendation will be made to include the appropriate propeller requirement references.
014	Proposal (c)(1) The NPA wording builds upon the words, which have been acceptable for the past 30 years. The commentor's proposal makes no 'Self explanatory' improvement. Proposal (c)(2), (3), (4) All of these proposals are already covered by JAR 25.1309. The purpose of the new ACJ material is to provide more information about the application of JAR 25.1309 to powerplant installations. The first paragraph of the ACJ explains that it describes an acceptable means of showing compliance and does not constitute a requirement. Conclusion: No revisions are required.
013, 012, 011,	Agreement noted.
010	There is no intention to suggest that remote structural failures can have hazardous or catastrophic effects; rather the opposite - remote structural failures must not cause this level of effect. However, to avoid this confusion being repeated, it is proposed to deleted the sentence "Since the probability of a given structural failure is normally considered remote, consideration of structural failures is normally limited to potentially hazardous and catastrophic failure conditions."
009	Agreement noted.
008	There is nothing in Section 7 which suggests that any particular Software level is required. It is just a list of typical failure conditions, which will require consideration. It is not intended that the probability of a fire should be set to 1.0 and it is not clear how the commentor comes to this conclusion. If the fire probability is 1E-5 per flight hour, the probability of losing fire detection needs to be 1E-4 per flight hour. This should be achievable by a Level C software system, with a pre-flight test facility; it's what we approve at the moment. Conclusion: No revisions are required.
007	Comment disagreed. JAR 25.1309 is applicable to 'installations'. JAR 25.901(a)

	defines the powerplant installation as 'each component that is necessary for propulsion'. For some powerplant systems, 'structural' components may be required to take the loads. These components need to be included in the powerplant installation SSA. Conclusion: No revisions are required.
006	Comment disagreed. Although SAE ARP 4761 is a respected source for information on how a SSA may be conducted, it does not directly affect the JAR-25 Powerplant Installation SSA process. Conclusion: No revisions are required.
005	NPA 25E-337 contains material, which was produced under an ARAC Harmonisation activity, involving Industry, JAA, FAA and TC. JAA has had the requirement for powerplant installations to meet JAR 25.1309 for many years now and the ARAC Task Group concluded that this approach was acceptable to FAA and TC. So it is possible that AIA considers this package to be an escalation of the requirements, although the FAA will be able to provide a definitive answer. Section 6 is probably the most important section in the ACJ, since it provides guidance to applicants about the potential failure conditions arising from the powerplant installation and how those failure conditions may be analysed. It does not create new requirements. Paragraph a. Like all the other sections, the section on undetected thrust loss considers a known phenomenon, which has caused accidents in the past. The Potomac river B737 accident was the result of the crew not knowing that the engine (or aircraft) performance was degraded. These considerations need to be addressed by the applicants. Paragraph b. Appendix I was written early in the development of ATTCS systems and addresses the significant, known failure conditions. It is possible that new system architectures could introduce new failure conditions, not known at the time of writing the Appendix and these need to be addressed. Hopefully, AIA recognise that the current FAR 25.901(c) applies to ALL powerplant installation failure conditions, including any 'additional' ATTCS failure conditions. Paragraph d. It is recognised that in the area where systems involve flight crew interfaces, there will be a shared Certification task with the relevant specialist group. This is nothing new. Conclusion: No revisions are required.
004, 003, 002	Agreement noted.
001	No specific comment on this NPA found.

II-A. EXPLANATORY NOTE JAA NPA 25E-338

Originally JAA NPA 25E-338, Reversing System Requirement

1. The initial issue of CS-25 was based upon JAR-25 at amendment 16. During the transposition of airworthiness JARs into certification specifications the rulemaking activities under the JAA system where not stopped. In order to assure a smooth transition from JAA to EASA the Agency has committed itself to continue as much as possible of the JAA rulemaking activities. Therefore it has included most of it in its own rulemaking programme for 2004 and planning for 2005-2007. This part of present EASA NPA is a result of this commitment and a transposed version of the JAA NPA 25E-338 which was circulated for comments from 1 September 2002 till 1 December 2002, modified as per the conclusions of the JAA comment response document (see II.D)

2. In 1988, the JAA, in co-operation with the FAA and other organisations representing the European and U.S. aerospace industries, began a process to harmonise the airworthiness requirements of the European authorities with the airworthiness requirements of the United States. The objective was to achieve common requirements for the certification of large aeroplanes without a substantive change in the level of safety provided by the requirements. Other airworthiness authorities such as Transport Canada have also participated in this process.

In 1992, the harmonisation effort was tasked by the FAA to the Aviation Rulemaking Advisory Committee (ARAC) on the US side.

In co-operation and conjunction with ARAC, a working group comprised of specialists from both industry and aviation regulatory authorities from Europe, the United States, and Canada was established to work on the powerplant installation requirements of Subpart E of JAR/FAR 25, "Powerplant". This group is the Powerplant Installation Harmonization Working Group (PPIHWG).

A dedicated Task Group of the Powerplant Harmonization Working Group was set up to deal with the Reversing System requirements.

This notice contains the proposals made by this Task Group, necessary to achieve harmonisation for the Revering Systems design and analysis requirements of CS/FAR 25, contained currently in CS 25.933(a).

II-B. PROPOSALS TRANSPOSED JAA NPA 25E-338

The following amendments should be included in Decision No. 2003/2/RM of the Executive Director of the Agency of 17 October 2003:

1. To replace sub-paragraph CS 25.933 (a)(1) to read as follows:

CS 25.933 Reversing systems

(a) For turbojet reversing systems
(1) Each system intended for ground operation only must be designed so that either—
(i) The airplane can be shown to be capable of continued safe flight and landing during and after any thrust reversal in flight; or
(ii) It can be demonstrated that inflight thrust reversal is extremely improbable and does not result from a single failure or malfunction.
<u>(See AMC 25.933(a)(1).)</u>"

2. Introduce a new AMC to CS 25.933(a)(1), as follows :

AMC 25.933(a)(1)
Unwanted in-flight thrust reversal of turbojet thrust reversers

<u>1. PURPOSE</u>.
This –Acceptable Means of Compliance (AMC) describes various acceptable means, for showing compliance with the requirements of CS 25.933(a)(1), "Reversing systems", of CS-25. These means are intended to provide guidance to supplement the engineering and operational judgement that must form the basis of any compliance findings relative to inflight thrust reversal of turbojet thrust reversers. ___

<u>2. RELATED CS SECTIONS.</u>
CS 25.111, 25.143, 25.251, 25.571, 25.901, 25.903, 25.1155, 25.1305, 25.1309, 25.1322 and 25.1529

<u>3. APPLICABILITY.</u>
The requirements of CS 25.933 apply to turbojet thrust reverser systems. CS 25.933(a) specifically applies to reversers intended for ground operation only, while CS 25.933(b) applies to reversers intended for both ground and inflight use.
This AMC applies only to unwanted thrust reversal in flight phases when the landing gear is not in contact with the ground; other phases (i.e., ground operation) are addressed by CS 25.901(c) and CS 25.1309.

<u>4. BACKGROUND.</u>
4.a. <u>General.</u> Most thrust reversers are intended for ground operation only. Consequently, thrust reverser systems are generally sized and developed to provide high deceleration forces while avoiding foreign object debris (FOD) ingestion, aeroplane surface efflux impingement, and aeroplane handling difficulty during landing roll. Likewise, aircraft flight systems are generally sized and developed to provide lateral and directional controllability margins adequate for handling qualities, manoeuvrability requirements, and engine-out V_{MC} lateral drift conditions.
In early turbojet aeroplane designs, the combination of control system design and thrust reverser

characteristics resulted in control margins that were capable of recovering from unwanted inflight thrust reversal even on ground-use-only reversers; this was required by the previous versions of CS 25.933.
As the predominant large aeroplane configuration has developed into the high bypass ratio twin engine-powered model, control margins for the inflight thrust reversal case have decreased. Clearly, whenever and wherever thrust reversal is intended, the focus must remain on limiting any adverse effects of thrust reversal. However, when demonstrating compliance with CS 25.933(a) or 25.933(b), the Authority has accepted that applicants may either provide assurance that the aeroplane is controllable after an inflight thrust reversal event or that the unwanted inflight thrust reversal event will not occur.
Different historical forms of the rule have attempted to limit either the effect or the likelihood of unwanted thrust reversal during flight. However, experience has demonstrated that neither method is always both practical and effective. The current rule, and this related advisory material, are intended to allow either of these assurance methods to be applied in a manner which recognises the limitations of each, thereby maximising both the design flexibility and safety provided by compliance with the rule.

4.b. Minimising Adverse Effects. The primary purpose of reversing systems, especially those intended for ground operation only, is to assist in decelerating the aeroplane during landing and during an aborted takeoff. As such, the reverser must be rapid-acting and must be effective in producing sufficient reverse thrust. These requirements result in design characteristics (actuator sizing, efflux characteristics, reverse thrust levels, etc.) that, in the event of thrust during flight, could cause significant adverse effects on aeroplane controllability and performance.
If the effect of the thrust reversal occurring in flight produces an unacceptable risk to continued safe flight and landing, then the reverser operation and de-activation system must be designed to prevent unwanted thrust reversal. Alternatively, for certain aeroplane configurations, it may be possible to limit the adverse impacts of unwanted thrust reversal on aeroplane controllability and performance such that the risk to continued safe flight and landing is acceptable (discussed later in this AMC).
For reversing systems intended for operation in flight, the reverser system must be designed to adequately protect against unwanted inflight thrust reversal.
CS 25.1309 and 25.901(c) and the associated AMC (AMC 25.1309 and AMC 25.901(c) provide guidance for developing and assessing the safety of systems at the design stage. This methodology should be applied to the total reverser system, which includes:

- the reverser;
- the engine (if it can contribute to thrust reversal);
- the reverser motive power source;
- the reverser control system;
- the reverser command system in the cockpit; and
- the wiring, cable, or linkage system between the cockpit and engine.

Approved removal, deactivation, reinstallation, and repair procedures for any element in the reverser or related systems should result in a safety level equivalent to the certified baseline system configuration.
Qualitative assessments should be done, taking into account potential human errors (maintenance, aeroplane operation).
Data required to determine the level of the hazard to the aeroplane in case of inflight thrust reversal and, conversely, data necessary to define changes to the reverser or the aeroplane to eliminate the hazard, can be obtained from service experience, test, and/or analysis. These data also can be used to define the envelope for continued safe flight.
There are many opportunities during the design of an aeroplane to minimise both the likelihood and severity of unwanted inflight thrust reversal. These opportunities include design features of both the aeroplane and the engine/reverser system. During the design process, consideration should be

given to the existing stability and control design features, while preserving the intended function of the thrust reverser system.
Some design considerations, which may help reduce the risk from inflight thrust reversal, include:

4.b.(1) Engine location to:

4.b.(1)(a) Reduce sensitivity to efflux impingement.

4.b.(1)(b) Reduce effective reverse thrust moment arms

4.b.(2) Engine/Reverser System design to:

4.b.(2)(a) Optimise engine/reverser system integrity and reliability.

4.b.(2)(b) Rapidly reduce engine airflow (i.e. auto-idle) in the event of an unwanted thrust reversal. Generally, such a feature is considered a beneficial safety item. In this case, the probability and effect of any unwanted idle command or failure to provide adequate reverse thrust when selected should be verified to be consistent with AMC 25.1309 and AMC 25.901(c).

4.b.(2)(c) Give consideration to the aeroplane pitch, yaw, and roll characteristics.

4.b.(2)(d) Consider effective efflux diameter.

4.b.(2)(e) Consider efflux area.

4.b.(2)(f) Direct reverser efflux away from critical areas of the aeroplane.

4.b.(2)(g) Expedite detection of unwanted thrust reversal, and provide for rapid compensating action within the reversing system.

4.b.(2)(h) Optimise positive aerodynamic stowing forces.

4.b.(2)(i) Inhibit inflight thrust reversal of ground-use-only reversers, even if commanded by the flight crew.

4.b.(2)(j) Consider incorporation of a restow capability for unwanted thrust reversal.

4.b.(3) Airframe/System design to:

4.b.(3)(a) Maximise aerodynamic control capability.

4.b.(3) (b) Expedite detection of thrust reversal, and provide for rapid compensating action through other airframe systems.

4.b.(3) (c) Consider crew procedures and responses.

The use of formal «lessons learned»-based reviews early and often during design development may help avoid repeating previous errors and take advantage of previous successes.

5. DEFINITIONS.

The following definitions apply for the purpose of this AMC :

5.a. Catastrophic: see AMC 25.1309

5.b. Continued Safe Flight and Landing: The capability for continued controlled flight and safe landing at an airport, possibly using emergency procedures, but without requiring exceptional pilot skill or strength. Some aeroplane damage may be associated with a failure condition, during flight or upon landing.

5.c. Controllable Flight Envelope and Procedure: An area of the Normal Flight Envelope where, given an appropriate procedure, the aeroplane is capable of continued safe flight and landing following an inflight thrust reversal.

5.d. Deactivated Reverser: Any thrust reverser that has been deliberately inhibited such that it is precluded from performing a normal deploy/stow cycle, even if commanded to do so.

5.e. Exceptional Piloting Skill and/or Strength: Refer to CS 25.143(c) («Controllability and Manoeuvrability—General»).

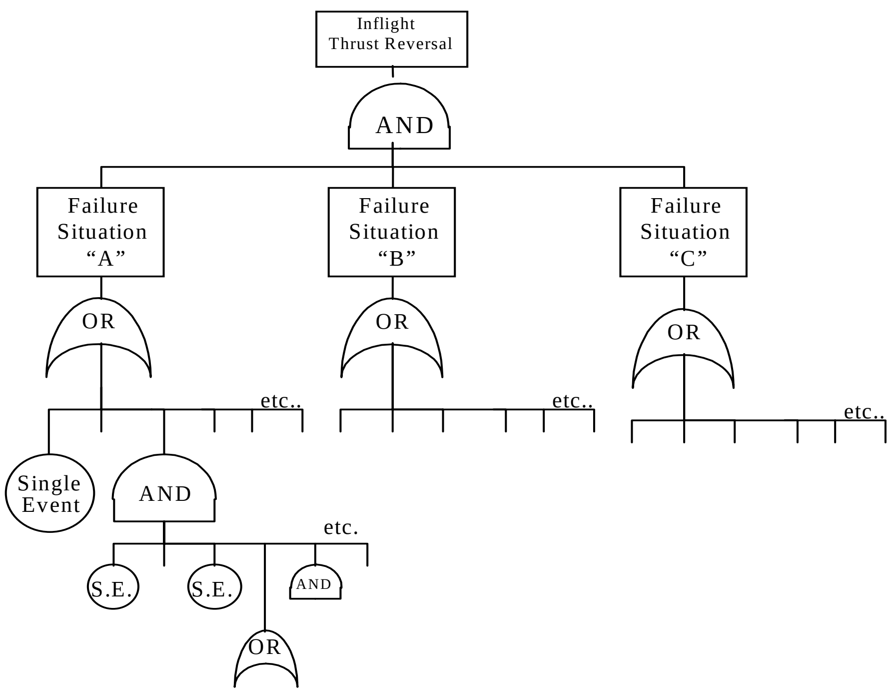
5.f. Extremely Improbable: see AMC 25.1309

5.g. Extremely Remote: see AMC 25.1309

5.h. Failure: see AMC 25.1309

5.i. Failure Situation: All failures that result in the malfunction of one independent command and/or restraint feature that directly contributes to the top level Fault Tree Analysis event (i.e., unwanted inflight thrust reversal). For the purpose of illustration, **Figure 1**, below, provides a fault tree example for a scenario of three «failure situations» leading to unwanted inflight thrust reversal.

Figure 1:
TOP EVENT



Reverser System with three independent command/restraint features shown for reference only.

5.j. Hazardous: see AMC 25.1309

5.k. Inflight: that part of aeroplane operation beginning when the wheels are no longer in contact with the ground during the takeoff and ending when the wheels again contact the ground during landing.

5.l. Light Crosswind: For purposes of this AMC, a light crosswind is a 10 Kt. wind at right angles to the direction of takeoff or landing which is assumed to occur on every flight.

5.m. Light Turbulence: Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, and/or yaw), which is assumed to occur on every flight.

5.n. Major: see AMC 25.1309

5.o. Maximum exposure time: The longest anticipated period between the occurrence and elimination of the failure.

5.p Normal Flight Envelope: An established boundary of parameters (velocity, altitude, angle of attack, attitude) associated with the practical and routine operation of a specific airplane that is likely to be encountered on a typical flight and in combination with prescribed conditions of light turbulence and light crosswind.

5.q. Pre-existing failure: Failure that can be present for more than one flight.

