Comment-Response Document 2015-07

Use of comparative analysis when showing compliance with SLD icing specifications

CRD TO NPA 2015-07 — RMT.0572 — 22.6.2016

Related Decision 2016/010/R

EXECUTIVE SUMMARY

This Comment-Response Document (CRD) contains the comments received on NPA 2015-07 (published on 12.6.2015) and the responses, or a summary thereof, provided thereto by the Agency.

100 comments were received from 13 organisations (5 aeroplane manufacturers, 7 aviation authorities, 1 pilots trade union).

Overall, the comments received were of technical natural and were useful to improve the explanatory note of the NPA (updated version provided in this CRD for reference), as well as the proposed regulatory text.

No major changes to the proposed regulatory text resulted from the comments.

Based on the comments and responses, Decision 2016/010/R was developed.

Applicability		Process map	
Affected regulations and decisions:	ED Decision 2003/2/RM Certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes ('CS-25')	Concept Paper:	No
		Terms of Reference:	28.1.2013
		Rulemaking group:	Yes
		RIA type:	Light
Affected stakeholders:	Large aeroplane manufacturers	Technical consultation during NPA drafting:	No
		Publication date of the NPA:	12.6.2015
		Duration of NPA consultation:	4 months
Driver/origin:	New CS-25 provisions for flight in icing conditions introduced through Amendment 16; Request from industry	Review group:	Yes
		Focussed consultation:	No
		Publication date of the Opinion:	N/A
		Publication date of the Decision:	2016/Q2
Reference:	NPA 2011-03; CRD 2011-03; NPA 2012-22; CRD 2012-22		

Table of contents

1. Procedural information

1.1. The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this Comment-Response Document (CRD) in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the Agency's 5-year Rulemaking Programme, under RMT.0572. The scope and timescale of the task were defined in the related Terms of Reference (see process map on the title page and the ToRs webpage).

The draft CS/AMC has been developed by the Agency based on the input of the Rulemaking Group RMT.0572. All interested parties were consulted through NPA 2015-07[3], which was published on 12.06.2015. During the NPA consultation 100 comments were received from interested parties, including industry, national aviation authorities and trade unions.

The text resulting from this CRD has been developed by the Agency based on the input of the review group RMT.0572.

The process map on the title page contains the major milestones of this rulemaking activity.

1.2. The structure of this CRD and related documents

This CRD provides a summary of comments and responses as well as the full set of individual comments (and responses thereto) received to NPA 2015-07. The resulting rule text is provided together with ED Decision 2016/010/R on 'CS-25 — Amendment 18'.

---

[1] Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1).

[2] The Agency is bound to follow a structured rulemaking process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'. See Management Board Decision concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications, acceptable means of compliance and guidance material ('Rulemaking Procedure'), EASA MB Decision No 18-2015 of 15 December 2015.

[3] https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2015-07

2. Summary of comments and responses

100 comments were received from 13 organisations (5 aeroplane manufacturers, 7 aviation authorities and 1 pilots trade union).

The comments were distributed as follows:

S	Page	Description	Comments
0	-	(General Comments)	8
1	1	Notice of Proposed Amendment 2015-07	1
2	1	EXECUTIVE SUMMARY	1
4	4	1. Procedural information	2
5	5	2. Explanatory Note — 2.3. Summary of the Regulatory Impact Assessment (RIA)	1
6	6-8	2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.1. Definitions	8
7	8-16	2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.2. Comparative analysis as a means of compliance — Explanatory note	17
8	16-17	2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.3. Proposed amendments to CS-25 Book 1 and Book 2	3
9	18-19	3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — CS 25.1420 Supercooled large drop icing conditions	7
10	19-21	3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.21(g) Performance and Handling Characteristics in Icing Conditions	1
11	26	3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.1093(b) Powerplant Icing	2
12	26-27	3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.1324 Flight instrument external probes	1
13	28-38	3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.1420 Supercooled large drop icing conditions	38
14	39-41	4. Regulatory Impact Assessment (RIA)	3
15	44-49	6. Appendices — 6.1. Appendix 1 — Explanation of the method used to determine the number of SLD encounters experienced by an aircraft fleet during a defined number of flights	2
16	50-53	6. Appendices — 6.2. Appendix 2— Application of the comparative analysis — Examples	5

General

Overall, the comments received were of a technical natural and were useful to improve the explanatory note of the NPA (updated version provided in this CRD for reference), as well as the proposed regulatory text.

No major changes to the proposed regulatory text resulted from the comments.

Explanatory note

Several terminologies and definitions were updated. More importantly, the method used for the calculation of the probability of encountering supercooled large drop (SLD) or heavy SLD icing conditions has been reviewed and simplified for the sake of clarity. But in the end, the values of these probabilities are unchanged, as well as the fleet history criterion of two million flights.

One comment highlighted an inconsistency in the calculation of Appendix 1 to the NPA ('Explanation of the method used to determine the number of SLD encounters experienced by an aircraft fleet during a defined number of flights'). The Appendix 1 methodology was reviewed, and it was concluded that the exposure time calculations are misleading and do not necessarily reflect the reality. To perform a correct calculation, data on average flight duration in SLD conditions is missing. Appendix 1 to the NPA attempted to address this issue but provided a misleading calculation methodology. Furthermore, Appendix 1 calculated the number of exposures to extreme SLD conditions (designated 'heavy SLD' in Appendix 1 but without the conservatism that was used in the calculation of the minimum reference fleet flights), which are beyond Appendix O and outside of the requirements of CS 25.1420. It has, therefore, been decided to limit the assessment to the number of SLD encounters experienced by the reference fleet considering the two-million-flights criterion. Appendix 1 has, therefore, been deleted, as well as paragraph 2.4.2.1.5 of the NPA explanatory note. The number of SLD encounters is now provided at the end of the conclusion providing the two-million-flights criterion, now re-numbered 2.4.2.1.5 (previously 2.4.2.1.6).

An updated Explanatory Note to NPA 2015-07 is provided as Appendix 1 to this CRD for reference.

<u>Appendix 1</u> 'Explanation of the method used to determine the number of SLD encounters experienced by an aircraft fleet during a defined number of flights':

Appendix 1 is deleted. See explanations above.

<u>Appendix 2</u> 'Application of the comparative analysis — Examples' is almost unchanged.

The first sentence is amended to add 'and its limits' at the end.

Within the example 1 on 'Wing ice protection system change': A sentence is added to the fourth paragraph to mention that the amount of runback ice produced in Appendix C icing conditions by the de-icing system when compared to reference fleet ice shapes/ice data should be analysed.

The amended list of examples is provided in Appendix 2 to this CRD for reference.

<u>Regulatory text</u>

The following improvements were made to the proposed regulatory text for amendment of CS-25 compared to the NPA proposal. These improvements resulted from the comments received and from additional reviews made by the review group.