5.r. Thrust Reversal: A movement of all or part of the thrust reverser from the forward thrust position to a position that spoils or redirects the engine airflow.

5.s. Thrust Reverser System: Those components that spoil or redirect the engine thrust to decelerate the aeroplane. The components include:

- the engine-mounted hardware,
- the reverser control system,
- indication and actuation systems, and
- any other aeroplane systems that have an effect on the thrust reverser operation.

5.t. Turbojet thrust reversing system: Any device that redirects the airflow momentum from a turbojet engine so as to create reverse thrust. Systems may include:

- cascade-type reversers,
- target or clamshell-type reversers,
- pivoted-door petal-type reversers,
- deflectors articulated off either the engine cowling or aeroplane structure,
- targetable thrust nozzles, or
- a propulsive fan stage with reversing pitch.

5.v. Turbojet (or turbofan): A gas turbine engine in which propulsive thrust is developed by the reaction of gases being directed through a nozzle.

6. DEMONSTRATING COMPLIANCE WITH CS 25.933(a).

The following Sections 7 through 10 of this AMC provide guidance on specific aspects of compliance with CS 25.933(a), according to four different means or methods:

- Controllability (Section 7),
- Reliability (Section 8),
- Mixed controllability / reliability (Section 9),
- Deactivated reverser (Section 10).

7. «CONTROLLABILITY OPTION»: PROVIDE CONTINUED SAFE FLIGHT AND LANDING FOLLOWING ANY INFLIGHT THRUST REVERSAL.

The following paragraphs provide guidance regarding an acceptable means of demonstrating compliance with CS 25.933(a)(1).

7.a. General. For compliance to be established with CS 25.933(a) by demonstrating that the aeroplane is capable of continued safe flight and landing following any inflight thrust reversal (the «controllability option» provided for under CS 25.933(a)(1)), the aspects of structural integrity, performance, and handling qualities must be taken into account. The level of accountability should be appropriate to the probability of inflight thrust reversal, in accordance with the following sections.

To identify the corresponding failure conditions and determine the probability of their occurrence, a safety analysis should be carried out, using the methodology described in CS 25.1309. The reliability of design features, such as auto-idle and automatic control configurations critical to meeting the following controllability criteria, also should be considered in the safety analysis. Appropriate alerts and/or other indications should be provided to the crew, as required by CS 25.1309(c) (Ref. AMC 25.1309).
The inhibition of alerts relating to the thrust reverser system during critical phases of flight should be evaluated in relation to the total effect on flight safety (Ref. AMC 25.1309).

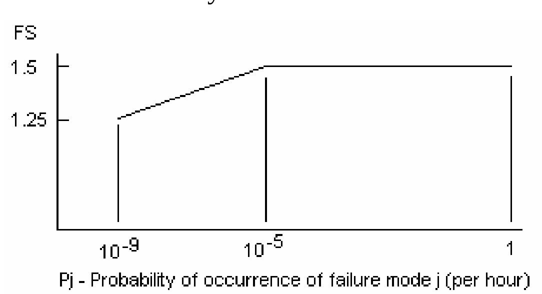
Thrust reversal of a cyclic or erratic nature (e.g., repeated deploy/stow movement of the thrust reverser) should be considered in the safety analysis and in the design of the alerting/indication systems.

Input from the flight crew and human factors specialists should be considered in the design of the alerting and/or indication provisions.
The controllability compliance analysis should include the relevant thrust reversal scenario that could be induced by a rotorburst event.
When demonstrating compliance using this «controllability option» approach, if the aeroplane might experience an inflight thrust reversal outside the «controllable flight envelope» anytime during the entire operational life of all aeroplanes of this type, then further compliance considerations as described in Section 9 («MIXED CONTROLLABILITY / RELIABILITY OPTION») of this AMC, below, should be taken into account.

7.b. Structural Integrity. For the «controllability option,» the aeroplane must be capable of successfully completing a flight during which an unwanted inflight thrust reversal occurs. An assessment of the integrity of the aeroplane structure is necessary, including an assessment of the structure of the deployed thrust reverser and its attachments to the aeroplane.
In conducting this assessment, the normal structural loads, as well as those induced by failures and forced vibration (including buffeting), both at the time of the event and for continuation of the flight, must be shown to be within the structural capability of the aeroplane.
At the time of occurrence, starting from 1-g level flight conditions, at speeds up to V_C, a realistic scenario, including pilot corrective actions, should be established to determine the loads occurring at the time of the event and during the recovery manoeuvre. The aeroplane should be able to withstand these loads multiplied by an appropriate factor of safety that is related to the probability of unwanted inflight thrust reversal. The factor of safety is defined in **Figure 2**, below. Conditions with high lift devices deployed also should be considered at speeds up to the appropriate flap limitation speed.

Figure 2

factor of safety at the time of occurrence



For continuation of the flight following inflight thrust reversal, considering any appropriate reconfiguration and flight limitations, the following apply:

7.b.(1) Static strength should be determined for loads derived from the following conditions at speeds up to V_C, or the speed limitation prescribed for the remainder of the flight:

7.b.(1)(a) 70% of the limit flight manoeuvre loads; and separately

7.b.(1)(b) the discrete gust conditions specified in CS 25.341(a) (but using 40% of the gust velocities specified for V_C).

7.b.(2) For the aeroplane with high lift devices deployed, static strength should be determined for loads derived from the following conditions at speeds up the appropriate flap design speed, or any lower flap speed limitation prescribed for the remainder of the flight:

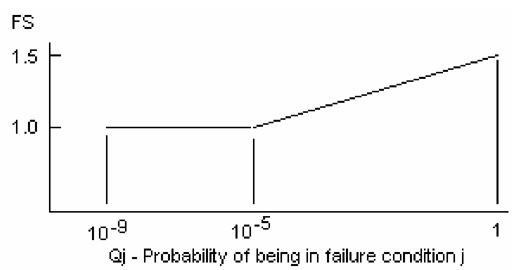
7.b.(2)(a) A balanced manoeuvre at a positive limit load factor of 1.4; and separately

7.b.(2)(b) the discrete gust conditions specified in CS 25.345(a)(2) (but using 40% of the gust velocities specified).

7.b.(3) For static strength substantiation, each part of the structure must be able to withstand the loads specified in sub-paragraph 7.b.(1) and 7.b.(2) of this paragraph, multiplied by a factor of safety depending on the probability of being in this failure state. The factor of safety is defined in **Figure 3**, below.

Figure 3

factor of safety for continuation of flight



Q - is the probability of being in the configuration with the unwanted inflight thrust reversal
Q = (T)(P) where:
T = average time spent with unwanted inflight thrust reversal(in hours)
P = probability of occurrence of unwanted inflight thrust reversal (per hour)
If the thrust reverser system is capable of being restowed following a thrust reversal, only those loads associated with the interval of thrust reversal need to be considered. Historically, thrust reversers have often been damaged as a result of unwanted thrust reversal during flight. Consequently, any claim that the thrust reverser is capable of being restowed must be adequately substantiated, taking into account this adverse service history.

7.c. Performance

7.c.(1) *General Considerations***:** Most failure conditions that have an effect on performance are adequately accounted for by the requirements addressing a «regular» engine failure (i.e., involving only loss of thrust and not experiencing any reverser anomaly). This is unlikely to be the case for failures involving an unwanted inflight thrust reversal, which can be expected to have a more adverse impact on thrust and drag than a regular engine failure. Such unwanted inflight thrust reversals, therefore, should be accounted for specifically, to a level commensurate with their probability of occurrence.
The performance accountability that should be provided is defined in Sections 7.c.(2) and 7.c.(3) as a function of the probability of the unwanted inflight thrust reversal. Obviously, for unwanted inflight thrust reversals less probable than 1 E-9/fh, certification may be based on reliability

alone, as described in Section 8 («RELIABILITY OPTION») of this AMC. Furthermore, for any failure conditions where unwanted inflight thrust reversal would impact safety, the aeroplane must meet the safety/reliability criteria delineated in CS 25.1309.

7.c.(2) *Probability of unwanted inflight thrust reversal greater than 1 E-7/fh*: Full performance accountability must be provided for the more critical of a regular engine failure and an unwanted inflight thrust reversal.

To determine if the unwanted inflight thrust reversal is more critical than a regular engine failure, the normal application of the performance requirements described in CS-25, Subpart B, as well as the applicable operating requirements, should be compared to the application of the following criteria, which replace the accountability for a critical engine failure with that of a critical unwanted inflight thrust reversal:

- CS 25.111, «Takeoff path»: The takeoff path should be determined with the critical unwanted thrust reversal occurring at V_{LOF} instead of the critical engine failure at V_{EF}. No change to the state of the engine with the thrust reversal that requires action by the pilot may be made until the aircraft is 400 ft above the takeoff surface.
- CS 25.121, «Climb: one-engine-inoperative»: Compliance with the one-engine-inoperative climb gradients should be shown with the critical unwanted inflight thrust reversal rather than the critical engine inoperative.
- CS 25.123, «En-route flight paths»: The en-route flight paths should be determined following occurrence of the critical unwanted inflight thrust reversal(s) instead of the critical engine failure(s), and allowing for the execution of appropriate crew procedures. For compliance with the applicable operating rules, an unwanted inflight thrust reversal(s) at the most critical point en-route should be substituted for the engine failure at the most critical point en-route.

Performance data determined in accordance with these provisions, where critical, should be furnished in the Aeroplane Flight Manual as operating limitations.

Operational data and advisory data related to fuel consumption and range should be provided for the critical unwanted inflight thrust reversal to assist the crew in decision making. These data may be supplied as simple factors or additives to apply to normal all-engines-operating fuel consumption and range data. For approvals to conduct extended range operations with two-engine aeroplanes (ETOPS), the critical unwanted inflight thrust reversal should be considered in the critical fuel scenario [paragraph 10d(4)(iii) of Information Leaflet no. 20 : ETOPS].

7.c.(3) *Probability of unwanted inflight thrust reversal equal to or less than 1 E-7/fh, but greater than 1 E-9/fh*: With the exception of the takeoff phase of flight, which needs not account for unwanted inflight thrust reversal, the same criteria should be applied as in Section 7.c.(2), above, for the purposes of providing advisory data and procedures to the flight crew. Such performance data, however, need not be applied as operating limitations. The takeoff data addressed by Section 7.c.(2), above (takeoff speeds, if limited by V_{MC}, takeoff path, and takeoff climb gradients), does not need to be provided, as it would be of only limited usefulness if not applied as a dispatch limitation.

However, the takeoff data should be determined and applied as operating limitations if the unwanted inflight thrust reversal during the take-off phase is the result of a single failure.

As part of this assessment, the effect of an unwanted inflight thrust reversal on approach climb performance, and the ability to execute a go-around manoeuvre should be determined and used to specify crew procedures for an approach and landing following a thrust reversal. For example, the procedures may specify the use of a flap setting less than that specified for landing, or an airspeed greater than the stabilised final approach airspeed, until the flight crew is satisfied that a landing is assured and a go-around capability need no longer be maintained. Allowance may be assumed for execution of appropriate crew procedures subsequent to the unwanted thrust reversal having occurred. Where a number of thrust reversal states may occur, these procedures for approach and landing may, at the option of the applicant, be determined either for the critical thrust reversal state or for each thrust reversal state that is clearly distinguishable by the flight crew.

Operational data and advice related to fuel consumption and range should be provided for the critical unwanted inflight thrust reversal to assist the crew in decision-making. These data may be supplied as simple factors or additives to apply to normal all-engines-operating fuel consumption and range data.

7.d. Handling Qualities

7.d.(1) *Probability of unwanted inflight thrust reversal greater than 1 E-7/fh*: The more critical of an engine failure [or flight with engine(s) inoperative], and an unwanted inflight thrust reversal, should be used to show compliance with the controllability and trim requirements of CS-25, Subpart B. In addition, the criteria defined in Section 7.d.(2), below, also should be applied. To determine if the unwanted inflight thrust reversal is more critical than an engine failure, the normal application of the CS-25, Subpart B, controllability and trim requirements should be compared to the application of the following criteria, which replace the accountability for a critical engine failure with that of a critical unwanted inflight thrust reversal:

- CS 25.143, «Controllability and Manoeuvrability - General» : the effect of a sudden unwanted inflight thrust reversal of the critical engine, rather than the sudden failure of the critical engine, should be evaluated in accordance with CS 25.143(b)(1) and the associated guidance material.
  – Control forces associated with the failure should comply with CS 25.143(c).
- CS 25.147, «Directional and lateral control» : the requirements of CS 25.147(a), (b), (c), and (d) should be complied with following critical unwanted inflight thrust reversal(s) rather than with one or more engines inoperative.
- CS 25.149, «Minimum control speed» : the values of V_{MC} and V_{MCL} should be determined with a sudden unwanted inflight thrust reversal of the critical engine rather than a sudden failure of the critical engine.
- CS 25.161, «Trim» the trim requirements of CS 25.161(d) and (e) should be complied with following critical unwanted inflight thrust reversal(s), rather than with one or more engines inoperative.

Compliance with these requirements should be demonstrated by flight test. Simulation or analysis will not normally be an acceptable means of compliance for such probable failures.

7.d.(2) *Probability of unwanted thrust reversal equal to or less than 1 E-7/fh, but greater than 1 E-9/fh*: failure conditions with a probability equal to or less than 1 E-7/fh are not normally evaluated against the specific controllability and trim requirements of CS-25, Subpart B. Instead, the effects of unwanted inflight thrust reversal should be evaluated on the basis of maintaining the capability for continued safe flight and landing, taking into account pilot recognition and reaction time. One exception is that the minimum control speed requirement of CS 25.149 should be evaluated to the extent necessary to support the performance criteria specified in Section 7.c.(3), above, related to approach, landing, and go-around.

Recognition of the failure may be through the behaviour of the aircraft or an appropriate failure alerting system, and the recognition time should not be less than one second. Following recognition, additional pilot reaction times should be taken into account, prior to any corrective pilot actions, as follows:

- Landing : no additional delay
- Approach : 1 second
- Climb, cruise, and descent : 3 seconds; except when in auto-pilot engaged manoeuvring flight, or in manual flight, when 1 second should apply.

Both auto-pilot engaged and manual flight should be considered.

The unwanted inflight thrust reversal should not result in any of the following:

- exceedance of an airspeed halfway between V_{MO} and V_{DF}, or Mach Number halfway between M_{MO} and M_{DF}.
- a stall.
- a normal acceleration less than a value of 0g.
- bank angles of more than 60° en-route, or more than 30° below a height of 1000 ft.
- degradation of flying qualities assessed as greater than *Major* for unwanted inflight thrust reversal more probable than 1 E-7/fh; or assessed as greater than *Hazardous* for failures with a probability equal to or less than 1 E-7/fh, but greater 1 E-9/fh
- the roll control forces specified in CS 25.143(c), except that the long term roll control force should not exceed 10 lb.
- structural loads in excess of those specified in Section 7.b., above.

Demonstrations of compliance may be by flight test, by simulation, or by analysis suitably validated by flight test or other data.

7.d.(3) *Probability of inflight thrust reversal less than 1 E-9/fh*: Certification can be based on reliability alone as described in Section 8, below.

8. «RELIABILITY OPTION»: PROVIDE CONTINUED SAFE FLIGHT AND LANDING BY PREVENTING ANY INFLIGHT THRUST REVERSAL

The following paragraphs provide guidance regarding an acceptable means of demonstrating compliance with CS 25.933(a)(2).

8.a. General. For compliance to be established with CS 25.933(a) by demonstrating that unwanted inflight thrust reversal is not anticipated to occur (the «reliability option» provided for under CS 25.933(a)(2)), the aspects of system reliability, maintainability, and fault tolerance; structural integrity; and protection against zonal threats such as uncontained engine rotor failure or fire must be taken into account.

8.b. System Safety Assessment (SSA): Any demonstration of compliance should include an assessment of the thrust reverser control, indication and actuation system(s), including all interfacing power-plant and aeroplane systems (such as electrical supply, hydraulic supply, flight/ground status signals, thrust lever position signals, etc.) and maintenance.
The reliability assessment should include:

- the possible modes of normal operation and of failure;
- the resulting effect on the aeroplane considering the phase of flight and operating conditions;
- the crew awareness of the failure conditions and the corrective action required;
- failure detection capabilities and maintenance procedures, etc.; and
- the likelihood of the failure condition.

Consideration should be given to failure conditions being accompanied or caused by external events or errors.
The SSA should be used to identify critical failure paths for the purpose of conducting in-depth validation of their supporting failure mode, failure rates, exposure time, reliance on redundant subsystems, and assumptions, if any. In addition, the SSA can be used to determine acceptable time intervals for any required maintenance intervals (ref. AMC 25.1309 and AMC25.19).
The primary intent of this approach to compliance is to improve safety by promoting more reliable designs and better maintenance, including minimising pre-existing faults. However, it also recognises that flexibility of design and maintenance are necessary for practical application.

8.b.(1) The thrust reverser system should be designed so that any inflight thrust reversal that is not shown to be controllable in accordance with Section 7,above, is extremely improbable (i.e., average probability per hour of flight of the order of 1 E-9/fh. or less) and does not result from a single failure or malfunction. **And**

8.b.(2) For configurations in which combinations of two-failure situations (ref. Section 5, above) result in inflight thrust reversal, the following apply:

- Neither failure may be pre-existing (i.e., neither failure situation can be undetected or exist for more than one flight); the means of failure detection must be appropriate in consideration of the monitoring device reliability, inspection intervals, and procedures.
- The occurrence of either failure should result in appropriate cockpit indication or be self-evident to the crew to enable the crew to take necessary actions such as discontinuing a take-off, going to a controllable flight envelope en-route, diverting to a suitable airport, or reconfiguring the system in order to recover single failure tolerance, etc. **And**

8.b.(3) For configurations in which combinations of three or more failure situations result in inflight thrust reversal, the following applies:

- In order to limit the exposure to pre-existing failure situations, the maximum time each pre-existing failure situation is expected to be present should be related to the frequency with which the failure situation is anticipated to occur, such that their product is 1 E-3 or less.
- The time each failure situation is expected to be present should take into account the expected delays in detection, isolation, and repair of the causal failures.

8.c. Structural Aspects: For the «reliability option,» those structural load paths that affect thrust reversal should be shown to comply with the static strength, fatigue, damage tolerance, and deformation requirements of CS-25. This will ensure that unwanted inflight thrust reversal is not anticipated to occur due to failure of a structural load path, or due to loss of retention under ultimate load throughout the operational life of the aeroplane.

8.d. Uncontained Rotor Failure: In case of rotor failure, compliance with CS 25.903(d)(1) should be shown, using advisory materials (AC, user manual, etc.) supplemented by the methods described below. The effects of associated loads and vibration on the reverser system should be considered in all of the following methods of minimising hazards:

8.d.(1) Show that engine spool-down characteristics or potential reverser damage are such that compliance with Section 7, above, can be shown.

8.d.(2) Show that forces that keep the thrust reverser in stable stowed position during and after the rotor burst event are adequate.

8.d.(3) Locate the thrust reverser outside the rotor burst zone.

8.d.(4) Protection of thrust reverser restraint devices: The following guidance material describes methods of minimising the hazard to thrust reverser stow position restraint devices located within rotorburst zones. The following guidance material has been developed on the basis of all of the data available to date and engineering judgement.

8.d.(4)(a) Fragment Hazard Model:

8.d.(4)(a)(i) Large Fragments

- Ring Disks (see **Figure 4.a.**) **-** Compressor drum rotors or spools with ring disks have typically failed in a rim peeling mode when failure origins are in the rim area. This type of failure typically produces uncontained fragment energies, which are mitigated by a single layer of conventional aluminium honeycomb structure. (Note: This guidance material is based upon field experience and, as such, its application should be limited to aluminium sheet and honeycomb fan reverser construction. Typical construction consists of a half inch (12.7 mm) thickness of .003-.004 aluminium foil honeycomb with .030" thick aluminium facing sheets**.** Alternative materials and methods of construction should have at least equivalent impact energy absorption characteristics). Failures with the origins in the bore of these same drum sections have resulted in fragments which can be characterised as a single 1/3 disk fragment and multiple smaller fragments. The 1/3 disk fragment may or may not be contained by the thrust reverser structure. The remaining intermediate and small disk fragments, while escaping the engine case, have been contained by the thrust reverser structure.

- Deep Bore Disks (see **Figure 4.b**.) and Single Disks (see **Figure 4.c**.) **-** For compressor drum rotors or spools with deep bore disks, and single compressor and turbine disks, the experience, while limited, indicates either a 1/3 and a 2/3 fragment, or a 1/3 fragment and multiple intermediate and small discrete fragments should be considered. These fragments can be randomly released within an impact area that ranges ± 5 degrees from the plane of rotation.

8.d.(4)(a)(ii) Small Fragments (Debris): Consider small fragments (reference AMC 20-128A, paragraph 9.d.) that could impact the thrust reverser at ± 15 degrees axial spread angle.

8.d.(4)(b) Minimisation: Minimisation guidance provided below is for fragments from axial flow rotors surrounded by fan flow thrust reversers located over the intermediate or high-pressure core rotors.
NOTE: See attached **Figure 5**: Typical High Bypass Turbofan Low and High Pressure Compressor with Fan Thrust Reverser Cross Section

8.d.(4)(b)(i) Large Fragments: For the large fragments defined in Section 8.d.(4)(a)(i), above, the thrust reverser retention systems should be redundant and separated as follows:

- Ring Disks Compressor Spools:
  Retention systems located in the outer barrel section of the thrust reverser should be separated circumferentially (circumferential distance greater than the 1/3 disk fragment model as described in AMC20-128A) or axially (outside the ± 5 degree impact area) so that a 1/3 disk segment can not damage all redundant retention elements and allow thrust reversal (i.e., deployment of a door or translating reverser sleeve half). Retention systems located between the inner fan flow path wall and the engine casing should be located axially outside the ± 5 degree impact area.
- Deep-bore Disk Spools and Single Disks***:*** Retention systems should be separated axially with at least one retention element located outside the ± 5 degree impact area.

8.d.(4)(b)(ii) Small Fragments: For the small fragments defined in Section 8.d.(4)(a)(ii), above, thrust reverser retention systems should be provided with either:

- At least one retention element shielded in accordance with AMC20-128A, paragraph 7(c), or capable of maintaining its retention capabilities after impact; or
- One retention element located outside the ± 15 degree impact area.

9. «MIXED CONTROLLABILITY / RELIABILITY» OPTION.

If the aeroplane might experience an unwanted inflight thrust reversal outside the «controllable flight envelope» anytime during the entire operational life of all aeroplanes of this type, then outside the controllable envelope reliability compliance must be shown, taking into account associated risk exposure time and the other considerations described in Section 8, above.
Conversely, if reliability compliance is selected to be shown within a given limited flight envelope with associated risk exposure time, then outside this envelope controllability must be demonstrated taking into account the considerations described in Section 7, above.
Mixed controllability/reliability compliance should be shown in accordance with guidance developed in Sections 7 and 8, above, respectively.

10. DEACTIVATED REVERSER.

The thrust reverser system deactivation design should follow the same «fail-safe» principles as the actuation system design, insofar as failure and systems/hardware integrity. The effects of thrust reverser system deactivation on other aeroplane systems, and on the new configuration of the thrust reverser system itself, should be evaluated according to Section 8.a., above. The location and load capability of the mechanical lock-out system (thrust reverser structure and lock-out device) should be evaluated according to Sections 8.b. and 8.d., above. The evaluation should show that the level of safety associated with the deactivated thrust reverser system is equivalent to or better than that associated with the active system.

11. CS 25.933(b) COMPLIANCE.

For thrust reversing systems intended for inflight use, compliance with CS 25.933(b) may be shown for unwanted inflight thrust reversal, as appropriate, using the methods specified in Sections 7 through 10, above.

12. CONTINUED AIRWORTHINESS.

12.a. Manufacturing/Quality: Due to the criticality of the thrust reverser, manufacturing and quality assurance processes should be assessed and implemented, as appropriate, to ensure the design integrity of the critical components.

12.b. Reliability Monitoring: An appropriate system should be implemented for the purpose of periodic monitoring and reporting of in-service reliability performance. The system should also include reporting of in-service concerns related to design, quality, or maintenance that have the potential of affecting the reliability of the thrust reverser.

12.c. Maintenance and Alterations: The following material provides guidance for maintenance designs and activity to assist in demonstrating compliance with Sections 7 through 10, above (also reference CS 25.901(b)(2) and CS 25.1529/Appendix H). The criticality of the thrust reverser and its control system requires that maintenance and maintainability be emphasised in the design process and derivation of the maintenance control program, as well as subsequent field maintenance, repairs, or alterations.

12.c.(1) *Design:* Design aspects for providing adequate maintainability should address :

12.c.(1)(a) Ease of maintenance. The following items should be taken into consideration:

- It should be possible to operate the thrust reverser for ground testing/trouble shooting without the engine operating.
- Lock-out procedures (deactivation for flight) of the thrust reverser system should be simple, and clearly described in the maintenance manual. Additionally, a placard describing the procedure may be installed in a conspicuous place on the nacelle.
- Provisions should be made in system design to allow easy and safe access to the components for fault isolation, replacement, inspection, lubrication, etc. This is particularly important where inspections are required to detect latent failures. Providing safe access should include consideration of risks both to the mechanic and to any critical design elements that might be inadvertently damaged during maintenance.
- Provisions should be provided for easy rigging of the thrust reverser and adjustment of latches, switches, actuators, etc.

12.c.(1)(b) Fault identification and elimination:

- System design should allow simple, accurate fault isolation and repair.
- System design personnel should be actively involved in the development, documentation, and validation of the troubleshooting/fault isolation manual and other maintenance publications. The systems design personnel should verify that maintenance assumptions critical to any SSA conclusion are supported by these publications (e.g., perform fault insertion testing to verify that the published means of detecting, isolating, and eliminating the fault are effective).
- Thrust reverser unstowed and unlocked indications should be easily discernible during pre-flight inspections.
- If the aeroplane has onboard maintenance monitoring and recording systems, the system should have provisions for storing all fault indications. This would be of significant help to maintenance personnel in locating the source of intermittent faults.

12.c.(1)(c) Minimisation of errors: Minimisation of errors during maintenance activity should be addressed during the design process. Examples include physical design features, installation orientation markings, dissimilar connections, etc. The use of a formal «lessons learned»-based review early and often during design development may help avoid repeating previous errors.

12.c.(1)(d) System Reliability: The design process should, where appropriate, use previous field reliability data for specific and similar components to ensure system design reliability.

12.c.(2) *Maintenance Control*:

12.c.(2)(a) Maintenance Program: The development of the initial maintenance plan for the aeroplane, including the thrust reverser, should consider, as necessary, the following:

- Involvement of the manufacturers of the aeroplane, engine, and thrust reverser.
- The compatibility of the SSA information and the Maintenance Review Board Report, Maintenance Planning Document, Master Minimum Equipment List, etc. (ref AMC25.19).
- Identification by the manufacturer of all maintenance tasks critical to continued safe flight. The operator should consider these tasks when identifying and documenting Required Inspection Items.
- The complexity of lock-out procedures and appropriate verification.
- Appropriate tests, including an operational tests, of the thrust reverser to verify correct system operation after the performance of any procedure that would require removal, installation, or adjustment of a component; or disconnection of a tube, hose, or electrical harness of the entire thrust reverser actuation control system.

12.c.(2)(b) Training: The following considerations should be taken into account when developing training documentation:

- The reason and the significance of accomplishing critical tasks as prescribed. This would clarify why a particular task needs to be performed in a certain manner.
- Instructions or references as to what to do if the results of a check or operational test do not agree with those given in the Aeroplane Maintenance Manual (AMM). The manual should recommend some corrective action if a system fails a test or check. This would help ensure that the critical components are not overlooked in the trouble shooting process.
- Emphasis on the total system training by a single training source (preferably the aeroplane manufacturer) to preclude fragmented information without a clear system understanding. This training concept should be used in the initial training and subsequent retraining.
- Inclusion of fault isolation and troubleshooting using the material furnished for the respective manuals.
- Evaluation of the training materials to assure consistency between the training material and the maintenance and troubleshooting manuals.

12.c.(2)(c) Repairs and Alterations: The Instructions for Continued Airworthiness essential to ensure that subsequent repairs or alterations do not unintentionally violate the integrity of the original thrust reverser system type design approval should be provided by the original airframe manufacturer. Additionally, the original airframe manufacturer should define a method of ensuring that this essential information will be evident to those that may perform and approve such repairs and alterations. One example would be maintaining the wire separation between relevant thrust reverser control electrical circuits. This sensitivity could be communicated by statements in appropriate manuals such as the Wiring Diagram Manual, and by decals or placards placed on visible areas of the thrust reverser and/or aeroplane structure.

12.c.(2)(d) Feedback of Service Experience: The maintenance process should initiate the feedback of service experience that will allow the monitoring of system reliability performance and improvements in system design and maintenance practices. Additionally, this service experience should be used to assure the most current and effective formal «lessons learned» design review process possible.

12.c.(2)(d)(i) Reliability Performance:
(Operators and Manufacturers should collaborate on these items:)

- Accurate reporting of functional discrepancies.
- Service investigation of hardware by manufacturer to confirm and determine failure modes and corrective actions if required.
- Update of failure rate data. (This will require co-ordination between the manufacturers and airlines.)

12.c.(2)(d)(ii) Improvements suggested by maintenance experience:
(This will provide data to effectively update these items:)

- Manuals
- Troubleshooting
- Removal/replacement procedures.

12.c.(2)(e) Publications/Procedures: The following considerations should be addressed in the preparation and revisions of the publications and procedures to support the thrust reverser in the field in conjunction with CS 25.901(b)(2) and CS 25.1529 (Appendix H).

12.c.(2)(e)(i) Documentation should be provided that describes a rigging check, if required after adjustment of any thrust reverser actuator drive system component.

12.c.(2)(e)(ii) Documentation should be provided that describes powered cycling of the thrust reverser to verify system integrity whenever maintenance is performed. This could also apply to any manual actuation of the reverser.

12.c.(2)(e)(iii) The reasons and the significance of accomplishing critical tasks should be included in the AMM.

12.c.(2)(e)(iv) The AMM should include instructions or references as to what to do if the results of a check or operational test do not agree with those given in the AMM.

12.c.(2)(e)(v) Provisions should be made to address inefficiencies and errors in the publications:

- Identified in the validation process of both critical and troubleshooting procedures.
- Input from field.
- Operators conferences.

12.c.(2)(e)(vi) Development of the publications should be a co-ordinated effort between the thrust reverser, engine, aeroplane manufacturers and airline customers especially in the areas of:

- AMM
- Troubleshooting
- Fault isolation
- Maintenance data computer output
- Procedure Validation
- Master Minimum Equipment List

12.c.(2)(e)(vii) Initial issue of the publication should include the required serviceable limits for the complete thrust reverser system.

13. FLIGHT CREW TRAINING.

In the case of compliance with the «controllability option,» and when the nature of the inflight thrust reversal is judged as unusual (compared to expected consequences on the aeroplane of other failures, both basic and recurrent), flight crew training should be considered on a training simulator representative of the aeroplane, that is equipped with thrust reverser inflight modelisation to avoid flight crew misunderstandings:

13.a. Transient manoeuvre: Recovery from the unwanted inflight thrust reversal.

13.b. Continued flight and landing: Manoeuvring appropriate to the recommended procedure (included trim and unattended operation) and precision tracking (ILS guide slope tracking, speed/altitude tracking, etc.).