Book 1:

— An amendment to CS 25.21(g)(2) and (3) is introduced to make it clear that a comparative analysis may be used to show compliance as an alternative to using the ice accretions defined in Part II of Appendix O. This reinforces the provisions already proposed for amending AMC 25.21(g).

— The proposed amendment to CS 25.1420 is revised to ensure that a comparative analysis may be used as an alternative to CS 25.1420(c) regarding methods of icing detection and activation of the airframe ice protection system (the reference was missing in the NPA proposal). CS 25.1420(c) is finally unchanged compared to CS-25 amendment 16, and the comparative analysis option is now provided in a new CS 25.1420(d).

Book 2:

— AMC 25.1420 is revised as follows:

- The order of the subpargraphs of the AMC is changed to be consistent with the changes made to the subparagraphs of CS 25.1420,
- Service history data ownership conditions are provided in paragraph (d)1.2.2.2,
- Concerning the icing event history, paragraph (d)1.2.2.4 is updated to add a condition that the aeroplane's ice protection systems are operating normally,
- In paragraph (f) CS 25.1420(d) 'Comparative analysis':
  - the second subparagraph is amended to better reflect that flight testing is not required when using a comparative analysis, but that other types of tests may be required,
  - the definition of '*comparative analysis*' is updated to include 'derivative' models in the key elements,
  - the definition of '*events*' is complemented with an explanation on how serious incidents should be identified with respect to the in-service history used for the comparative analysis,
  - under *5. Conducting Comparative Analysis*, the second paragraph is amended to add that a different design feature or margin may be shown to be acceptable when considered at the aircraft level, taking into account the other aircraft design features and margins that are deemed to contribute to safe flight in icing conditions,
  - under *5.4 Ice or Icing Conditions Detection*, the second subparagraph, dealing with the introduction of a new ice and/or icing conditions detection technology, is amended to better reflect the objective of the performance demonstration,
- Various terminologies are improved throughout the AMC.

3. Individual comments and responses

In responding to comments, a standard terminology has been applied to attest the Agency's position. This terminology is as follows:

(a) **Accepted** — The Agency agrees with the comment and any proposed amendment is wholly transferred to the revised text.

(b) **Partially accepted** — The Agency either agrees partially with the comment, or agrees with it but the proposed amendment is only partially transferred to the revised text.

(c) **Noted** — The Agency acknowledges the comment but no change to the existing text is considered necessary.

(d) **Not accepted** — The comment or proposed amendment is not shared by the Agency.

(General comments)	-

comment	*1* comment by: *EUROCONTROL* The EUROCONTROL Agency does not have comments on NPA 2015-07.
response	Noted.

comment	*2* comment by: *UK CAA* Thank you for the opportunity to comment on NPA 2015-07, Use of comparative analysis when showing compliance with SLD icing specifications. Please be advised that there are no comments from the UK CAA.
response	Noted.

comment	*3* comment by: *Luftfahrt-Bundesamt* The LBA has no comments on NPA 2015-07.
response	Noted.

comment	*4* comment by: *CAA-NL* The Nethertlands in general supports this proposal, we have just 2 minor comments to be made at the appropriate paragraph.
response	Noted.

comment	*36* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* There is a typographical error in footnote: "An Agency o the European Union" should be "An Agency of the European Union".
response	Accepted. This typo will be corrected in the NPA template.

comment	*63*	comment by: *DGAC France*
	DGAC France has no specific comment on this NPA	
response	Noted.	

comment	*64*	comment by: *DGAC France*
	DGAC France has no specific comment on this NPA.	
response	Noted.	

comment	*81*	comment by: *Boeing*
	GENERAL COMMENT: Boeing appreciates the opportunity to participate in the development of this AMC material and, in general, strongly supports EASA's proposed amendment. The practical necessity of the comparative analysis option for applicants seeking certification to the CS-25 requirements related to the SLD icing conditions represented by App. O, as well as the benefits of this option both for applicants and the Agency, make this a very positive and important proposal that may well prove to be historically significant. While we would have preferred a harmonized approach between the FAA and EASA, we commend EASA for working with industry via the Rulemaking Group to develop this proposal.	
response	Noted.	

Notice of Proposed Amendment 2015-07 p. 1

comment	*13*	comment by: *FAA*
	Comment: The report uses conditional probability, but not always with clear explanation and without using standard notation. It is strongly recommended that standard notation be used. **Rationale:** The use of standard notation will improve readability and assist in avoiding possible errors.	
response	Accepted.	

EXECUTIVE SUMMARY p. 1

comment	*11*	comment by: *FAA*
	Comment General: CS 25.21 at Amendment 16 adds requirements to consider SLD	

	conditions when demonstrating safe performance and handling margins defined throughout the regulations in Subpart B, with some exceptions. It is stated in 25.21(g)(3) that *"Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual."* NPA 2015-07 proposes the use of similarity and in-service experience to show compliance and proposes a revision to CS 25.1420 to allow use of such analysis. However, no such changes are proposed to the regulatory requirements in CS 25.21. NPA 2015-07 only proposed changes to AMC 25.21 and appears to add a means of compliance which would not meet the intent of the CS. Either withdraw the use of similarity and in-service experience as an acceptable method of compliance or revise 25.21 to add an exception paragraph for airplanes that meet certain criteria from demonstrating compliance using critical ice shapes defined in part II of appendix O. **Rationale:** As proposed, CS 25.21 and subsequent subpart B specifications require applicants that want to operate without restrictions in Appendix O conditions to show various performance and handling margins. This would typically be accomplished by flight testing the airplane to such conditions with artificial critical ice shapes installed as described in part II of appendix O. However, the proposed AMC materials would allow the use of similarity and in-service experience as an alternative. The use of such analysis would not demonstrate that an adequate handling margin exists, it could only show that it is statistically improbable that an accident would occur over the life of the airplane based on previous history. While such an analysis may show that an airplane design is statistically safe, it would not show that the minimum required performance and handling margins are actually maintained while operating in the conditions described in part I of Appendix O.
response	Accepted. CS 25.21(g)(2) and (g)(3) are amended by adding a statement at the end of these two subparagraphs, such that if applicable, a comparative analysis may be used to show compliance as an alternative to using the ice accretions defined in Part II of Appendix O.