Figure 4 - Generic Disk and Rotor terminology used in interim thrust reverser guidance material for minimizing the hazard from engine rotor burst

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4.a - Ring Disk Drum Rotor Cross Section

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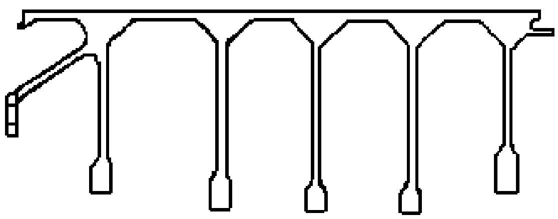

4.b - Deep Bore Disk Drum Rotor Cross Section

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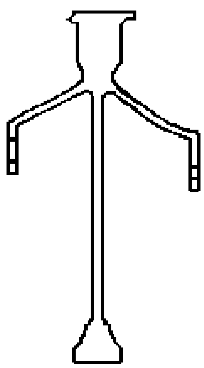

4.c - Single Stage Deep Bore Disk Cross Section

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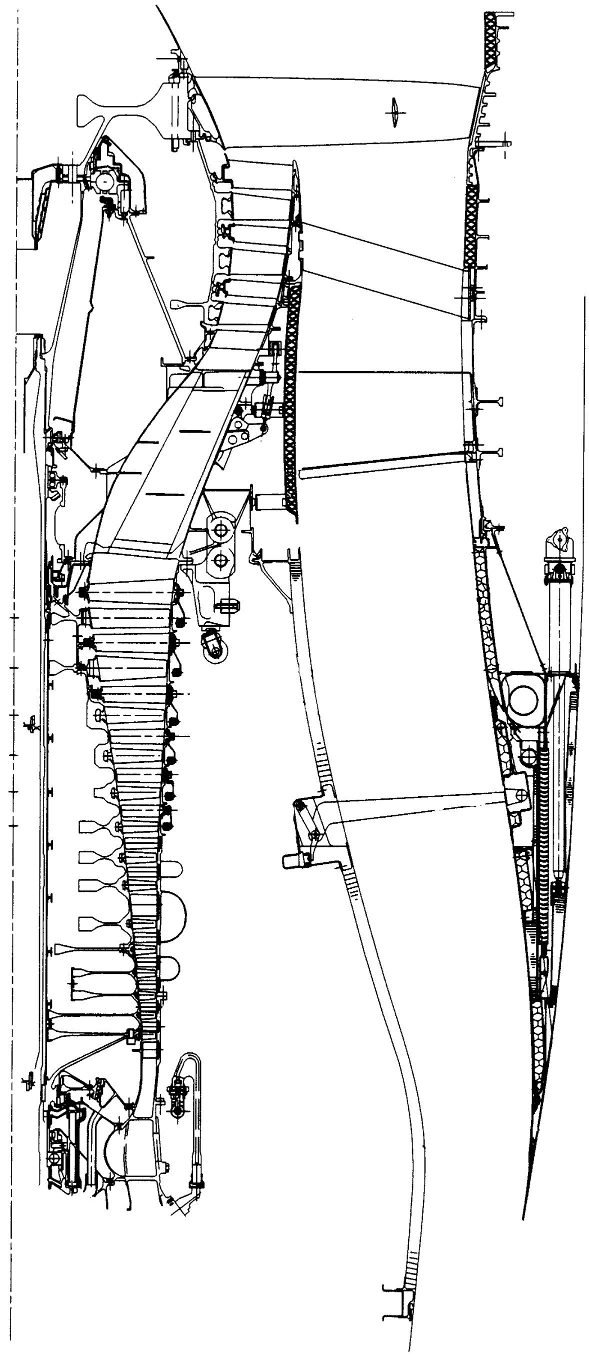

Figure 5:Typical High Bypass Turbofan Low and High Compressor with Fan Thrust Reverser Cross Section

II-C. ORIGINAL JAA NPA 25E-338 proposals justification

1. Summary

On May 26th, 1991, a Boeing Model 767 crashed during climb out from Bangkok, Thailand. The primary cause of the accident was determined to be loss of aircraft controllability following an unwantedinadvertent inflight engine thrust reverser deployment. During the subsequent investigation, it was determined that a reverser inflight deployment can cause previously unforeseen aerodynamic effects on flight control and lifting surfaces behind the reverser. Since these effects could possibly create unsafe conditions on other previously approved transport category airplane type designs, the US Federal Aviation Administration (FAA) and Aerospace Industries Association (AIA) established a steering committee consisting of representatives from transport aeroplane and engine manufacturers, the FAA, the Joint Airworthiness Authorities (JAA), and Transport Canada to assess and address "Transport Turbojet Fleet Thrust Reverser System Safety". The steering committee broke this activity up into three tasks. Task one was to gather relevant in service information. Task two was to provide guidelines for determining if an unsafe condition exists on any turbojet thrust reversing system within the subsonic transport category aeroplane fleet. Task three was to review the existing regulations and evaluate the need for amending those regulations.
The steering committee concluded that assuring adequate control margins is not practical for all transport aeroplane types, especially those with wing mounted high bypass ratio turbofan engines. Furthermore, the committee concluded that improved safeguards against the occurrence of unwantedinadvertent inflight deployment could provide at least an equivalent level of safety to assurances of adequate control margins following such a deployment.
Consequently both "reliability" and "controllability" acceptance criteria were developed by the steering committee to help the FAA assess whether or not a catastrophic inflight thrust reverser deployment is anticipated to occur on a given type design.
Following completion of tasks one and two, the FAA began performing evaluations under Section 609 of the Federal Aviation Act and requiring modifications to in service aeroplanes that did not meet either the "reliability" or "controllability" criteria established by the steering committee. This FAA Thrust Reverser Fleet Review is ongoing.
The FAA/AIA committee also concluded that changes to the regulations would likely be necessary. Since the steering committee was not an approved advisory committee to the FAA, the Aviation Rulemaking Advisory Committee (ARAC) was tasked with completing the review of existing regulations and with developing any needed amendments to those regulations and the associated guidance material.

Meanwhile, in order to provide guidance using lessons learned from the 767 accident and from the resulting activities and investigations, JAA had developed INT/POL/25/07 (current denomination TGM/25/01) to provide policy for showing compliance to JAR 25.933. The policy was based upon showing inflight thrust reverser deployment to be extremely improbable as per JAR 25.1309, or in absence of such a demonstration requiring flight tests to show full controllability across the entire flight envelope.

This NPA proposes to revise JAR 25.933 "Reversing systems" of the Joint Aviation Requirements for Large Aeroplanes (JAR-25) by incorporating changes developed in co-operation with the US Federal Aviation Administration (FAA) and the Aviation Rulemaking Advisory Committee (ARAC). These proposals are intended to achieve common requirements and language between the JAR and FAR requirements and also make some of the requirements more rational, while significantly improving the level of safety provided by the current requirements.

2. Background

The manufacturing, marketing and certification of large aeroplanes is increasingly an international endeavour. In order for European manufacturers to export aeroplanes to other countries, the aeroplane must be designed to comply, not only with the European airworthiness requirements for large aeroplanes (JAR-25), but also with the airworthiness requirements of the countries to which the aeroplane is to be exported.
JAR-25 is developed in a format similar to FAR 25. Many other countries have airworthiness codes that are aligned closely to JAR-25 or to FAR 25, or they use these codes directly for their own certification purposes.
Although JAR-25 is very similar to FAR 25, there are differences in methodologies and criteria that often result in the need to address the same design objective with more than one kind of analysis or test in order to satisfy both JAR and FAR 25. These differences result in additional costs to the large aeroplane manufacturers and additional costs to the JAA and foreign authorities that must continue to monitor compliance with a variety of different airworthiness codes.

In 1988, the JAA, in co-operation with the FAA and other organisations representing the European and U.S. aerospace industries, began a process to harmonise the airworthiness requirements of the European authorities with the airworthiness requirements of the United States. The objective was to achieve common requirements for the certification of large aeroplanes without a substantive change in the level of safety provided by the requirements. Other airworthiness authorities such as Transport Canada have also participated in this process.

In 1992, the harmonisation effort was tasked by the FAA to the Aviation Rulemaking Advisory Committee (ARAC) on the US side.

In co-operation and conjunction with ARAC, a working group comprised of specialists from both industry and aviation regulatory authorities from Europe, the United States, and Canada was established to work on the powerplant installation requirements of Subpart E of JAR/FAR 25, "Powerplant". This group is the Powerplant Installation Harmonization Working Group (PPIHWG).

A dedicated Task Group of the Powerplant Harmonization Working Group was set up to deal with the Reversing System requirements.

This notice contains the proposals made by this Task Group, necessary to achieve harmonisation for the Revering Systems design and analysis requirements of JAR/FAR 25, contained currently in JAR 25.933(a).

3. Discussion of the proposals

3.1 Relevant regulatory history

The precursor to the current FAA part 25 §25.933(a)(1) was introduced as CAR 4b.407 Amendment 1, effective December 31,1953. While this rule was applicable to “propeller reversing systems”, the concept that “no single failure or malfunctioning” should result in “a position substantially below the normal flight low-pitch stop” established a regulatory concept of preventing “unwanted reverse thrust” that would then be applied to all types of “reversing systems” by Amendment 11 to CAR 4b.407(a). CAR 4b.407(a) was recodified into §25.933(a) when FAR part 25 was created. While other thrust reverser regulatory activity occurred in Amendment 11 to CAR 4b.407 as well as in Amendments 25-11 and 25-38 to FAR 25.933, it was not until Amendment 25-40 that the approach to regulating unwanted reverse thrust changed significantly.

Amendment 25-40, effective February 17, 1977, introduced a requirement within §25.933(a) to show that :

"(a) Each engine reversing system intended for ground operation only must be designed so that during any reversal in flight the engine will produce no more than flight idle thrust. In addition, it must be shown by analysis or test, or both, that-

> (1) the reverser can be restored to the forward thrust position or
>
> (2) the airplane is capable of continued safe flight and landing under any possible position of the thrust reverser."

In part, the justification given for these changes was : "A review of the past operating history of aeroplane engine thrust reversers indicates that fail-safe design features in the reverser systems do not always prevent unwanted deployment in flight. Many of these unwanted deployments are not caused by deficiencies in design but can be attributed to maintenance omissions, wear and other like factors that cannot be completely accounted for in the original design and over which the manufacturer generally has no control even when comprehensive maintenance programs are established. Since the existing reverser design standards are inadequate, it is felt that it is incumbent on the aeroplane manufacturers to investigate the effects of various types of failures either by analysis and or flight and ground tests, as well as establishing operating limitations and incorporating safety features so that catastrophic situations do not develop from unwanted deployment in flight or on the ground."

Shortly after this Amendment was adopted, FAA realised that the word "or" in section 25.933 (a)(1)(i) should have been "and". Since unwantedinadvertent deployment is likely to render the reverser "inoperable", the FAA applied the regulation as if it read "each operable reverser can be restored to the forward thrust position <u>and</u> the airplane is capable of continued safe flight and landing under any possible position of the thrust reverser". The rule itself was revised to reflect this interpretation by Amendment 25-72, effective July 20, 1990. JAA did not adopt this amendment in JAR-25.

From a JAA perspective, the basic 25.933(a) rule was copied from FAR 25 and subsequent amendments to §25.933(a) have generally been adopted as proposed by FAA, except for the last one (Amendment 25-72). However, it should be noted that JAA certification usually placed emphasis on system reliability with demonstration by means of a numerical analysis, in addition to or replacing controllability demonstration. This was reflected in TGM/25/01, published after the 767 accident.

<u>3.2 Need for yet another regulatory change</u>

The service history of aeroplanes certified as being "capable of continued safe flight and landing under any possible position of the thrust reverser" indicates that the intent of this "fail-safe" requirement has also not been achieved. This service history is summarised in the FAA/AIA thrust reverser steering group document "Criteria for Assessing Transport Turbojet Fleet Thrust Reverser System Safety", Rev. A, dated June 1st, 1994.

Accidents have occurred on aeroplanes that apparently were "capable of continued safe flight and landing" had the flight crew responded to the unwantedinadvertent deployment in the manner assumed during certification. Accidents have also occurred on aeroplanes that apparently were not "capable of continued safe flight and landing" regardless of the flight crew response. In most cases the influences which caused the associated compliance findings to become invalid were either not identified or oversimplified during certification.

However, the complexity and diversity of conditions that might influence the actual probability or severity of unwanted reverse thrust make it logistically impractical to explicitly demonstrate compliance for any and all combinations of these conditions.

If future type designs are to be “capable of continued safe flight and landing under any possible position of the thrust reverser” as currently required or to “prevent unwanted reverse thrust” as required prior to Amendment 25-40, then certification compliance substantiation’s and instructions for continued airworthiness must become more comprehensive than those which proved ineffective in the past. However, the complexity and diversity of conditions that might influence the actual probability or severity of unwanted reverse thrust make it logistically impractical to explicitly demonstrate compliance for any and all combinations of these conditions. Consequently, it is essential to establish some acceptable conservative means of simplifying these compliance substantiation’s. The previously-accepted "simplifications" that have been addressed in reversing system compliance substantiation’s are reviewed below. These simplifications, each with their notable shortcomings, are described below:

Some previously accepted simplifications with notable shortcomings are: assuming flight, maintenance, or manufacturing/modifying personnel perform their duties as intended may be invalid due to the impacts of anticipated alternate human behaviours; assuming failure modes and effects will/will not occur may be invalid because all relevant variables, such as manufacturing/modifying variability, externally applied stresses, situational and conditional variations, etc. were not properly accounted for; assuming the aircraft is operating “normally” in a “wings level” attitude with no other faults present just prior to deployment may be invalid due to the impacts of anticipated latent failures, MMEL relief, transient manoeuvres, abnormal operations, etc.; assuming the effects of the initial engine power level are negligible or can be modelled as a simple decaying asymmetric force may be invalid due to non-linear engine power dependent aerodynamic influences (e.g. lift loss due to reverser efflux influences on the airflow over the wing).; assuming the “worst case” thrust reverser inflight deployment is a fully deployed reverser at the highest anticipated total pressure flight conditions may be invalid because other anticipated thrust reverser failures or flight conditions are more severe; assuming crew procedures and/or aeroplane simulations can be validated by extrapolating the results of limited testing may be invalid because all significant influences are not adequately accounted for in the extrapolation; and assuming an aeroplane which is capable of recovering from a deployment transient, descending, and landing with the reverser deployed is airworthy may be invalid due to the effects a deployment would have on range, performance, and/or other capabilities required to assure continued safe flight and landing at a suitable airport under any anticipated conditions.

When the FAA/AIA thrust reverser steering committee group considered into making compliance substantiation’s more comprehensive, it concluded: it is not practical to always assume a deployment occurs regardless of the probability; and certain otherwise beneficial design features can make it impractical to assure continued safe flight and landing following an inflight reverser deployment for the reasons discussed below under «Evaluation of Regulatory Options Pertaining to Thrust Reverser Systems»..

The ARAC Thrust Reverser Task Group evaluated the controllability of various aeroplane types to better understand the effects of thrust reverser deployment on aeroplane controllability. This group determined that newer technology aeroplanes with high bypass ratio engines located under the wing typically have the least control margin, particularly at high speeds. The primary causes of the lower control margin is the relatively large diameter and thrust level of the new technology high bypass ratio engines and the associated engine mounting systems which reduce the distance between the wing and the engine. These “short struts” are needed to reduce aerodynamic drag and provide ground clearance for these larger diameter engines. During a thrust reverser deployment at high speed, these "closely coupled" engines cause a significant disruption of the airflow over the wing upper surface resulting in a loss of wing lift that induces the aeroplane to roll and nose down. This reaction can be so dynamic that it is not reasonable to rely on pilot actions alone to accommodate them.

A review of developing engine technology shows that a major improvement in fuel efficiency is offered by a future generation of engines with bypass ratios well in excess of current engines and may incorporate variable geometry of the engine or nacelle to provide the needed reverse thrust (e.g. reversable pitch fan blades similar to current turbo propeller driven aeroplanes). The increased bypass ratios mean close coupled mounting systems will continue to be prevalent with these engines. Some increase in bypass ratio with fixed pitch fans is also likely in the near future.

The ARAC Thrust Reverser Task Group, in recognition of the adverse thrust reverser service history, the practical limitations on being “capable of continued safe flight and landing under any possible position of the thrust reverser”, the practical limitation on assuring a deployment will not occur delineated in the justifications for Amendment 40 to §25.933(a), determined that both a regulatory and policy amendment was required to provide the most comprehensive means of assuring an acceptable level of thrust reverser safety in the future.

3.3 Evaluation of thrust reverser regulatory options

The task group evaluated numerous design options to determine what technically feasible and economically justifiable change to the current standards would provide the desired level of safety. The following is a summary of the options considered and conclusions reached. The options considered included: 1) eliminating thrust reverser systems; 2) providing adequate assurances of continued safe flight and landing following an assumed unwantedinadvertent deployment as intended by the current requirement of JAR 25.933(a) (FAR 25.933 (a)(1)); and 3) providing adequate assurances that unwantedinadvertent deployment will not occur as intended by §25.933 (a) prior to Amendment 25-40.

<u>Option one - Eliminating thrust reverser systems</u>

Elimination of thrust reverser systems was not found to be an airworthiness improvement. Although thrust reverser systems are not required by the JAR requirements or FARs, these systems are helpful to safely stop aeroplanes on runways with contaminated and slippery surfaces. The use of reversers also reduces brake wear. The need for thrust reversers on many aeroplane types has been demonstrated by recent service history. Deactivation of thrust reverser systems of several aeroplane types as a result of the Boeing 767 accident resulted in a significant increase in landing field lengths on contaminated surfaces. During the short period when the thrust reversers systems were deactivated, one operator's aircraft, when landing on an icy runway, experienced an overrun due to lack of stopping power provided by the brakes[See NPRM Action #3]. . Other options for eliminating thrust reversers that were evaluated included: reduced landing speeds such that thrust reversing systems would not be necessary; and installation of runway overrun facilities or arresting gear at each airport. Given the service history of overruns, the later option was seen as beneficial even if reversers were retained. However, implementing any of these options was considered impractical due to obviously prohibitive costs and logistical problems.

<u>Option two - Assuring continued safe flight and landing following inflight deployment</u>

The task group concluded that option two requires aeroplane control margins such that, even with a reasonable delay in flight crew response following an unwantedinadvertent deployment, the aeroplane would still clearly be capable of continued safe flight and landing. This means that the control margins on some aeroplane types would have to be substantially improved. The methods for improving aeroplane control margins that were evaluated include : 1) increasing the size of aeroplane control surfaces, 2) increasing the separation distance between engine and wing so that the resulting reverser efflux would not impinge on the upper wing surface, 3) revising the reverser efflux pattern such that only a minor disruption of airflow over the wing would occur, 4) mounting the engines on the aft fuselage such that a reverser deployment would not result in wing lift loss, 5) commanding the engine power from high power to low power during an unwanted inflight reversal in a rapid fashion such that the engine compressor will stall thereby resulting in only a minor disruption of airflow over the wing. The following are summaries of the economic evaluation of each of the proposals.

To assess the impact and cost of the control system changes required for a typical aircraft to achieve full controllability across the normal flight envelope, a study was conducted in August 1993. Results indicate an increase in direct operating costs of approximately 0.5 % for typical airline operation. The increased cost arises from the additional drag and weight associated with increases in both control surface area and actuation system capability. Results for wing mounted twin and quad jet engine installations were similar.

Not counted in this assessment is the effect of the harsh ride associated with faster control response nor the cost of advanced avionics to operate the fast-response aspect. Also not counted are the additional significant costs that would be associated with adhering to the proposed roll angle limits, control forces limits, and post-event performance requirements now required by the controllability option.

Increasing the wing to engine separation distance was found to significantly inhibit aeroplane design. Installation of large diameter high bypass engines under the wing results in the need to close couple the engines to the wing to maintain entry door sill heights so that current terminals can be utilised. Additional costs of increasing the separation distance include added drag, and increased weight because longer landing gear and engine struts would be required.

Revising the efflux pattern of the thrust reversers, while maintaining the thrust reverser effectiveness, was found to not be technically feasible. Currently the thrust reverse efflux pattern is "tuned" such that; 1) the airflow is directed away from the fuselage so that foreign object/ice damage to the fuselage will not occur, 2) the airflow will not discharge under the wing and cause a net lifting of the airframe and subsequent reduced braking effectiveness. Based on these design constraints, wing mounted engine efflux patterns are generally limited to four areas around the engine circumference at roughly 45° angles from the horizontal. Redirection of the efflux pattern in the upper quadrant would result in loss of reverser effectiveness and asymmetric loading of the engine fan, thereby significantly increasing weight and operating costs.

The option of mounting all future engines in the aft fuselage location or above the wing, so wing lift loss would not occur, was evaluated and found to result in severe economic penalties. These costs primarily are the result of increased interference drag and weight penalties associated with the aft fuselage location.

The option of designing engines so that a non-recoverable compressor stall would occur if an unwantedinadvertant inflight deployment were detected was found to be effective at improving aeroplane controllability for certain aeroplane types. However, introduction of this feature could reduce engine reliability, increase engine maintenance costs, and was not found to be effective on certain aeroplane or engine types.

Option three - Assuring deployment will not occur inflight
The requirements used to assure that other critical systems don't prevent continued safe flight and landing were evaluated to determine if they could be effectively applied to thrust reverser systems. Unwanted deployments have occurred on thrust reverser systems that were certificated as critical systems due to factors deemed by the Preamble to Amendment 25-40 to §25.933(a) to be beyond the control of the manufacturer. Even more recent service history indicates that these unwanted deployments continue to occur due to factors such as: inappropriate maintenance; intermittent wiring faults; etc., that are not traditionally covered by system safety assessments.

As a result of other JAA and FAA tasking, ARAC Task Group is proposing revisions to FAR/JAR25.1309 and FAR/JAR25.901(c) and the associated advisory materials (i.e. AMC25.1309 and the new ACJ 25.901) that was established within the PPIHWG to determine the applicability of FAR/JAR25.1309 to powerplant installations and to harmonize FAR/JAR25.901(c). It is the intent of this group that the revised §25.901(c) requirement and new Advisory Circular they are developing will better address system safetythose factors that have contributed to previous unwanted thrust reverser deployments.

Incorporation of additional redundant locking mechanisms within the reverser system has been identified as one option for increasing the safeguards against deployment. Additional redundant locking mechanisms have been incorporated into several aircraft type designs by Airworthiness Directive to address unsafe conditions in service. Also, during several recent JAR-25 or FAR 25 certification programs additional redundant locking mechanisms in conjunction with more rigorous design and maintenance assessments have been found necessary to comply with JAR 25.933(a) using TGM/25/01 principles or to provide an "Equivalent Level of Safety" to comply with FAR 25.933(a)(1)(ii). However, this is only one option and can result in reduced thrust reverser operational reliability as well as increased manufacturing and operating costs.

Conclusion reached
Evaluation of the options discussed above indicates that there are means of improving the historical level of safety through both options two and three. Given the foreseeable constraints on transport category aeroplane type designs, neither option can exclusively provide an effective, technologically feasible, and economically practical alternative for all future designs. Consequently,

the group concluded that the applicant should be able to select the most suitable option for a particular type design or failure condition.

A minority proposed that the rule and ACJ should restrict the use of the “reliability option” to those cases where the “controllability option” is not “practicable”. That is, the objective of the current rule would be retained but the rule would be revised to provide a “built in exemption”. This minority contended that, given the Amendment 40 justifications for no longer allowing a “reliability option”, it would be inappropriate to unconditionally re-introduce the “reliability option”. The majority concluded that, given the improved “reliability option” guidance provided in the proposed Advisory Materials, that the two options can be viewed as equivalent. Therefore no “bias” towards the “controllability option” is warranted. The comment document in the docket associated with the related Advisory Material (i.e. ACJ 25.933(a)) contains a more detailed record of minority and majority comments on this Minority Position.

Some members of the group contended If the “restow” and “idle” related prescriptive design requirements within the current JAR 25.933(a) rule should be retained. However, the majority concluded that if such design features are required to meet the objective of the proposed rule, then they would be implicitly made part of any approved design. However, if such features are not required to meet the objective of the proposed rule, then there is no justification for making them mandatory. Consequently, the group concluded that these prescriptive design requirements should not be explicitly included in the proposed rule. (Note: Minority Opinion)

Lastly, the group concluded that each thrust reversing system intended for ground use only should be inhibited from selection inflight. The group decided this proposal should not be part of this rule change, but rather should be part of another ARAC task currently aimed at amending FAR/JAR 25.1155 to : “prevent the flight crew of turbopropeller powered aeroplanes from unwantedinadvertently or intentionally placing the power lever below flight idle (beta operation) while inflight, unless the aeroplane has been certified for inflight beta operation”. The scope of this activity would be expanded to include reverser thrust from turbojet as well as turbopropeller powered aeroplanes.

Therefore, it is proposed to revise JAR-25 as discussed below.

<u>3. 4 Discussion of the proposals</u>

It is proposed amending JAR 25.933(a), as recommended by the ARAC, to incorporate needed flexibility in the standards applicable to engine thrust reverser systems and to harmonise these sections with FAR 25. The FAA intend to publish a Notice of Proposed Rule Making (NPRM), also developed by the Powerplant Installation Harmonization Working Group, to revise FAR 25 to ensure harmonisation in those areas for which the proposed amendments differ from the current FAR 25. Actually, this NPA is using some of the material intended to be published in the FAA NPRM.

It is proposed to amend JAR 25.933(a) to read as follows :
"(a) For turbojet reversing systems
(1) Each system intended for ground operation only must be designed so that either—
(i) The aeroplane can be shown to be capable of continued safe flight and landing during and after any thrust reversal in flight; or
(ii) It can be demonstrated that inflight thrust reversal is extremely improbable and does not result from a single failure or malfunction.
<u>(See ACJ 25.933(a)(1).)</u>"

Issuance of a new ACJ is also proposed to promote consistent and effective application of these proposed revised standards. Appendix 1 to this NPA is containing the text of the ACJ.

4. Economic Impact Evaluation / Assessment

The economic analysis performed using the proposal made by the Thrust reverser Task Group from PPIHWG has been performed by a FAA economist. Due to the lack of JAA economists, no equivalent analysis has been performed on the European side, however, the FAA analysis is providing sufficient data for the purpose of this NPA.

In conducting the economic analysis, the FAA has determined that this proposed rule would generate benefits that justify its costs.

4.1 Benefits

The proposed rule would generate threewo types of benefits. The first type of benefit would be derived from that the proposed enhancement of requirements would aeroplane controllability and thrust reverser system reliability requirements, thereby minimisinge the potential for a catastrophic accident arising from an unwantedinadvertent inflight thrust reversaler activation. The second type of benefit would be the increased safety that the continued use of thrust reversers provides during landings and rejected take-off - particularly on rainy or snowy runways. The thirdsecond type of benefit would be to reduce future compliance costs because that the flexibility in compliance provided by the proposed rule would allow airplane and engine manufacturers to achieve this increased level of safety in the most cost-effectiveicient manner for their their individual future aeroplane models.

The principal benefit from the proposed rule would be that increasing thrust reverser reliability or airplane controllability would minimize the potential, either for an unwantedinadvertent inflight thrust reversaler activation or for that inflight thrust reversalactivation to result in an uncontrollable airplane. The FAA cannot precisely quantify However, the expected potential increased safety benefits from the enhanced requirements from this proposed rule cannot be quantified because the Agency cannot predict the number of preventable future unwanted inflight thrust reversal accidents that would occur it would apply only to new type certificated aeroplanes. and neither the number of future type certificates nor the number of those models that would be sold can be predicted with any degree of accuracy. Nevertheless, the potential benefits from preventing even one such accident can be illustrated by using a hypothetical accident occurring to a twin turbofan engine aeroplane between 5 years and 10 years old and carrying between 150 and 250 people. as demonstrated by the following example involving the 223 fatalities in the May 26, 1991, accident, the potential benefits from preventing one such accident would be substantial. Using the Department of Transportation's estimate that society would be willing to pay $2.7 million to prevent a single fatality in an aeroplane accident, the FAA estimates that preventing those 150 to 250 223 fatalities would have produce resulted in a benefit of about $405602 million to $675 million. An average 5 year to 10 year old aeroplane would have a value of between $25 million and $60 million. In addition, the destroyed Boeing 767-300ER was 2 years old, which would give it an average value of about $85 million. Finally, the cost of investigating such an accident would be (based on the Pan Am 103 bombing over Lockerbie, Scotland) about $30 million. Thus, the potential potential benefits from preventing one such future accident similar to the accident that occurred would be between about $460717 million and $765 million.

The fact that nearly all turbofan aeroplanes use thrust reversers even though they are expensive to maintain and operate and they are not required equipment for compliance with FAA regulations presents strong evidence that operators view thrust reversers as an important component of aeroplane safety. A January, 1994, National Aeronautics and Space Administration (NASA)/FAA/Industry Aircraft Deceleration Working Group study (Thrust reversers: are they really needed?) estimated (p. 4) that the thrust reverser system costs for a large transport category aeroplane is approximately $221,550 per aeroplane (updated to 1997 dollars). It also reported (p. 4) that thrust reversers reduce annual braking system maintenance by about $13,775 per aeroplane (study estimate updated to 1997 dollars). Thus, the annualised net cost of using thrust reversers was estimated to be about $207,775 per aeroplane. Clearly, most operators have determined that these expensive systems provide a positive (although unquantified in this analysis) safety benefit.

Although the FAA cannot quantify this potential future cost savings from allowing either reliability or controllability because the forms that future technologies will take and their impacts on costs is not capable of being predicted, the FAA concludes that greater compliance flexibility could reduce compliance costs.

4.2 Costs of compliance

Since the 1991 Lauda accident, enhanced criteria have been used when demonstrating an aeroplane is controllable under the existing rule. This proposal does not change the existing controllability requirements, it merely provides a reliability based alternative. Under this proposal, an applicant would either have to demonstrate that the aeroplane is controllable as required by the existing rule, or that the thrust reverser system meets the optional reliability requirements added by this proposal. Since the costs of demonstrating controllability are unchanged and demonstrating reliability is optional, this proposal does not require any additional compliance costs to be incurred.

4.3 Alternative means of addressing this issue

In addition to the proposed rule, the Group reviewed 6 alternatives means of addressing this issue. One alternative would be to eliminate thrust reversers. A second alternative would be to require greater aeroplane controllability without allowing the option of the applicant meeting a reliability criterion. The other 45 alternatives would require were to specificy methods that wouldcould, potentially, provide greater aeroplane controllability but which have been rejected for technical reasons delineated elsewhere in this NPA and economic reasons delineated below. in the event of an unwantedinadvertent inflight thrust reversaler deployment.

4.3.1 Benefits and costs from eliminating thrust reversers

With respect to eliminating thrust reversers, the ain January, 1994,, a joint National Aeronautics and Space Administration (NASA)/FAA/Industry study reported (p. 8) calculated that thrust reversers contribute less than about 20 percent of the overall stopping retarding force on a dry runway. butHowever, on a slippery runway (from rain, snow, etc.) the thrust reverser braking effect can nearly equal wheel braking forces. nearly 50 percent of the overall stopping retarding force on a wet or icy runwa Similarly, thrust reversers significantly contribute to stopping an aeroplane safely during a rejected takeoff. As noted earlier in the Notice, one runway overrun event occurred during the short period of time that thrust reversers were deactivated. Consequently, tThe FAA evaluated several believes that eliminating thrust reversers without introducing compensating factors for thrust reversers (such as reducing landing speeds, extending runways, and having arresting gear at

airports), but determined that at the current state of technology, these compensating factors would be **eatures in the airplane design or airports** would reduce overall airline operational safety.either more hazardous or technologically infeasible. As a result, the FAA believes that eliminating thrust reversers would reduce overall airline operational safety.
In addition to those safety benefits from using thrust reversers, thrust reversers substantially reduce the wear and tear on the airplane's brakes. The NASA/FAA/Industry study reported that thrust reversers reduce brake maintenance costs by about 25 percent. On page 13 of that study, it was reported that an airline spends an average of $33,250 to $59,750 per airplane with a weighted average of $43,400 per airplane on annual brake system maintenance. Thus, the use of thrust reversers would reduce the average annual brake maintenance cost by about $10,850 per airplane. (Note: the study's reported costs are updated to 1997 dollars for this report). In the FAA Aviation Forecast, it is reported that about 4,950 transport category airplanes are in the 1997 U.S. fleet and this number will increase by 3.4 percent annually (p. III-42). Thus, the annual brake maintenance cost savings due to thrust reverser use would be about $53.708 million and would increase by about $1.826 million every year. (Where do you address/contrast the costs of having, using, and maintaining thrust reversers ?)

4.3.2 Benefits and costs from requiring greater aeroplane controllability for all aeroplanes

As previously discussed, the FAA believes that compliance with the reliability criterion would provide the same level of safety as compliance with the controllability criterion. Thus, requiring all aeroplanes to meet the controllability criterion would not increase the level of safety.

It is likely that some transport category aeroplanes could achieve greater aeroplane controllability at little or no additional cost. However, given current technology, some other transport category aeroplanes, especially those using high bypass turbofan engines, could only attain greater aeroplane controllability through a redesign that would necessitate additional equipment. This additional equipment would, in turn, increase those aeroplanes' weight, aerodynamic drag, and maintenance. Thus, this alternative would generate increased annual operating costs as well as increase the manufacturing cost.

In order to estimate the potential cost increases that would occur if only the controllability criterion were allowed, the FAA assumes that the typical future larger transport category type certificate aeroplane would be similar in overall design to recent certificated models. The FAA has relied upon two manufacturers' estimates of the impact that compliance with controllability would produce. For those aeroplane models, the manufacturers estimated that controllability would require a The second alternative was to 50 percent increase in the size of airplane control surfaces. One airframe manufacturer provided estimates of the changes that would need to be made on a future design four engine widebody if, using current technology, controllability were to be required. They first determinedthat the aeroplane's rudder surface (a 0.2 percent increase in the aeroplane's weight) and the addition of 12 spoilers and 4 ailerons (a 0.3 percent increase in the aeroplane's weight). Thus, this alternative would increase an would need to be increased by 50 percent. It was not reported whether this larger rudder surface would result in increased installation costs. However, it would aeroplane's weight by about add00.52 percent. in weight to the airplane.