Table of contents p. 2-3

comment	*7* comment by: *Society of Chartered Surveyors Ireland*
	Re: Introduction of a regulatory framework for the operation of drones 25th September 2015 To whom it may concern, The SCSI is the largest professional body for the property, construction and land sectors in Ireland and works in partnership with RICS in the public interest; setting and maintaining the highest standards of competence and integrity among the profession and providing impartial, authoritative advice on key issues for business, society and governments worldwide

	In response to the request for submissions in relation to proposed Draft Regulations for the Operation of Drones our Mineral Surveying Professional Group has compiled the following comments: The proposed regulations do not provide for recognition of *Remotely Piloted Aircraft System Pilots* (RPAS) pilot qualifications that many operators have already obtained in member states. For example, some of our members are fully qualified and licenced RPAS operators in Ireland. This has cost considerable time and expense. Whilst the proposed draft regulations recognise that there are existing licencing regimes in place in some member states they provide no dispensation for existing licenced operators. This point needs to be addressed in the regulations. There should be no further training / licencing requirements for existing licenced operators in member states. This is not exhaustive list of comments on the proposed regulations and the SCSI would welcome the opportunity to discuss the impact of the regulations and there impact on Ireland in more detail Regards, Peter Kinghan Chair of the Minerals Surveying Professional Group Society of Chartered Surveyors Ireland Ben King Chair of the Geomatics Professional Group Society of Chartered Surveyors Ireland
response	Noted. This comment has been forwarded to the EASA focal point in charge of the A-NPA 2015-10 on 'Introduction of a regulatory framework for the operation of drones'.

1. Procedural information p. 4

comment	*37* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 4, paragraph 1.4** This paragraph states that the CRD will be published concurrently with the Decision amending CS-25. Given the importance and complexity of the discussions involving this NPA, Embraer believes the CRD should be published prior to the final Decision, with public consultation period.
response	Not accepted. A CRD reaction time is provided in exceptional cases only, e.g. when a new and very complex regulation has been proposed, or when some changes have been made as a result of the NPA comments which could raise the need to have stakeholders attention on them.

comment	*82* comment by: *Boeing* Page: 4 Paragraph: 1.4

	<u>The proposed text states</u>: *"… The Agency will publish the CRD concurrently with the Decision amending CS-25."* **<u>REQUESTED CHANGE</u>:** We recommend revising the text as follows: *"… The Agency will publish the CRD **<u>within 90 days of the close of the public consultation of this NPA. Public consultation and comments on the CRD will then be solicited. CRD comments will be dispositioned and published</u>** concurrently with the Decision amending CS-25."* We respectfully request that the Agency provide the CRD for this NPA, along with a public consultation period, prior to the final Decision amending CS-25. We find the CRD process to be an extremely valuable aspect of the Agency's rulemaking process. We consider it one of the ways in which the Agency's rulemaking process is superior to that of other airworthiness authorities. We encourage the Agency to reconsider only providing the CRD with the final Decision. With regard to the 90 days suggested, we understand that the dispositioning of these comments might not occur until later than that; the Agency should adjust the days accordingly.
response	Not accepted. ACRD reaction time is provided in exceptional cases only, e.g. when a new and very complex regulation has been proposed, or when some changes have been made as a result of the NPA comments which could raise the need to have stakeholders attention on them.

2. Explanatory Note — 2.3. Summary of the Regulatory Impact Assessment (RIA) p. 5

comment	*83* comment by: *Boeing* Page: 5 Paragraph: *2.3 - Summary of the Regulatory Impact Assessment (RIA)* *EDITORIAL COMMENT* **<u>The proposed text states</u>:** *"… This would provide a benefit in terms of safety level harmonisation, and would facilitate the certification process for both the applicants and the Agency when eligible to the comparative analysis, with an overall economic benefit. …"* **<u>REQUESTED CHANGE</u>:** We recommend revising the text as follows: *"… This would provide a benefit in terms of safety level harmonisation and would facilitate the certification process for both the applicants and the Agency when eligible to **<u>utilize</u>** the comparative analysis, with an overall economic benefit. …"* **<u>JUSTIFICATION</u>:** There seems to be a verb missing from the phrase, *"when eligible to the*

	comparative analysis." While *"utilize"* is suggested, any appropriately descriptive verb would complete the phrase.
response	Accepted.

2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.1. Definitions p. 6-8

comment	*8* comment by: *Vereinigung Cockpit* Additional Definitions Freezing Drizzle In my feeling "...but freeze upon impact with the ground or <u>exposed objects</u>." is missleading, as freezing rain/drizzle by definition are precipitations reaching the ground. Large droplets impinging on the aircraft surface during flight can only be Freezing Rain or Drizzel, if they are also reaching the ground. Otherwise these droplets should be defined as SLD. Note, that meteorologists report or forecast Freezing Rain or Drizzle only, if the supercooled droplets are falling on to the earth's surface. Text of the definition Freezing Drizzle / Rain should read: Liquid precipitation in the form of water drops with... ...but freeze upon impact with the ground or exposed objects <u>at or close to the ground.</u>
response	Not accepted. The definition provided in the explanatory note is copied from SAE ARP5624, 'Aircraft Inflight Icing Terminology'. It is consistent with CS-25 Appendix O.

comment	*9* comment by: *Vereinigung Cockpit* Definitions Runback Ice Freezing of impinging water due to removal of energy of fusion never is instantanious. With the Messinger Freezing Fraction anywhere between 0 and 1, only a part of the impinging water will freeze, while the remaining liquid water will be driven downstream. The surface temperature of the water/ice mixture will be exactly 0°C. Runback ice therefore does not neccessarily require an area with temperature above freezing in order to freeze further downstream. Text of definition should read: Ice formed from the freezing or refreezing of water flowing downwind to an area that is sufficiently cooled for freezing to take place. Sources of runback ice can be impinging supercooled water not freezing completely or water from ice melting on surfaces above freezing. The latter is frequently associated as unwanted product of thermal anti-icing or de-icing systems.
response	Not accepted. The definition provided in the explanatory note is copied from SAE ARP5624, 'Aircraft Inflight Icing Terminology'

comment	_14_	comment by: _FAA_
	Comment Definitions: In this proposal, EASA uses the term “serious incident” as defined in ICAO annex 13, chapter 1. The ICAO definition is “An incident involving circumstances indicating that an accident nearly occurred.” In addition, there are examples of “serious incidents” included in Attachment C of Annex 13. The most fitting example related to flight in icing is “System failures, weather phenomena, operations outside the approved flight envelope or other occurrences which could have caused difficulties controlling the aircraft.” EASA should make it clear in this document that pilot reports of difficulty maintaining control or temporary loss of control in icing conditions is considered a serious incident with respect to the in-service history used for the comparative analysis **Rationale:** For the purposes of this comparative analysis, it should be made clear what is considered a “serious incident”. The ICAO definition may be open to interpretation in that it may be expected that flight in icing is more difficult than flight in dry air so as long as an accident did not nearly occur then it is not considered serious, such as may be the case for investigative authorities. However, for the purposes of this comparative analysis, any unforeseen issue during operations in icing conditions should be considered serious for the purposes of evaluating in-service experience. It is expected that any issues in the more probable appendix C conditions would be increased as icing conditions are more severe, such as in SLD.	
response	Accepted. For your information, the quoted definition is not the latest version. ICAO Annex 13 Tenth Edition dated July 2010 provides the following definition for a Serious Incident: ‘_An incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down_.’ Appendix C to Annex 13 example mentioned has also been slightly updated: ‘_System failures, weather phenomena, operations outside the approved flight envelope or other occurrences which caused or could have caused difficulties controlling the aircraft_.’ It is agreed that there is no Annex 13 Appendix C example corresponding to the type of events we are pointing at. The following statement is therefore added in the definition of events in the explanatory note: _‘For the purpose of identifying serious incidents with respect to the in-service history used for the comparative analysis, this should include reports where the flight crew encountered difficulties controlling the aeroplane, or temporarily lost its control, when flying in icing conditions.’_ This statement is also added to the definition of ‘events’ in AMC 25.1420, paragraph (e)1. ‘Definitions’.	

comment	_70_	comment by: _AIRBUS_
	<u>Original text:</u> "Key paramaters _Parameters that can be shown to have contributed to the safe operation in icing conditions of the reference fleet_."	