The FAA assumes that the percentage increase in weight would approximately translate into an equivalent percentage increase in fuel and oil consumption. The FAA's <u>Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs</u> reports (Table 4-1B on p. 4-4) that the average per airborne hour fuel and oil cost is $2,703 for a four-engine widebody, $1,152 for a two-engine widebody, and $665 for a two-engine narrowbody. Applying the 0.5 percent increased weight factor produces an increased per airborne hourly cost of about $13.50

for a four-engine widebody, about $5.75 for a two-engine widebody, and about $3.30 for a two-engine narrowbody. Using data derived from Tables 16 and 17 (pp. IX-18 and IX-19) in the FAA Aviation Forecasts Fiscal Years 1998-2009, the average annual airborne hours is about 3,000 hours for a four-engine widebody, about 3,100 hours for a two-engine widebody, and about 2,800 hours for a two-engine narrowbody. Thus, the increased annual fuel and oil costs that would be due to this additional weight are estimated to be about $40,000 per four-engine widebody, about $17,825 for a two-engine widebody, and about $9,250 for a two-engine narrowbody. For a typical four engine widebody with an empty weight (a gross takeoff weight) of about 145,000 (542,300) pounds, a 0.2 percent increase would be about 290 (1,085) additional pounds.

Further, the larger increased rudder surface would raise increase airplane friction aerodynamic drag by 1.5 percent, which would be equivalent to a 0.35 percent increase in direct operating costs. The FAA estimates that the direct operating costs per airborne hour would be about $4,880 for a four-engine widebody, about $2,265 for a two-engine widebody, and about $1,340 for a two-engine narrowbody. Multiplying those per airborne hour additional cost by the reported number of average airborne hours per year and then by 0.35 percent produces an additional annual per aeroplane cost due to the increased aerodynamic drag of about $49,400 for a four-engine widebody, about $24,550 for a two-engine widebody, and about $1,125 for a two-engine narrowbody.In addition to the increased rudder surface, each airplane would need 12 additional spoilers and 4 additional ailerons. Each spoiler was reported to cost about $8,000 and each aileron actuator was reported to cost about $10,000 in 1992 dollars. Updating these 1992 dollars to 1997 values results in unit costs of about $9,350 and $11,675. Thus, this additional equipment would cost about $112,200 for the spoilers and $46,700 for the ailerons, for a total equipment cost increase of $156,900 per air

These additional spoilers and ailerons would increase the airplane's weight by 0.3 percent, or about 435 (1,625) pounds.

Further, there would also be additional maintenance costs for these additional spoilerss and ailerons would require annual maintenance that would . These maintenance costs were reported cost (in 1992 dollars) to be about $1 per airborne flight hour for each aileron and to be, on average, on average, $0.05 per airborne flight hour for each spoiler. Updating the estimated costs to 1997 dollars results in an Thus, the total annual increased maintenance cost of would be $5.154.60 (in 1992 dollars) per airborne flight hour. Multiplying these per airborne hour additional maintenance by the reported number of . Updating to 1997 values results in a per flight hour additional maintenance cost of $5.35. annual airborne hours per aeroplane produces an additional annual maintenance cost of about $15,450 for a four-engine widebody, about $15,950 for a two-engine widebody, and about $14,425 for a two-engine narrowbody.Based on an FAA study, each additional pound on a four engine widebody airplane would require an additional 15.4 gallons of fuel per year. Thus, for an increased weight of 725 (2,710) pounds and an estimated average fuel cost of $0.62 per gallon, the total annual weight fuel penalty would be about $6,925 ($25,875) for each airplane.[Note: the use of the empty and (max gross weight) points is confusing and not very informative. Couldn't you just use an average operating weight of around 40% of max gross ?]

The total overall increase in airplane drag of 1.5 percent was reported to be equivalent to a 0.28 percent increase in direct operating costs. The FAA currently estimates that direct operating costs for a commercial transport category airplane of approximately $3,800 per flight hour. The FAA has estimated in its 1997 FAA Aviation Forecasts for Fiscal Years 1998-2009 that the average widebody operates about 3,200 flight hours per year. Thus, the additional annual drag cost is estimated to be about $34,050 per airplane.

Further, the additional maintenance cost of $5.35 per flight hour when multiplied by the 3,200 annual flight hours typically flown by a four engine widebody would produce an estimated annual maintenance cost increase of about $17,125 per airplane.

Consequently, the total increase in annual operational costs per aeroplane due to the increased weight and drag would be about $58,100 ($75,050) $104,850 for a four-engine widebody, about $58,325 for a two-engine widebody, and about $36,800 for a two-engine narrowbody.

In 1997 dollars, the reported cost would be about $8,960 for each spoiler actuator and would be about $11,200 each aileron actuator. Thus, this additional equipment would cost about $107,500 for the 12 additional spoiler actuators and $44,800 for the 4 additional aileron actuators, for a cost increase of $152,300 per aeroplane.

In addition, the oversized flight controls would need more complex control systems that are estimated to add 0.1 percent to the price of the aeroplane. Based on average prices of about $140 million for a new four-engine widebody, about $100 million for a new two-engine widebody, and about $40 million for a new two-engine narrowbody, the FAA estimates that the resultant increase in aeroplane cost due to the more complex control systems would be about $140,000 for a new four-engine widebody, about $100,000 for a new two-engine widebody, and about $40,000 for a new two-engine narrowbody.

Thus, the total increase in the cost of a new aeroplane due to the additional or upgraded equipment would be about $292,300 for a four-engine widebody, about $252,300 for a two-engine widebody, and about $192,300 for a two-engine narrowbody.

In addition to the increased operational costs, In addition, the additional 725 (2,710) weight and drag may reduce an aeroplane’s revenue because pounds could require the the operator may be required either to carrier either to offload people and cargo or to limit the flight range on certain flights. The difficulty in estimating this revenue loss is that an offloaded person would generally either take a different flight on that airline or take a different airline. Thus, the loss to one operator may result in a revenue gain to another operator. One manufacturer estimated that the effect of these factors would be a 1.5 percent range loss or a 3.5 percent seat capacity loss for a typical 7,000 mile mission. For a hypothetical typical European airline with 40 long range aircraft and 120 short/medium range aircraft, the manufacturer estimated that the annual total revenue loss from these limitations would be $20 million, for an average annual aircraft revenue loss of $125,000. As detailed in the Initial Regulatory Evaluation for this proposed rulemaking, the FAA estimates that the annual average revenue loss from these limitations would be about $110,000 for a four-engine widebody, about $53,000 for a two-engine widebody, and about $10,000 for a two engine narrowbody.A previous FAA study calculated that an additional airplane weight of between 40 pounds and 300 pounds would place weight limitations on 5 percent of the flights and that 12 percent of the displaced passengers or cargo would not obtain another flight. These calculations were based on the average U.S. domestic commercial flight data. That study also, by using a weighted average of passenger and cargo revenue derived from revenue, enplanement, and freight data collected by the Department of Transportation, Office of Airline Statistics, calculated that the average revenue lost would be about $0.30 per pound per average trip of 780 miles. However, the subset of four engine widebody airplanes would have a higher average load factor, an average flight of about 5,000 miles, and average about 600 flights per year. For this report, the FAA further assumes that whereas 12 percent of the displaced passengers on these airplanes would not obtain another flight all of the cargo would obtain another flight. On those bases, the FAA has estimated that approximately 10 percent of a four engine widebody flights (about 60 per year) would be weight limited. Further, with the increased average flight length from 780 miles to 5,000 miles and the assumption that all of the lost revenue would be derived from passenger loss, the lost revenue per pound per flight is estimated to be about $2.50. Assuming that the amount of poundage bumped would equal the added 725 (2,710) pounds] per affected flight, the annual revenue loss would be (60 flights X 725 (2,710) pounds X $2.50 per pound X 0.12) about $13,050 ($48,775) per airpl

Consequently, the FAA estimates that the range (including the manufacturer’s estimated per aeroplane lost revenue of $125,000 per aeroplane) of total annual negative economic impact (increased cost (annual operational cost plus annual lost revenue) would be between $402,000 and

$417,000 for a four engine widebody airplane, would be about $71,150 ($123,825).between $305,000 and $377,000 for a two-engine widebody, and between $202,000 and $317,000 for a two-engine narrowbody.
Another manufacturer reported that the compliance costs for a 2 engine narrowbody may even be larger than those costs for a 4 engine widebody because an entirely new control system may need to be developed. The manufacturer was unable to quantify potential costs for a system that had yet to be developed.
Finally, it should be noted that there are several other factors that would increase costs but were not able to be quantified. For example, the costs from the additional weight and the increased manufacturing costs associated with reinforcing the wing structure; the costs of the advanced avionics to operate the fast-response aspect; and the costs associated with adhering to the proposed roll angle limits, control forces limits, and post-event performance requirements required by the controllability option.

4.3.3 Benefits and costs of the other alternatives reviewed

The third alternative would be as to lengthen increase the separation distance (the length of the nacelle) between the wing and the engine, which .would improve aeroplane controllability after an unwanted inflight thrust reversal. By lengthening the nacelles, aerodynamic drag and operational costs would be increased. In addition, aeroplane weight would be increased because longer landing gear and engine struts would be required. However, the increased length required for the desired level of safety would depend on the specific aeroplane/engine/thrust reverser combination. This method would also increase costs by adding drag and increasing the airplane's weight because longer landing gear and engine struts would be required. Consequently, the FAA could not quantify these potential increased operational These costs. costs were unable to be quantified. Further, the future larger diameter high bypass ratio engines will require either a shorter closer distance between the wing and the engine because the aeroplane would needs to maintain 19 feet entry door sill heights in order to use current terminals or a reduction in the engine's ground clearance. The FAA believes that it would be very costly for airports to modify terminal gate heights to adjust to aeroplanes with different entry door sill heights. In addition, the closer the engine is would be to the ground, the greater the probability that an hard landing or an aeroplane roll during a landings or a takeoffs wcould cause the engine to strike the pavement, resulting in potential engine loss, or damage, or fire orand associated possibly damage to the hull. Given these limitations, the FAA is unwilling to require this alternative in the rule.

The fourth alternative would be as to revise the efflux pattern of the thrust reversers. of the thrust reversers. This method was determined to not be technically feasible. Since this alternative was considered to be technologically impracticable, no consideration was given to the potential economic impact.

The fifth alternative would be as to require that all future engines to be located either in the aft fuselage or above the wing, which would eliminate the loss of wing lift during an unwanted inflight thrust reversal. - thereby eliminating under the wing engines. However, fFor large high bypass large turbofan ine engines, with a high bypass ratio, such locations would generate severe economic penalties due to increased interference drag and weight penalties. The FAA was unable to quantify these operational costs. As a further consideration, these alternative engine locations may increase overall risk because they could have a significantly negative effect on an aeroplane's weight and balance configuration. Further, they may produce substantial additional stresses on the fuselage, which may result in more rapid ageing of the airframe. These costs were unable to be quantified.Given these limitations, the FAA is unwilling to require this alternative in the rule.

The sixth alternative would be as to design engines so that a non-recoverable compressor stall would occur if an unwanted inflight thrust reversal were detected.introduce auto surge logic into engine designs. The FAA determined that this alternative method would be effective at improvinge aeroplane controllability for certain aeroplane models. However, this feature could reduce engine reliability and increase engine maintenance costs in those same aeroplane models. The FAA was unable to quantify these potential increased costs. In addition, this alternative method would not be effective on certain other aeroplane models or and engine types. Given these limitations, the FAA is unwilling to require this alternative in the rule.

Nevertheless, although the FAA believes that it is unlikely at this time that future type certificated aeroplanes would elect to use any of these specified alternativesmethods, the FAA would not preclude their use in this proposed rulemaking because future technology developments may make one or more of them technologically and economically viable.

4.4 Conclusion

Because the proposed changes to the thrust reverser requirements of part 25 of the FAR are not expected to result in substantial economic cost, the FAA has determined that this proposed regulation would be cost effective. JAA does accept this conclusion.

II-D. JAA NPA 25E-338 COMMENT-RESPONSE DOCUMENT

Note : the comments are not included in the text of below responses. Should you wish to get the content of a specific comment, please contact

Ms. Inge van Opzeeland, EASA rulemaking directorate
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Tel: +49 221 89990 5008

This document provides responses to comments on the above NPA, provided in JAA letter, dated 9 December 2002. The responses, given in the table below, use the same numbering, as in the JAA letter. As this has been a Harmonisation project, no commitment will be made here about revisions to the text, but, where appropriate, changes or recommendations will be made.

Commentors are advised that the main purpose of the work behind the production of NPA 25 E-338 was to produce a Harmonised text with FAR 25, taking into account FAA policies following accidents which occurred in the early nineties.

Note 1: a non negligible portion of the comments were focussed around the ‘no rulemaking by advisory material’ principle. The PPIHWG took great care in adhering to that principle. The rule itself, albeit quite short, is, for the demonstration of controllability, referring to ‘continued safe flight and landing’, which is covering several aspects, such as handling qualities, performance, etc…, requiring a substantial amount of guidance to be interpreted in its entirety.

Note 2: the initial publication of the NPA was made with an ACJ which, for technical reasons (possibly due to the word processing software), lacked the figures, or featured corrupted figures. The ‘full up’ version of the ACJ is now available, featuring also various amendments, of minor nature, resulting from the comments detailed hereafter.

Note 3: the majority of the comments where submitted by an individual, acting on his own. For those comments, obviously lacking the blessing of a recognised body, the disposition has been in this case to the same standard as for the other comments, submitted by AIA or AECMA members or by AA, which may not the case for future NPA.

Comment	Response
OO1 ?? The commenter provides 3 comments, the last one being editorial : 1) On the economic analysis, questioning the annual cost a thrust reverser unit. 2) On § 8d3, the effects of rotorburst, stating that the guidance provided is impracticable, requiring the addition of guidance for showing compliance through rapid spool-down / engine stall, requiring guidance on software DAL for t/r control, and in the end questioning the inclusion of uncontained engine requirement into the ACJ.	1) The economic analysis is copied from the FAA NPRM, prepared by a FAA economist. This is not vital for the JAA NPA, and was included there for reference only. 2) As most of the rotorburst material, the primary idea is to minimise. So, if the precautions presented are taken (or their equivalent), the design will be acceptable. As stated by the commenter, no one as ever proposed to show compliance using rapid spool-down / engine stall, the ACJ mentions this idea, and should any applicant proceed with this way, further work will be needed, but at this stage no advisory material is available. No change of the proposed ACJ is therefore needed. The software level should be determined in the same manner as any other software on the airplane. And the ACJ is not just addressing the reliability requirement of the t/r, but all requirements applicable on this system.
002 JAA OPS division The commenter is suggesting to clarify that the simulator required in § 13 of the ACJ is representative of the type of aeroplane, modelising the failure.	Agreed, the ACJ will be amended.
003 No comment from CAA-CZ	Noted.
004 No comment from CAA-DK.	Noted.
005 GEAE The commenter is objecting to the need to consider engine rotor failure in this ACJ, considering that the engine will stop delivering thrust very rapidly following an engine uncontained failure, and that the guidance provided in the ACJ is impracticable.	This comment was discussed by the PPIHWG, and the conclusion was to retain the proposed text. It can not be excluded that following an engine uncontained failure, the engine will deliver some thrust for some time, e few seconds being sufficient to result in the loss of the control of the airplane. Furthermore, most if not all recent thrust reverser designs have features meeting the proposed guidelines in the ACJ.
006 No comment from CAA-NL.	Noted.
007 AIA The commenter suggest there is a typo in § 4.b of the ACJ, and that the third paragraph addresses thrust reverser not intended for in-flight operation. The commenter also supports simultaneous JAA and FAA publications.	Disagreed. Unwanted thrust reverser deployment can be catastrophic, even if the thrust reverser can be used in flight. The paragraph is related to § 11 (25.933(b)). Agreed, but beyond our control.
008 CAA-UK The commenter is concerned that a special treatment is given to the thrust reverser system, instead on relying on 1309 as for any other system.	Noted. This is (1) the result of harmonisation with FAA, which was very firm on the assessments principle, and (2) derived from lessons learned in the field, where latent failures caused thrust reverser deployments and accidents. Also, the combined FAA/JAA Prioritized Rulemaking Project List includes the “Phase 2” work on §25.1309 that is intended, in part, to address this issue.
009 CAA-UK	

The commenter points out §5.e refers to FAA Flight Test Guide (AC 25.7), which has not been accepted by JAA.	Agreed. The reference will be deleted.