	Proposed text: "Key parameters Parameters deemed to have contributed to the safe operation in icing conditions of the reference fleet." Comment applies throughout the document. Rationale: The word "deemed" is a more appropriate word than "shown". The comparative analysis is based on in-service statistics for a range of aircraft with comparable but not necessarily identical design features and margins. It may not be possible in all cases to fully deterministically "show" or "demonstrate" that a key parameter has contributed to the safe in-service operation in all icing conditions. However this does not mean that the key parameter is not valid. When determining the list of key parameters contributing to the safe in-service history of the reference fleet a combination of engineering data, judgement and experience will be applied. The word "deemed" more accurately reflects this methodology.
response	Partially accepted. The definition is updated to read ‘Parameters that contributed to the safe operation(…)’.

comment	*72* comment by: *AIRBUS* General Comment Throughout the document, replace "*Appendix C/Appendix O icing conditions*" with following term: "The icing conditions represented by Appendix C/Appendix O" Rationale: Appendix C & O are not naturally occuring icing conditions but are rather engineering standards intended to represent actual icing conditions. This clarification is important in the interpretation of some parts of the "SLD requirements and guidance". The proposed wording should therefore be used consistently throughout the proposed AMC. Specific Comment Original Text: "*Comparative analysis:* *- The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in the icing environment of Appendix C with a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been certified for operation in the icing environment of Appendix O*." Proposed Text: “The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in all icing conditions via the environment represented by Appendix C and have a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been explicitly certified for operation in the icing environment represented by Appendix. Rationale: Existing Aircraft that are already certified to the icing conditions represented by Appendix

C are certified for all icing conditions without restriction. These aircraft (originally certified prior to the SLD icing requirements) are still approved for flight in all icing conditions after the publication of the new requirements.

response

Partially accepted.
The proposed text is accepted, except that the word 'all' is removed. The previous certifications were based on Appendix C. However, Appendix C was not deemed to represent all icing conditions. 'Any' is added before 'supercooled liquid water icing conditions'.

comment *84* comment by: *Boeing*

Pages: 6 and 31-32
Paragraph*: 2.4.1.1 and 3.1.11.e.1*

The proposed text states:

"Comparative analysis
– The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in the icing environment of Appendix C with a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been certified for operation in the icing environment of Appendix O. …"

REQUESTED CHANGE: We recommend revising the text as follows:

"Comparative analysis
*– The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in **all icing conditions via** the icing environment ~~of~~ **represented by** Appendix C ~~with~~ **and have** a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been **explicitly** certified for operation in the icing environment ~~of~~ **represented by** Appendix O. …"*

JUSTIFICATION: We request that it be noted that aeroplanes certificated prior to Amendment 16 and CS 25.1420, which used only the App. C standards, are certified for flight in all icing conditions (unless they have AFM Limitations), but were not specifically required to consider the SLD icing environment represented by App. O.

We recommend always being mindful that Appendices C and O are merely engineering standards to be used for aircraft certification. They are intended to be representative of non-SLD and SLD icing conditions, respectively. Therefore, we request that references to *"the icing environment of"* be modified to state instead, "*the icing environment* ***represented by*** *Appendix* [C or O]". This is particularly important for Appendix O, due to its four specific drop distributions (which are only statistical means of the research-data distributions); those are the *"Appendix O conditions."* Thus, if it is desired to refer to *"SLD icing conditions,"* then one should either state that or refer to the SLD icing environment represented by Appendix O. This comment is applicable throughout the document.

response

Partially accepted.
The proposed text is accepted, except that the word 'all' is removed. The previous certifications were based on Appendix C. However, Appendix C was not deemed to represent all icing conditions. 'Any' is added before 'supercooled liquid water icing conditions'.

comment	*85*	comment by: *Boeing*
	Pages: 7 & 32 Paragraphs: *2.4.1.1 & 3.1.11.e.1* **The proposed text states:** ***"Key parameters*** *Parameters that can be shown to have contributed to the safe operation in icing conditions of the reference fleet. These parameters should be defined and provided by the applicant for each of the topics addressed in comparative analysis. …"* **REQUESTED CHANGE:** We recommend revising the text as follows: ***"Key parameters*** *Parameters that can be ~~shown~~ **deemed** to have contributed to the safe operation in icing conditions of the reference fleet. These parameters should be defined and provided by the applicant for each of the topics addressed ~~in~~ **using** comparative analysis. …"* **JUSTIFICATION:** Deletion of the word "shown" in favor of "deemed" is requested because we consider that it is a more representative description for the manner in which engineering judgment will be required for the application of comparative analysis. In the second sentence, *"topics addressed in comparative analysis"* is an odd phrase (underscore added). It is assumed that the intention is to refer to topics "addressed using" or "addressed by" comparative analysis.	
response	Partially accepted. The definition is updated to read 'Parameters that contributed to the safe operation(…)'.	

comment	*86*	comment by: *Boeing*
	Page: 8 Paragraph: *2.4.1.2* *Editorial Comment* **The proposed text states:** ***"Liquid Water Content (LWC)*** *The total mass of water contained in liquid drops within a unit volume or mass of cloud or precipitation, usually given in units of grams of water per cubic metre or kilogram of dry air (g/m3, g/kg).* **REQUESTED CHANGE:** We recommend revising the text as follows: ***"Liquid Water Content (LWC)*** *The total mass of water contained in liquid drops within a unit volume or mass of cloud or precipitation, usually given in units of grams of water per cubic metre or kilogram of dry air (g/m^3~~3~~, g/kg)."*	

	JUSTIFICATION: The representation of "cubic metre" as "m3" is incorrect; the "3" needs to be an exponent/superscript.
response	Accepted.

2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.2. Comparative analysis as a means of compliance — Explanatory note p. 8-16

comment	*5* comment by: *CAA-NL* **Comment on Paragraph 2.4.2.1.5 (page 14 of 53)** The analysis in paragraph 2.4.2.1.5 is based on the conditions as defined in the study of Dr Stewart Cober and Dr James Riley as described in Annex 1. The study is based on the atmosphere as encountered in their specific winter weather SLD campaigns, probably within the North American atmospheric conditions. How can EASA asure that these are representative for global application?
response	Noted. It is true that the SLD observation data used from report DOT/FAA/AR-09/10 Section 3.9 reflect North America during the winter season. However, in Section 4.1 and 4.2 it is concluded that, based on numerical models and ground observations, these figures can be used globally. Please note that Appendix O was also built based on the same data.

comment	*15* comment by: *FAA* **Comment2.4.2.1.2**: The term "heavy SLD" should be defined prior to the first usage of the term. As an alternative, when the term is first used, there should be reference made to where the term is defined. The first usage is on page 10, but the term is not defined until later in the proposal on page 11. **Rationale**: Editorial, for clarity
response	Accepted. A definition for 'Heavy SLD icing conditions' has been added in paragraph 2.4.1.2 of the explanatory note.

comment	*16* comment by: *FAA* **Comment: Para 2.4.2.1.2:** The term "heavy SLD" should be defined prior to the first usage of the term. As an alternative, when the term is first used, there should be reference made to where the term is defined. The first usage is on page 10, but the term is not defined until later in the proposal on page 11. **Rationale:** Editorial, for clarity **Comment: Para 2.4.2.1.3.1:** The probability used should be the probability of "heavy" LWC AND near the cold OAT envelope limit of Appendix O. **Rationale:** It is likely that for thermal systems, the upper left corner of the LWC/OAT

	Appendix O envelopes may be the most critical. (Reference page 35 of the Part 23 Icing Aviation Rulemaking Committee final report). Colder OATs in SLD conditions are more critical for propeller ice accretion (Reference DOT/FAA/AR-06/60, Propeller Icing Tunnel Test on a Full Scale Turboprop Engine). However, as noted in DOT/FAA/AR-09/10 which is referenced throughout this proposal, there were very few icing encounters in this region, figures 11 and 12. In general, the majority of measured SLD encounters occurred at temperatures near freezing. So, it's more probable that airplanes in service have encountered SLD conditions near freezing much more than they have encountered SLD at colder temperatures. However, from a design perspective, the colder region is traditionally more limiting or difficult to substantiate. **Comment: Para 2.4.2.1.3.1**: This section uses conditional probability; if the discussion and notation reflected the use of conditional probability, it would be much easier to follow, and there would be no need to introduce the term "scenario." For example, using conditional probability, the equation at the bottom of page 10 should be written as follows: *P(Heavy SLD encounter)= P(Icing encounter) x P(SLD encounter|Icing encounter) x P(Heavy SLD encounter| SLD icing encounter)* Note. The notation P(B|A) denotes the conditional probability of the occurrence of B given the occurrence of A. So what the report calls P(Scenario) is actually P(Heavy SLD encounter). The same comment applies to the rest of the proposal. The proposal should use notation that explicitly identifies conditional probabilities when they are used, and should replace P(Scenario) with P(Heavy SLD encounter) in all locations. **Rationale:** The methodology of using conditional probability contained in the proposal would be easier to follow if standard notations are used.
response	1) Comment on Para 2.4.2.1.2 related to 'heavy SLD' definition: this is a repetition of FAA comment 15. Please refer to the reply to this comment. 2) Comment on Para 2.4.2.1.3.1: 'The probability used should be the probability of 'heavy' LWC AND near the cold OAT envelope limit of Appendix O': Not accepted. Firstly, these SLD conditions may be critical for a propeller, but not necessarily for an airframe ice protection system. Secondly, there is no data available in report DOT/FAA/AR-09/10 allowing to calculate the probability for these SLD conditions. Finally, we have added a factor of 10 over the 1 percent probability of encountering icing conditions beyond Appendix O which adds conservatism for calculating the minimum number of flights, covering any assumption made during the probability calculation. 3) Comment on the notation of conditional probabilities: Accepted.

comment	*17* comment by: *FAA* **Comment: Para 2.4.1.3.2**: When referencing information contained in FAA research

document DOT/FAA/AR-09/10, the proposal states that *"The report concludes that the probability of SLD in any region of the North America during the winter season is between 0.5 % and 5% (P from 0.005 to 0.05)."*

The actual conclusion statement from the referenced research document should be used rather than paraphrasing the statement. The actual conclusion was:

Determining the actual occurrence of SLD in the atmosphere is difficult using the data sets available. It is recognized that there are large geographical differences and changes with season. However, to a first approximation, the probability of occurrence of SLD for any particular location in North America, representing the altitude ranges between 0 and 15,000 ft (5km), which aircraft normally encounter upon takeoff and landing, is typically 0.5% to 5% over a winter season for a large portion of the continent**.**

Rationale: The proposal should make it clear that the probability of SLD forming, as noted in the referenced report, is not the same as the probability of encountering SLD icing conditions as a function of flight time. Depending on the flight profile of the airplane, the exposure to supercooled liquid icing conditions will most likely occur at lower altitudes, such as during takeoff and landing which may only be a small portion of the total flight time depending on the airplane and type of flights typically flown.

Comment: Para 2.4.1.3.2: Also when referring to FAA research document DOT/FAA/AR-09/10, the proposal states that *"On page 25 of the referenced report, the ratio of SLD icing to normal icing conditions is stated as 17 % (P of 0.17)."* The derivation formula is contained in footnote 8 on page 11.

This is the wrong probability. An estimate of the correct probability is needed. As discussed in previous comments, this should be an estimate of encountering SLD conditions at low outside air temperatures since those conditions are generally the worst case from a design perspective. However, they are less likely to have been encountered.

Rationale: The probability that is needed, is

P(SLD encounter|Icing encounter)

However, the probability that is calculated in the footnote and originally intended in the referenced research document is

P(Operating in SLD conditions|Operating in icing conditions)

It is possible for these probabilities to be very different, as the following simple example shows:

Assume 10 flights, all of which encounter icing conditions for exactly 15 minutes.

Assume 5 of these flights encounter SLD conditions for exactly 5 of those minutes.