010 CAA-UK The commenter points out that JAR 25.145 'Longitudinal control' should be pointed out.	Disagreed. The concerned handling qualities requirements were reviewed and established after several meetings with the JAA Flight Study Group, and with FAA specialists. Also, those regulatory references are not intended to be inclusive, but rather cover the typical case. If for a particular design there could be a substantial "longitudinal control" issue, that should be taken into account.
011 CAA-UK The commenter is concerned about the inclusion of aspects not under JAR-25 direct scope, such as maintenance, operation or flight crew training.	Noted. This is however considered acceptable, since those are really notes to the airplane manufacturer (in an ACJ), which will be responsible to deal with those different aspects with the appropriate forums. The guidance material is strictly aimed at the responsibilities of the type certificate holder not the operator. However, JAR-25 requires the type certificate holder provide the necessary instructions for continued airworthiness which may often be relevant to maintenance, operation and/or flight crew training. There is much ongoing work being accomplished to improve this interface. This ACJ is simply leading the way.
012 CAA-UK The commenter is concerned about reference to a FAA docket, about the inclusion of a 'Background' section, and points out the final ACJ lacked various figures.	FAA dockets are indeed accessible to the public, there is no benefit to reproduce the content here. The inclusion of a 'Background' section is a result of harmonisation with FAA AC format. The figures were either corrupted or missing as a result of word processing errors, the ACJ will be re-circulated.
013 Agreement from Cessna.	Noted.
014 No comment from Austro Control.	Noted.
015 No comment from LFV	Noted.
016 Mr Fagegaltier The commenter is concerned that the ACJ is attempting to do 'rulemaking by advisory material', citing several instances.	Disagreed. The examples cited are not rulemaking by ACJ, but clarification on the interpretation of the main rule. The commenter concern that other requirements than 25.933 are cited in the ACJ is simply the result of the adoption of a format similar to FAA AC.
017 Mr Fagegaltier Rulemaking by ACJ in ACJ §7.d – see 016.	Disagreed.
018 Mr Fagegaltier Rulemaking by ACJ in ACJ §8.b – see 016.	Disagreed.
019 Mr Fagegaltier Rulemaking by ACJ in ACJ §9 – see 016.	The 'controllable flight envelope' is simply the part of the flight envelope where the airplane is controllable – an option definitively offered by the rule.
020 Mr Fagegaltier Rulemaking by ACJ in ACJ §10 – see 016.	A deactivated thrust reverser is just a specific configuration of a thrust reverser, hence, no new rule are needed.
021 Mr Fagegaltier The commenter is concerned by the lack of definition of the concept of a 'critical component' in § 12.a.	Noted. This will possibly considered in future rulemaking activity.
022 Mr Fagegaltier The commenter is proposing to considering the proposed JAR-E 515 for 'critical part' (ACJ §12.c).	Noted. Any future activity on critical part will take JAR-E 515 into account.
023 Mr Fagegaltier In the same manner, the commenter is proposing to address 'minimisation of errors during maintenance activity' based upon the new JAR E-510 as introduced by NPA E-38.	Noted. It was not the intent to provide general requirements on minimisation of maintenance errors, but indeed to remind the applicant there is an issue. Any general requirements should be

	addressed at aircraft level.
024 Mr Fagegaltier The commenter is concerned that § 12c(2)(d)(i) tries to address relation between operator and manufacturer, while the issue is still being debated elsewhere.	Noted. ACJ 25.933 features some very general guidelines, learned from in service experience, that should be kept. Any other activity, more general, on the subject will be very much supported.
025 Mr Fagegaltier The commenter is concerned about the lack of explanation about 'controllability option', and the relation between continued safe flight and landing and flight crew training (ACJ §13).	'Controllability option' is self explanatory to anybody with some basic knowledge of aircraft certification. It is obvious that flight crew training will be essential if continued safe flight and landing is to be accomplished after a thrust reverser deployment. In the past, certification relying on controllability demonstration following such an event, were not related to flight crew training, a fact dramatically pointed out in the 767 accident.
026 Mr Fagegaltier Rulemaking by ACJ in ACJ §4b – see 016.	Disagreed.
027 Mr Fagegaltier Rulemaking by ACJ in ACJ § 7 and 7a	Disagreed.
028 Mr Fagegaltier How are defined 'critical task' (cf ACJ § 12c(2)(e)(iii) ?	No definition is provided in the ACJ, but the intent – judged self explanatory when the ACJ was drafted – is that those tasks are the one essential for the thrust reverser maintenance, including any CMR or mandatory structural inspection. This also includes those tasks that if not performed properly or completely could lead to an unsafe system operating condition.(e.g. deactivation).
029 CAA-NL The commenter points out the final ACJ lacked various figures.	The figures were either corrupted or missing as a result of word processing errors, the ACJ will be re-circulated.
030 Rolls-Royce Rulemaking by AC, for example in ACJ §7.c.2.	Disagreed, in that case the ACJ simply state the obvious – if the thrust reverser deployment probability is really greater than 10-7/fh, it should be taken into account for performance. Performance demonstrations are needed for demonstrating continued safe flight and landing, clearly referenced in the rule itself.
031 Rolls-Royce The commenter proposes a better wording for ACJ §8.b.2.	Disagreed, the proposed text is already clear enough.
032 Rolls-Royce The commenter disagrees with the affirmation made in ACJ §8.D.4.a.i.	Disagreed. As explained in the ACJ, this is based upon actual in-service experience, and was already investigated into details.
033 Rolls-Royce The commenter wishes to indicate that flight crew reaction time should be based on 'normal' pilot (not test pilot), and considers an example of additional retention device should be included.	Pilot reaction time : agreed, pilot reaction is addressed in § 7.d 'handling qualities'. The benefit to describe specific design feature was discussed and rejected on the basis that this typically not done in JAR-25, including section 2 or 3.
034 FAA <u>Note : those comments were not part of the JAA file, due a transmission problem.</u> This NPA is acceptable as proposed. However, the following editorial problems should be fixed: 1) There is a "typo" error in the definition in section 5.o. This should be two separate term definitions and read: "5.o <u>Maximum exposure time</u>: The longest anticipated period between the occurrence and elimination of the failure. 5.p <u>Normal Flight Envelope</u>: An established boundary of parameters (velocity, altitude, angle of attack, attitude) associated with the	Agreed.

practical and routine operation of a specific airplane that is likely to be encountered on a typical flight and in combination with prescribed conditions of light turbulence and light crosswind." The subsequent section numbering should be modified accordingly.	
2) The curves are missing from figures 2 and 3; and Figures 4a, 4b, and 5 are missing entirely.	The figures were either corrupted or missing as a result of word processing errors, the ACJ will be re-circulated.
3) There is a paragraph break and bullet missing in Section 8.d.(2) between "apply:" and "Neither".	Agreed (for 8.b.2, actually).
4) The phrase "on the order of" should be removed from Section 8.b.(3) as $1E^{-3}$ is intended to be an upper bound for this "acceptable means".	Agreed.

III-A. EXPLANATORY NOTE JAA 25E-339

Originally JAA NPA 25E-339, "Powerplant Shut-Off"

1. The initial issue of CS-25 was based upon JAR-25 at amendment 16. During the transposition of airworthiness JARs into certification specifications the rulemaking activities under the JAA system where not stopped. In order to assure a smooth transition from JAA to EASA the Agency has committed itself to continue as much as possible of the JAA rulemaking activities. Therefore it has included most of it in its own rulemaking programme for 2004 and planning for 2005-2007. This part of present EASA NPA is a result of this commitment and a transposed version of the JAA NPA 25E-337 which was circulated for comments from 1 September 2002 till 1 December 2002, and modified as per the conclusions of the JAA comment response document (see III.D)

2. In the past both JAA and FAA allowed some aircraft manufacturers to do without a shut-off valve for hydraulic systems. The regulation allows this due to its provisions for otherwise preventing flow of a hazardous quantity, however, no guidance exists in this context and application of this provision has been inconsistent. The means of compliance for preventing hazardous quantity drainage following shutoff has also been inconsistent due to lack of guidance.

3. The purpose of this NPA is to introduce an Acceptable Means of Compliance (AMC) to CS 25.1189 (main engine) and CS 25J1189 (APU). This AMC will clarify what "hazardous quantity" means, define when a shutoff means is required, and provide guidance to prevent use of a system which may allow a hazardous quantity of fluid.

III-B. PROPOSALS TRANSPOSED JAA 25E-339

The following amendments should be included in Decision No. 2003/2/RM of the Executive Director of the Agency of 17 October 2003:

1. To add "See AMC 25.1189" under paragraphs CS 25.1189 Shut-off means and CS 25J1189 Shut-off means

2. To add an AMC 25.1189 to read as follows:

AMC 25.1189
Flammable fluid shut-off means

1. **PURPOSE.**

This Acceptable Means of Compliance (AMC) provides information and guidance concerning a means, but not the only means, of compliance with JAR 25.1189 which pertains to the shut-off of flammable fluids for fire zones of Transport Category Aeroplanes. Accordingly, this material is neither mandatory nor regulatory in nature and does not constitute a regulation. In lieu of following this method, the applicant may elect to establish an alternate method of compliance that is acceptable to the Agency for complying with the requirements of the CS-25 sections listed below.

2. **SCOPE.**

This AMC provides guidance for a means of showing compliance with regulations applicable to flammable fluid shut-off capability in Transport Category Airplanes. This guidance applies to new designs as well as modifications such as the installation of new engines or APU's or modifications of existing designs that would affect compliance to the requirements for flammable fluid shut-off means to a fire zone.

3. **RELATED JAR SECTIONS.**

CS 25.1181, 25.1182, 25.1189, 25J1189.

4. **OBJECTIVE**

This advisory material provides guidelines for determining hazardous quantity of flammable fluids:

A. With respect to the requirement CS 25.1189(a) that each fire zone must have a means to shut-off or otherwise prevent hazardous quantities of flammable fluids from flow into, within, or through the fire zone.

B. With respect to the requirement of CS 25.1189 (e) that no hazardous quantity of flammable fluid may drain into any designated fire zone following shut-off.

5. **BACKGROUND.**

Guidance is required because of different and sometimes inconsistent interpretation of what hazardous quantity means.

Service History: The fire zone fire safety service history of CS-25 turbine engine aircraft has been very good, especially considering the potential hazards involved. This is attributed to the multi-faceted fire protection means required by CS-25. While it is not generally possible to define the contribution of each individual fire protection means, such as flammable fluid shut-off means, it is noted that the relatively few serious accidents that have occurred often involve initiating events such as engine separation or rotor non-containment, which can potentially negate some fire protection means, and in which flammable fluid shut-off means represent an important, or possibly sole, backup.
Previous incidents have shown that hydraulic system leaks have fueled fires, especially when fluid mist is produced at high pressure due to small (pinhole) leaks. This type of leakage can be of considerable duration, even with a limited quantity of flammable fluid at the source.

6. **DEFINITIONS.**

A. Hazardous Quantity: An amount which could sustain a fire of sufficient severity and duration so as to result in a hazardous condition.

B. Hazardous Condition: Failure Conditions which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be:
(i) A large reduction in safety margins or functional capabilities;
(ii) Physical distress or higher workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or
(iii) Serious or fatal injury to a relatively small number of the occupants.
(iv) For the purposes of this AMC, and specifically with respect to fire zone fires, any condition which could breach or exceed the fire zone integrity requirements or structural fireproofness requirements of CS-25.

C. Flammable Fluid. Flammable, with respect to a fluid or gas, means susceptible to igniting readily or to exploding. For the purpose of this AMC igniting readily includes ignition and burning when introduced into an existing flame, and includes fluids such as fuels, hydraulic fluid (including phosphate ester based fluids), oils, and deicing fluids.

7. **COMPLIANCE METHODOLOGY:**

The quantity of flammable fluid which is hazardous may vary with fire zone size and design, fluid characteristics, different fire scenarios, and other factors. Since one of these factors is the presence or absence of flammable fluid shut-off means, the requirements of CS 25.1189(a) and 25.1189(e) are discussed separately below.

7.1 Shut-off Means Requirements (CS 25.1189(a))

Compliance with CS 25.1189(a) has been typically been shown by installation of shut-off means for flammable fluids that could contribute to the hazards associated with an engine fire, except for lines fittings, and components forming an integral part of an engine and/or fireproof oil system components, which are not required to have a shut-off means per CS 25.1189(a)(1) and (a)(2). Flammable fluids that have been considered include fuel supplied to the engine/APU, fuel that may enter the fire zone from engine recirculation systems and hydraulic fluids entering the fire zone. Oil that may be supplied from outside the fire zone, deicing fluid, and other fluids would require similar consideration, however these are not typically incorporated in modern CS-25 aircraft engine installations.

Although shut-off means are typically incorporated, CS 25.1189(a) allows the option of otherwise preventing flow of hazardous quantities of flammable fluids. A shut-off means is, therefore, not required if no possible scenario will result in the flow of hazardous quantities of flammable fluid. Factors to be considered in determination of whether this compliance means is acceptable include the following:

A. Considerations

1) Leakage rates and characteristics, including massive leakage caused by component failure or fire damage, and slow leakage, which may be a spray or mist if the source is under pressure, caused by failures such as cracks or pinholes.

2) The amount of fluid in the system that is subject to leakage.

3) Combining A.1), and A.2), the range of potential duration of leakage.

4) Scenarios in which the analysed system leakage is subject to ignition and is the initial fire source.

5) Scenarios in which the initial fire source is a different system, and fire damage to the analysed system can result in leakage which contributes to the magnitude or duration of the fire.

B. Compliance

Considering the above factors and service experience of oil systems without shut-off means, it is acceptable to not install a shut-off means for specific systems which contain flammable fluid if the following conditions are met:

1) All components of the analysed system within the fire zone are fireproof,

and

2) The quantity of fluid which can flow into the fire zone is not greater than the fluid quantity of the engine or APU oil system for an engine or APU fire zone.

and

3) Accomplishment of AFM Emergency Procedures will preclude continuation of a pressurized spray or mist.

The meeting of conditions (1)-(3) are considered acceptable in precluding a hazardous quantity of flammable fluids from flowing into, within or through any designated fire zone.

<u>7.2 Drainage Following Shut-off Requirements (CS 25.1189(e))</u>

Following shut-off, flammable fluid will be contained within the components and plumbing in the fire zone, and usually within plumbing between the firewall and shut-off means. This is due to other requirements which affect the location of the shut-off means and, therefore, the amount of fluid between the shut-off means and the firewall that may drain into the fire zone following shut-off. These include the requirement to protect the shut-off means from a fire zone fire (CS 25.1189(d)), a powerplant or engine mount structural failure (CS § 25.1189(g)), and engine rotor failure (CS 25.903(d)(1)).

An analysis is required for each individual flammable fluid system to determine that the total amount is not hazardous. The analysis should consider the aircraft attitudes expected to be encountered during continued flight following shut-off, which may include emergency descent attitudes, but would not be expected to include climb attitudes steeper than those associated with one engine inoperative flight at V2. If the analyzed system traverses more than one fire zone, each fire zone should be analyzed separately for the maximum fluid volume which can drain into that fire zone. Credit should not be taken for fire extinguishing provisions. The following are alternate criteria for hazardous quantities of flammable fluid for this condition:

A. A volume not exceeding 0.95 liter (1 US quarts) is not hazardous.

or

B. An amount shown not to be hazardous by analysis considering the factors listed in 7.2.A above. Additional factors relevant to this condition following shut-off are reduction in pressurized spray or mist due to reduction or absence of system pressure, and the possibility of rapid leakage or drainage due to either an initial leak or fire damage of plumbing and components, such as aluminum components or non-metallic hoses, following the required fire resistance period. Hazard assessment of such rapid leakage and drainage may include airflow ventilation limitation of fire intensity, and fire duration limitation through fire zone drainage.

The analysis may consider that volume which is capable of being drained from the nacelle within a suitable period is not hazardous. The suitable period should be such that fluid leakage into the fire zone will not aggravate a fire beyond a fifteen minute period from its initiation. A five minute period may be suitable when considering fire resistant components and plumbing for which leakage due to fire damage will not occur during the first five minute period and may not occur immediately thereafter.

III-C. ORIGINAL JAA NPA 25E-339 proposals justification

1 Background

The manufacturing, marketing and certification of large aeroplanes is increasingly an international endeavour. In order for European manufacturers to export aeroplanes to other countries, the aeroplane must be designed to comply, not only with the European airworthiness requirements for large aeroplanes (JAR-25), but also with the airworthiness requirements of the countries to which the aeroplane is to be exported.
JAR-25 is developed in a format similar to FAR 25. Many other countries have airworthiness codes that are aligned closely to JAR-25 or to FAR 25, or they use these codes directly for their own certification purposes.
Although JAR-25 is very similar to FAR 25, there are differences in methodologies and criteria that often result in the need to address the same design objective with more than one kind of analysis or test in order to satisfy both JAR and FAR 25. These differences result in additional costs to the large aeroplane manufacturers and additional costs to the JAA and foreign authorities that must continue to monitor compliance with a variety of different airworthiness codes.

In 1988, the JAA, in co-operation with the FAA and other organisations representing the European and U.S. aerospace industries, began a process to harmonise the airworthiness requirements of the European authorities with the airworthiness requirements of the United States. The objective was to achieve common requirements for the certification of large aeroplanes without a substantive change in the level of safety provided by the requirements. Other airworthiness authorities such as Transport Canada have also participated in this process.