Then

P(SLD encounter|Icing encounter) = 5/10 = 0.5

	*P(Operating in SLD conditions│Operating in icing conditions) = (5*5)/(10*15) = 25/150 = .17* **Comment: Para 2.4.2.1.3.2:** Revise the next to last sentence in the first paragraph as follows: The number of flights by members of the fleet for an expected single encounter is inversely proportional to this probability and therefore a lower probability implies more required flights for an encounter. **Rationale:** Correction as to the meaning of the inverse of the probability estimated
response	Comment 1 on Para 2.4.2.1.3.2 recommending to use the actual conclusion statement from document DOT/FAA/AR-09/10: Accepted. Comment 2 on Para 2.4.2.1.3.2 recommending to correct the calculation of P_{SLD}: Not accepted. In order to calculate a ration of numbers of encounters, we need the number of SLD encounters and the number of supercooled liquid icing encounters. The number of SLD encounters (305) could be retrieved from the data gathered during the flight measurement campaigns, with the support of two of the authors of report DOT/FAA/AR-09/10 (Stewart Cober and Jim Riley). However, the number of supercooled liquid icing encounters is not available. Therefore, a ratio based on the numbers of 30-second data points (provided in report DOT/FAA/AR-09/10, page 25) was used. Further to this comment, additional ratio calculations were performed with the support of Stewart Cober, in order to check how the ratio changes as a function of the duration of the averaging interval. The explanatory note of the NPA has been updated and provides the result. This shows that the ratio increases slightly when the averaging interval increases. It is also concluded that a ratio of 0.17 can be retained in our calculation, because it is the most conservative one. Comment 3 on Para 2.4.2.1.3.2 recommending to revise the next to last sentence in the first paragraph: Not accepted. The initial sentence is considered clear enough; the proposed change would have the same meaning.

comment	*18* comment by: *FAA* **Comment: Para 2.4.2.1.3.2**: The probability of encountering either FZDZ or FZRA is used. Instead, the probability of encountering FZRA at cold OAT or FZDZ at cold OAT should be used, whichever is lower **Rationale:** FZRA may result in quite different ice accretions and resulting aerodynamic effect than FZDZ.
response	Not accepted. There is no data available in report DOT/FAA/AR-09/10 allowing to calculate the probability for these SLD conditions. Furthermore, we have added a factor of 10 over the 1 percent probability of encountering icing conditions beyond Appendix O which adds conservatism for calculating the minimum number of flights, covering any assumption made during the probability calculation.

comment	*19* comment by: *FAA* **Comment: Para 2.4.2.1.4:** The document states a Saab 340 experienced an event in 2006 but there was no consensus on whether SLD was the cause. In lieu of consensus, only a

majority should be needed after reviewing the NTSB probable cause, but more importantly, the performance group report in the NTSB docket. Assuming that a majority of the working group agreed that the 2006 Saab 340 incident was SLD related, the in-service experience analysis should be revised to ensure that the fleet analysis history would capture models such as the Saab 340.

Rationale: The NTSB report analyzed the FDR data and shows a 40% loss of CLMAX compared to a clean airplane. This is very similar to the lift loss of Comair 5054, which the majority of the FAA's IPHWG concluded was SLD. Certification experience of the last 15 years and research shows that the most critical Appendix C ice shapes on pneumatic boot equipped airplanes results in about a 20-25% maximum lift loss. For example see DOT/FAA/AR-06/48. The NTSB performance group report also show Saab 340 incidents prior to 2006 with similar lift losses.

response Noted.
As explained in paragraph 2.4.2.1.4, the rulemaking group included in its review all events involving supercooled liquid icing conditions, and not only SLD icing conditions.
The Cessna 560 and the Saab 340 were identified as having experienced events in icing conditions although the actual encounter of SLD by the aircraft could not be 100 % ascertained. The history of events of these two types was nevertheless taken into account to ensure that the proposed fleet history threshold would cover them.

comment *20* comment by: *FAA*

Comment: Para 2.4.2.1.4: For acceptable in-service experience, the SLD event criteria with a higher flight number from figure 2 should be used in lieu of 2 million flights without an icing event.

Rationale: Two million flights without any icing accident or serious incident is used rather than a higher number of flights prior to an SLD event. Historically, SLD events have been preceded by non SLD icing events. While this may have been true of previous designs, it's unlikely that it will remain true for airplanes designed as of the late 1990's. After the older icing related events, especially Roselawn in 1994, airplane manufacturers and industry in general have been continually improving the methods used to demonstrate safe flight in icing conditions on new type designs. The methods used to determine critical ice shapes for each flight phase and the installation of artificial ice shapes on flight test airplanes during the airplane certification process has vastly improved. Although new regulations that introduced such requirements are not always in the cert basis for newly designed derivative products, the general concept and more robust certification test methods have been in place for some time. In addition, many airplanes in service have had design improvements intended to prevent incidents in icing conditions, such as the addition of low speed alerting systems. Over the last 15 years, or more, airplane manufacturers have improved the methods used to generate artificial ice shapes and demonstrate safe performance and handling in icing conditions for recent airplane designs.

Comment: Para 2.4.2.1.4: This analysis should include the number of SLD events at cold OAT

Rationale: It is likely that for thermal systems, the upper left corner of the LWC/OAT Appendix O envelopes may be the most critical. (Reference page 35 of the Part 23 Icing Aviation Rulemaking Committee final report). Colder OATs in SLD conditions are more critical for propeller ice accretion (Reference DOT/FAA/AR-06/60, Propeller Icing Tunnel Test on a Full Scale Turboprop Engine).

response

Comment 1 on the proposed fleet history threshold: Not accepted. The approach used was to first calculate a minimum number of flights based on the probability of encountering SLD derived from meteorological data, and second to use accidents/incidents data to check that this value is consistent. Increasing the final minimum number of flights based on the consideration explained in this comment is not deemed justified as it would add another layer of conservatism to an already conservative probabilistic analysis.

Comment 2 on the number of SLD events at cold OAT: Noted. The in-service events review did not discriminate on the OAT parameter. Any incident or accident in supercooled liquid icing conditions has been considered.

comment *49* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

2.4.2.1.4 Page 13

There are some minor typographical errors, which should be corrected:

- “Error! Reference source not found” Correct reference to be added to text.
- The letter a is missing from the word “accidents”.
- The carriage return before the word “Table 2” should be removed.

response

Accepted.

comment *52* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

Page 14, section 2.4.2.1.4

Original Text

"(...) Table 2 shows that the first recorded icing incident occurred for the Embraer after 540000 flights"

Proposed Text

"(...) Table 2 shows that the first recorded icing incident occurred for the ***EMB-120*** *after 540000 flights*".

Rationale

The proposed text aims to make this passage coherent to other references to aircraft models in the text, such as those on pages 12 and 13, where the model is mentioned, not the manufacturer.
This change would also be suitable for other passages of this NPA, such as item 2.4.2.1.4 on page 13, Table 1, Table 2.

response

Accepted.

comment	_66_ comment by: _AIRBUS_ **Paragraph 2.4.2.1.3.3 Probability of heavy SLD icing conditions** <u>Original Text:</u> "_The final term in the SLD scenario probability equation is the probability of SLD conditions being heavy. Again, based on the data of DOT/FAA/AR-09/10, 99 % and 99.9 % exceedance probabilities were presented for Appendix O icing conditions. Figures 37 through 40 of the referenced report show that the 99 % exceedance limits of Appendix O are consistent with the Newton definition of heavy icing conditions (refer to DOT/FAA/AR-09/10 section 3.22). Indeed, Appendix O is based on 99 % exceedance limits. The 99.9 % Liquid Water Content (LWC) analysis contained in this report has significant confidence limits, and there were no SLD observations that exceeded the upper confidence limit of the 99.9 % LWC envelopes. Therefore, to provide an additional element of conservatism, a probability of exceeding Appendix O icing conditions was defined as 0.001_." <u>Proposed Text:</u> “The final term in the SLD scenario probability equation is the probability of SLD conditions being heavy. <u>For the purpose of these analyses, SLD icing conditions beyond those represented by Appendix O are termed "heavy".</u> ~~Again, based on the data of DOT/FAA/AR-09/10, 99 % and 99.9 % exceedance probabilities were presented for Appendix O icing conditions. Figures 37 through 40 of the referenced report show that the 99 % exceedance limits of Appendix O are consistent with the Newton definition of heavy icing conditions (refer to DOT/FAA/AR-09/10 section 3.22). Indeed, Appendix O is based on 99 % exceedance limits.~~ <u>For</u> the 99.9 % Liquid Water Content (LWC) analysis ~~contained in this report has significant confidence limits, and~~ there were no SLD observations that exceeded the upper confidence limit of the 99.9 % LWC envelopes. Therefore, to provide an additional element of conservatism, a probability of exceeding Appendix O icing conditions was defined as 0.001. <u>Rationale:</u> The term "heavy" was adopted by the RMT group to denote and encounter sufficient severity whilst avoiding the term "severe”. It is recommended to highlight that this term was defined by the group and not D. Newton as indicated by the report. The proposed text simplifies the explanation of how the probability of heavy SLD icing conditions was defined to aid understanding.
response	Partially accepted. This comment has been considered together with comment 89 dealing with the same paragraph. A definition for ‘Heavy SLD icing conditions’ has been added in paragarph 2.4.1.2 of the Explanatory note. The definition is, therefore ,not repeated in paragraph 2.4.2.1.3.3. The other proposed changes are partially implemented, as proposed by comment 89 hasve been accepted.

comment	_71_ comment by: _AIRBUS_ **Paragraph 2.4.2.1.3.1 Introduction** Add at the end of the last paragraph:

	"For the purpose of these analyses, SLD icing conditions beyond those represented by App. O are termed "heavy". "
response	Partially accepted. A new definition for 'Heavy SLD icing conditions' has been added to paragraph 2.4.1.2 of the explanatory note. The content of this definition corresponds to the one proposed in your comment.

comment	*73* comment by: *Bombardier* **NPA Proposed Text** *2.4. Overview of the proposed amendments* *….* *2.4.2. Comparative analysis as a means of compliance — Explanatory note* *To use a comparative analysis as a MoC for a new or derivative aeroplane model, four main elements should be established:* 1. *A reference fleet with an adequately safe history in icing conditions;* **Bombardier Comment** While the majority of OEMs have reference fleets with adequate flight hours and a safe operational history under SLD conditions, other OEMs may not be able to provide a reference fleet with adequate in-service flight hours for some of their specific aeroplane models. This NPA would put these OEMs at a competitive disadvantage. This is a concern and it is recommended that the authorities review and consider ways to ensure a level playing field for all OEMs prior to publication of this AMC.
response	Noted. The concept of allowing a comparative analysis was introduced in the frame of RMT.0058. It is acknowledged that not all applicants may be eligible to use it.

comment	*74* comment by: *Bombardier* **NPA Proposed Text** *2.4.2.4 Additional considerations — Augmenting comparative analysis* *At the time of this rulemaking task, the SLD tools required to design and certify new or derivative aeroplane model are not adequately mature. For example, little data and few analysis and test tools are available for use in predicting the ice accretions associated with flight in all SLD icing conditions as represented in Appendix O. However, various organisations are working towards generating more information on SLD ice accretions and improving the associated tools. In the future, this additional information can be expected to lead to improved knowledge leading to alternative types of analyses.* *The comparative analysis may be used in combination with new methodologies (test or analysis) at the applicant's discretion in order to establish a comparison between the new or derivative model and the reference fleet. The use of any new methodologies should be agreed by the Agency....* **Bombardier Comment**

	Smaller OEMs will incur significant economic cost to develop in-house tools to allow them to predict ice accretions in SLD conditions. In order to ensure level playing field, it is recommended that authorities review ways to ensure availability of current and future tools to all OEMs
response	Noted. The Agency expects comparative analysis to be accessible also to small OEMs. Concerning means of compliance other than comparative analysis, the European Union provided support to the industry for developing SLD icing simulation tools. For instance, the EU-funded projects EURICE and EXTICE contributed to identifying, understanding and predicting SLD icing conditions and their accretions on aircraft surfaces. Information and report can be found here: http://cordis.europa.eu/result/rcn/54172_en.html Other research projects are foreseen to further improve CFD and icing wind tunnels capabilities to simulate SLD icing accretions. Industry participation to this effort is required in addition to funding provided by institutions or States.

comment	*87* comment by: *Boeing* Page: 10-11 Paragraph: *2.4.2.1.3.1 - Introduction* **The proposed text states:** *"This paragraph describes how the required number of flights was determined based on the probability of a heavy SLD icing encounter. It is first necessary to define an appropriately conservative icing scenario and the associated probability.* *It was considered that the scenario must include the severity of the SLD conditions in order to ensure that a fleet of aircraft had encountered sufficiently conservative exposure. To ensure this, the probability computations are based on heavy SLD icing conditions which reduces the probability of the scenario which is conservative because it increases the number of flights that the reference fleet must have accumulated. Therefore, it was necessary to determine the probability of encountering icing in flight (P_{ICING}), the proportion of in-flight icing conditions that are SLD (P_{SLD}) and finally the probability of encountering heavy SLD ($P_{HEAVY\ SLD}$) conditions. …"* **REQUESTED CHANGE:** We recommend revising the text as follows: *"… This ~~paragraph~~ **section** describes how the required number of flights was determined based on the probability of a heavy SLD icing encounter. It is first necessary to define an appropriately conservative icing scenario and the associated probability**. For the purposes of these analyses, SLD icing conditions beyond those represented by Appendix O are termed 'heavy.'*** *It was considered that the scenario must include the severity of the SLD conditions in order to ensure that a fleet of aircraft had encountered sufficiently conservative exposure. To ensure this, the probability computations are based on heavy SLD icing conditions, which reduces the probability of the scenario; ~~which~~ **this** is conservative because it increases the number of flights that the reference fleet must have accumulated. Therefore, it was necessary to determine the probability of encountering icing in flight (P_{ICING}), the proportion of in-flight*