In 1992, the harmonisation effort was tasked by the FAA to the Aviation Rulemaking Advisory Committee (ARAC) on the US side.

In co-operation and conjunction with ARAC, a working group comprised of specialists from both industry and aviation regulatory authorities from Europe, the United States, and Canada was established to work on the powerplant installation requirements of Subpart E of JAR/FAR 25, "Powerplant". This group is the Powerplant Installation Harmonization Working Group (PPIHWG).

A dedicated Task Group of the Powerplant Harmonization Working Group was set up to deal with the Reversing System requirements.

This notice contains the proposals made by this Task Group, necessary to achieve harmonisation for the powerplant fire protection requirements of JAR/FAR 25, contained currently in JAR 25 subpart E (and subpart J for Auxiliary Power Units).

2 Discussion of the proposals

2.1 Relevant regulatory history

The flammable fluid requirements of §25.1189(a),(b),(c), (d), (e), & (f) originated from section 4b.445 of the Civil Aeronautics Manual 4b, December 31, 1953. This section was amended by 25-23. Notice 68-18 proposed amendment of §25.1189 to remove the requirements for shutoff valves in engine oil systems. The proposal to add a new (g),(h), and (i) was discussed as follows: Section 25.1189(a) requires flammable fluid shutoff means. However, the majority of the large turbine-powered transport airplanes have been certificated without a shutoff means for their oil systems. The deviations from the oil shutoff means requirement were permitted on the basis that equivalent safety was otherwise achieved since the oil tanks were close to the engine, the quantities of oil were relatively small, and all components materials were fireproof. The service experience of these airplanes has shown that oil shutoff means are not essential, and the proposal would relax the requirement for oil shutoff means on turbine engine installations. The preamble to Amendment 25-23 discussed the proposal as follows: "Proposed §25.1189 (a)(2) has been changed to make it clear that a shutoff means is not required for oil systems for turbine engine installations in which all external components of the oil system, including the oil tanks, are fireproof. The Notice proposed to add a new §25.1189(g) to require each flammable fluid shutoff valve control to be fireproof or to be located so that exposure to fire will not affect its operation. In response to comments received and consistent with the intent of the Notice, the proposal has been changed to make it clear that it applies only to flammable fluid shutoff means and controls located in a fire zone or that would be affected by a fire in a fire zone. The proposal as revised is adopted as an amendment to current paragraph (d).

This regulation was amended by 25-57. The proposal was discussed **in Notice 80-21** dated November 20, 1980, as follows: "Section 25.1189 is revised to clarify the requirement for shutoff means in terms of the vulnerability of oil system components to engine fire sources, and to ensure that fittings and components are considered along with lines that form an integral part of an engine when determining the need for shutoff means, since they are in the same category when installed. Comments were discussed within the preamble as follows: "One commenter recommends that this rule be cross referenced to Part 33 for clarity sake. The FAA does not consider a cross reference necessary since the emphasis of this section is upon the aircraft manufacturers' responsibility to ensure a fireproof engine installation. Adding the word "installation," however, will provide additional clarification. The proposed regulation is adopted with this change.

Currently, JAR 25.1189 is strictly identical to FAR 25.1189. The difference of interpretation noted between projects should be addressed by the definition of a common Advisory Material.

2.2 Service History

The fire zone fire safety service history of FAR/JAR 25 turbine engine aircraft has been very good, especially considering the potential hazards involved. This is attributed to the multi-faceted fire protection means required by FAR/JAR 25. While it is not generally possible to define the contribution of each individual fire protection means, such as flammable fluid shutoff means, it is noted that the relatively few serious accidents that have occurred often involve initiating events such as engine separation or rotor non-containment, which can potentially negate some fire protection means, and in which flammable fluid shutoff means represent an important, or possibly sole, backup.

Previous incidents have shown that hydraulic system leaks have fueled fires, especially when fluid mist is produced at high pressure due to small (pinhole) leaks. This type of leakage can be of considerable duration, even with a limited quantity of flammable fluid at the source.

2.3 Discussion of the proposal

The purpose of this NPA is to introduce Advisory Material in the form of an Advisory Circular – Joint (ACJ) to JAR 25.1189 (main engine) and JAR 25A1189 (APU). This ACJ will clarify what “hazardous quantity” means and defines when a shutoff means is required, and provides guidance to prevent use of a system which may allow a hazardous quantity of fluid.

The text of the proposed ACJ is largely based upon the current practices of both FAA and JAA. It therefore maintains current level of safety for most applications. It increases the level of safety for few applications which may be required to install a hydraulic shutoff means where they were not previously required to do so.

3 Economic impact and evaluation assessment

Most applications will have no cost. Some applications which may be required to install a hydraulic shutoff means where they were not previously required to do so, may experience a recurring cost estimated to be within the range of $1,000 to $10,000 per aircraft.

On this basis, it is expected the FAA will determine that this proposed regulation would be cost effective. JAA does accept this conclusion.

III-D. JAA NPA 25E-339 COMMENT-RESPONSE DOCUMENT

This document provides responses to comments on the above NPA, provided in JAA letter, dated 9 December 2002. The responses, given in the table below, use the same numbering, as in the JAA letter. As this has been a Harmonisation project, no commitment will be made here about revisions to the text, but, where appropriate, changes or recommendations will be made.

Comment	Response
001 GE (via ESG) Typo in page 3.	The typo will be corrected..
002 CAA Denmark Agree with the proposal.	Noted.
003 CAA Czech Republic Agree with the proposal.	Noted.
004 CAA Netherlands Agree with the proposal.	Noted.
005 AIA USA Suggest adding in §7.a.1, the following items in the list of considerations to determining hazardous quantities : - fluid types, - possible leak locations with respect to potential ignition sources, and - shielding.	The considerations raised by AIA are valid, but are covered in the compliance to JAR 25.863. Therefore, duplicating them into 25.1189 will have no benefit. In addition, it should be pointed out 25.1189 is addressing leak into a designated fire zone, and is not directly taking into account the ignition probability.
006 Cessna Agree with the proposal	Noted
007 Rolls-Royce 1) is concerned that the definition of hazardous quantity may be not helpful, and suggest reference to NPA 25 E-37. 2) Points out some typographical errors and reference to FAR 25. .	See 011. Hopefully corrected.
008 CAA 1) Use “shut-off” throughout. 2) FAR 25 in the ACJ § 3 title 3) Same in 1st paragraph of page 8. 4) Replace FAR/JAR by JAR 5) Two sections §7.1 6) Grammar correction in § 7.1 7) Typo in §7.1 page 9 sub-section A 8) Ujse uf §US units instead of SI units 9) Typo in §7.1 page 9 sub-section B.	All items taken into account.
009 ACG Agree with the proposal.	Noted.
010 LFV Agree with the proposal	Noted.
011 Francis Fagegaltier Hazardous quantity not quantified.	Noted. The only consensus that could be reached was that quantity below 0,95 l (1 US quarts) were OK (the value is different from JAR-E, considering JAR-25 installation are usually bigger than some smaller engine installation that can certified under JAR-E).
012 FAA <u>Note : those comments were not part of the JAA</u>	Noted. A new NPA (or rulemaking activity) will be

file, due a transmission problem. NPA25E-339: Powerplant Shutoff This NPA should be withdrawn and replaced by a rule change which reads something like: §25.1189 Shutoff Means. (a) Each engine installation and each fire zone specified in §25.1181(a)(4) and (5) must have a shutoff means to minimize the flow of fuel, oil, deicer, and other flammable fluids into, within or through any designated fire zone following activation of that shutoff, except that shutoff means are not required for – (the rest of the rule would be unchanged) Predominant current practice is to always require a shut-off means which minimizes the flammable fluid that can enter the fire zone following activation of that shut-off. This interpretation of the rule combined with the "minimization" policies provided in AC20-128A constitute current FAA policy. The JAA has occasionally allowed installations without shut-off means when they have determined the quantity of flammable fluid was not hazardous. This was the primary difference which needed to be harmonized under the subject tasking. A lot of work was done in an attempt to develop an acceptable and effective definition of "hazardous quantity". Nevertheless, during internal FAA coordination of the ARAC "Phase 2" Fast Track Report on §25.1189(a) "Shut-off Means", the FAA has concluded that adopting the complex indeterminate process recommended for establishing what is "a hazardous quantity" would result in a reduction in the level of safety provided by current FAA practice. Unfortunately, the FAA cannot suggest supplemental guidance that would make this approach more effective. Consequently, the FAA intends to reject the initial recommendations of ARAC and propose instead to promulgate the current FAA practices more clearly within the §25.1189(a) rule. To that end, the FAA will be drafting an NPRM (and perhaps some additional guidance) and return that to ARAC during "Phase 3" of the Fast Track process. The proposed revision would result in a rule that reads something like that proposed above.	initiated taking into account the FAA NPRM when it becomes available.

IV-A. EXPLANATORY NOTE JAA NPA 25E-340

Originally JAA NPA 25E-340, Powerplant Controls

1. The initial issue of CS-25 was based upon JAR-25 at amendment 16. During the transposition of airworthiness JARs into certification specifications the rulemaking activities under the JAA system where not stopped. In order to assure a smooth transition from JAA to EASA the Agency has committed itself to continue as much as possible of the JAA rulemaking activities. Therefore it has included most of it in its own rulemaking programme for 2004 and planning for 2005-2007. This part of present EASA NPA is a result of this commitment and a transposed version of the JAA NPA 25E-340 which was circulated for comments from 1 September 2002 till 1 December 2002, and modified as per the conclusions of the JAA comment response document (see IV.D)

2. It is proposed to amend the design requirements for powerplant valves controlled from the flight deck. The proposed rule would clarify the requirements for a means to select the intended position of the valve, to indicate the selected position, and to indicate if the valve has not attained the selected position. Adopting this proposal would eliminate regulatory differences between FAA airworthiness standards and EASA requirements, without affecting current industry design practices.

IV-B. PROPOSALS TRANSPOSED JAA NPA 25E-340

1. To modify CS 25.1141 (f) to read as follows:

(f) For Powerplant valve controls located in the flight deck there must be a means:

(1) for the flightcrew to select each intended position or function of the valve; and

(2) to indicate to the flightcrew:

(i) the selected position or function of the valve; and
(ii) when the valve has not responded as intended to the selected position or function.

IV-C. ORIGINAL JAA NPA 25E-340 proposals justification

1. Background

The manufacturing, marketing and certification of large aeroplanes is increasingly an international endeavour. In order for European manufacturers to export aeroplanes to other countries, the aeroplane must be designed to comply, not only with the European airworthiness requirements for large aeroplanes (JAR-25), but also with the airworthiness requirements of the countries to which the aeroplane is to be exported. JAR 25 is developed in a format similar to FAR 25. Many other countries have airworthiness codes that are aligned closely to JAR-25 or to FAR 25, or they use these codes directly for their own certification purposes.
Although JAR 25 is very similar to FAR 25, there are differences in methodologies and criteria that often result in the need to address the same design objective with more than one kind of analysis or test in order to satisfy both JAR and FAR 25. These differences result in additional costs to the large aeroplane manufacturers and additional costs to the JAA and foreign authorities that must continue to monitor compliance with a variety of different airworthiness codes.

In 1988, the JAA, in co-operation with the FAA and other organisations representing the European and U.S. aerospace industries, began a process to harmonise the airworthiness requirements of the European authorities with the airworthiness requirements of the United States. The objective was to achieve common requirements for the certification of large aeroplanes without a substantive change in the level of safety provided by the requirements. Other airworthiness authorities such as Transport Canada have also participated in this process.

In 1992, the harmonisation effort was tasked by the FAA to the Aviation Rulemaking Advisory Committee (ARAC) on the US side.

In co-operation and conjunction with ARAC, a working group comprised of specialists from both industry and aviation regulatory authorities from Europe, the United States, and Canada was established to work on the powerplant installation requirements of Subpart E of JAR/FAR 25, "Powerplant". This group is the Powerplant Installation Harmonization Working Group (PPIHWG).

A dedicated Task Group of the Powerplant Harmonization Working Group was set up to deal with the Reversing System requirements.

This notice contains the proposals made by this Task Group, necessary to achieve harmonisation for the powerplant fire protection requirements of JAR/FAR 25, contained currently in JAR 25 subpart E (and subpart J for Auxiliary Power Units).

2. Discussion of proposals

2.1 Relevant regulatory history

The proposed “enveloped” standard clarifies the existing practices in both JAR/FAR that have been found to achieve an acceptable level of safety.

2.2 Discussion of the proposal

The intent of this standard is to mitigate the potential for flight crews to select an inappropriate position for, or be unaware of the position of powerplant valves that are controlled from the flight deck.
There are four differences between the JAA/FAA standards in paragraph 25.1141(f)(2). These differences are:
1. To describe the applicable valves, part 25 uses the term ‘‘power-assisted.’’
The JAR uses the phrase ‘‘other than by mechanical means.’’
2. The JAR uses the phrase ‘‘where the correct functioning of such a valve is essential for the safe operation of the aeroplane’’ to reduce the applicability to
be more consistent with the requirements of JAR 25.1309(c) relating to indications. Part 25 does not use such a phrase.
3. For the basic indicating requirement, the JAR uses the phrase ‘‘a valve position indicator operated by a system which senses directly that the valve has attained the position selected.’’ Part 25 uses the phrase ‘‘a means to indicate to the flight crew when the valve is in the fully open or fully closed position, or is moving between the fully open and fully closed position.’’
4. By including the phrase ‘‘unless other indications in the flight deck give the flight crew a clear indication that the valve has moved to the selected position,’’ the JAR specifically acknowledges that a dedicated indication is not required.

The new 25.1141(f) rule proposes to revise the current standard to include the more stringent requirements of JAR/FAR regulations. The text of the rule would be updated, however, so that it more clearly reflects the existing practices that have been found to achieve an acceptable level of safety. Specifically, the proposed revision would require that powerplant valve controls located in the flight deck must provide the crew with means to:
- Select each intended position of the valve;
- Indicate the selected position of the valve; and
- Indicate when the valve has not responded as intended to the selected position or function.

As used in the proposed rule, the ‘‘means to indicate’’ can be:
- Provided either by a dedicated ‘‘indicator’’ or through the inherent response of the airplane, system, or valve control;
- Provided by either the presence or lack of indication; or

Provided either continuously or on an ‘‘as required’’ basis. In any case, however, the means to indicate must be clearly evident to the crew. As used in the proposed rule, the ‘‘means to indicate’’ must comply with all other relevant regulations such as §§ 25.1309(c), 25.1321, 25.1322, etc.

3. Economic Evaluation

It is determined that this proposal would result in a cost-savings by a reduction in duplicative testing. It is concluded that, for the reasons previously discussed in the preamble, the adoption of the proposed requirements is the most efficient way to harmonise the JAR/FAR standards maintaining the existing level of safety. The requirements of the proposed rule will not impose additional costs neither on U.S. manufacturers of part 25 airplanes nor on European manufacturers.

IV-D. JAA NPA 25E-340 COMMENT-RESPONSE DOCUMENT

Note : the comments are not included in the text of below responses. Should you wish to get the content of a specific comment, please contact

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9 comments were submitted, 8 during the comment period, and one after (FAA).

Out of the 8 original comments, 6 were concurring with the proposal, whereas one was proposing an amended text (comment # 004), and another was supporting addition of some advisory material in the form of an ACJ (comment # 006).

In addition, the FAA provided its position after the closure of the comment period. FAA had been working on the same harmonization proposal, and came with a revised text, clarifying the ARAC proposal.

The FAA proposal was discussed during a meeting of the PowerPlant Study Group (PPSG). The PPSG concluded that the text, as worded by FAA, is much clearer, with an identical technical content (see below). PPSG also believed the revised text will address the concerns raised in comment # 004.

Original ARAC proposal	FAA revised text
(f) Powerplant valve controls located in the flight deck must provide the flight crew with means to: (1) Select each intended position or function of the valve; (2) Indicate the selected position or function of the valve; and (3) Indicate when the valve has not responded as intended to the selected position or function.	(f) For Powerplant valve controls located in the flight deck there must be a means: (1) for the flightcrew to select each intended position or function of the valve; and (2) to indicate to the flightcrew: (i) the selected position or function of the valve; and (ii) when the valve has not responded as intended to the selected position or function.

The FAA text has since been published as part of a FAR 25 Amendment.

Considering the FAA proposed text is an improvement of the wording ARAC proposal, with a strictly identical technical intent, the PPSG decided during its final meeting that the NPA should be revised to adopt FAA format.

Regarding comment # 007 and the suggestion to include advisory material, this appears as unnecessary at this stage since the proposed rule is in line with current industry practices. This position will however be reviewed in front of actual certification exercises.