	*icing conditions that are SLD **as represented by Appendix O** (P_{SLD}), and finally the probability of encountering heavy SLD ~~($P_{HEAVY SLD}$)~~ conditions **($P_{HEAVY SLD}$).** …”* **JUSTIFICATION:** The addition at the end of the first paragraph is requested because, although SLD icing conditions beyond Appendix O include more than those of “heavy” intensity, for the purposes of the analyses contained in this material, it is desirable to use just one word. This simplifies the nomenclature while also acknowledging that there are more than “heavy” conditions beyond Appendix O. Note that this comment is the first of two that address this issue; also see our comment on paragraph 2.4.2.1.3.3 (p. 11 of NPA). At the end of the second paragraph, it is appropriate to qualify P_{SLD} as being the SLD conditions represented by Appendix O. The remaining revision requests are editorial; for example, moving “($P_{HEAVY SLD}$)” to the end of the phrase corresponds to the format used for the other probabilities. We also point out that because of the numerous conservatisms incorporated into the “number of flights” calculation via the selected probabilities, the resulting 1.2 million flights is very conservative. In addition, 1.2 million flights is a conservative number relative to the in-service experience of the current fleet of CS-25 aeroplanes. This is discussed in section 2.4.2.1.4 of the NPA, where it is concluded that 600,000 flights would be sufficient based on that data. The recommended requirement of 2 million flights, adding yet another layer of conservatism, may be unwarranted and excessive.
response	Partially accepted. A definition of ‘Heavy SLD icing conditions’ has been added in paragraph 2.4.1.2 of the explanatory note and is, therefore, not repeated here. The other proposed changes are adopted.

comment	*88* comment by: *Boeing* Page: 11 Paragraph: *2.4.2.1.3.2 -- Probability of SLD icing conditions* **<u>The proposed text states</u>:** *“… Next, the probability of encountering SLD icing conditions aloft at altitudes up to 22 000 feet, whilst in icing conditions, is taken from FAA report DOT/FAA/AR-09/10[7]. The report concludes that the probability of SLD in any region of the North America during the winter season is between 0.5 % and 5% (P from 0.005 to 0.05). On page 25 of the referenced report, the ratio of SLD icing to normal icing conditions is stated as 17 % (P of 0.17)[8]. The report also states, however, that because the intent of the testing conducted to gather that data was to fly in SLD conditions, the ratio of SLD icing to non-SLD icing found during the research flight tests could be as much as ten times higher than typically found in icing conditions of all types. This is consistent with the factor of 10 shown in the range of SLD probability of 0.05 to 0.005. Therefore, a conservative probability for SLD conditions of 0.017 was used for this analysis. …”* **<u>REQUESTED CHANGE</u>:** We recommend revising the text as follows:

"… Next, the probability of encountering SLD icing conditions aloft at altitudes up to 22 000 feet, whilst in icing conditions, ~~is taken~~ was derived from the FAA report on the development of an SLD engineering standard to be used for certification [which became Appendix O], DOT/FAA/AR-09/10[7]. The report concludes that the probability of SLD ~~in any region~~ icing conditions existing between 0 and 15,000 ft. altitude for most of ~~the~~ North America during the winter season is between 0.5 ~~%~~ and 5 ~~%~~ percent (P from 0.005 to 0.05). This probability range reflects the difference in the occurrence of SLD icing conditions at various geographical locations. ~~On~~ Per page 25 of the referenced report, the ratio of SLD icing to normal icing conditions ~~is stated as~~ for the research encounters was 17 ~~%~~percent (P of 0.17)[8]. The report also states, however, that because the intent of the testing conducted to gather that data was to fly in SLD conditions, the ratio of SLD icing to non-SLD icing found during the research flight tests ~~could be as much as ten times higher than typically found in icing conditions of all types. This is consistent with the factor of 10 shown in the range of SLD probability of 0.05 to 0.005.~~ was higher than would be expected for commercial flights. Therefore, a conservative probability for SLD conditions of 0.017 was used for this analysis. …"

JUSTIFICATION: Based upon the data contained in the report, clarification of the meteorological data from the FAA report would benefit the proposed text. We request that the proposed paragraph be revised to be more consistent with the report.

The altitude for the cited probabilities is expressly stated in the report (p. 71) to be between 0 and 15,000 ft. Thus, the NPA is proposing to apply those probabilities to an extended altitude of 22,000 ft., no doubt to be commensurate with the FZDZ temperature vs. altitude standard of App. O. This might be reasonable, but it is an extrapolation and could imply that further examination of the flight data at altitudes from 15,000 to 22,000 ft. is needed for verification.

The range of probabilities given at the conclusion of the report is primarily a function of geographical differences within North America. That aspect is thoroughly discussed in the report. (Also note that we highly recommend that percent symbols should not be used in this text; "percent" should be spelled out so that there is no chance for misinterpretation. This revision is applicable throughout the document.)

The FAA report does not *"state"* a 17 percent ratio; rather, as shown in the footnote, the data are provided from which the reader can calculate the percentage.

From the data in the report, it is difficult to draw the stated conclusions regarding the probability range's *"factor of 10"* (from 0.5 to 5 percent). The report states that the research-based probability data cannot be used to determine the probability of an SLD encounter for a given flight, which is expected to be lower but is not quantified. It is therefore difficult to calculate the probability of encountering SLD for a given fight. The report describes comparisons of the flight data to surface data and explains that, *"the percentiles for freezing drizzle and freezing rain based on unbiased surface measurements are very similar to those obtained from the in-flight measurements used to produce App. X"* (p. 60; note that App. X became App. O). Without additional reference, the logic leading to the probability conclusions is not clear. Nonetheless, the use of conservatism resulted in reasonable probabilities being used for the analysis.

Our recommended revisions will make this paragraph more accurate relative to the report, while the proposed probability of 17 percent used for SLD icing conditions will remain reasonable.

response | Accepted.

comment | *89* | comment by: *Boeing*

Page: 11
Paragraph: *2.4.2.1.3.3 - Probability of heavy SLD icing conditions*

The proposed text states:

"The final term in the SLD scenario probability equation is the probability of SLD conditions being heavy. Again, based on the data of DOT/FAA/AR-09/10, 99 % and 99.9 % exceedance probabilities were presented for Appendix O icing conditions. Figures 37 through 40 of the referenced report show that the 99 % exceedance limits of Appendix O are consistent with the Newton definition of heavy icing conditions (refer to DOT/FAA/AR-09/10 section 3.22). Indeed, Appendix O is based on 99 % exceedance limits. The 99.9 % Liquid Water Content (LWC) analysis contained in this report has significant confidence limits, and there were no SLD observations that exceeded the upper confidence limit of the 99.9 % LWC envelopes. Therefore, to provide an additional element of conservatism, a probability of exceeding Appendix O icing conditions was defined as 0.001. …"

REQUESTED CHANGE: We recommend revising the text as follows:

"The final term in the SLD scenario probability equation is the probability of SLD conditions being heavy. Again, based on the data ~~of~~ **contained in the FAA report**, DOT/FAA/AR-09/10, 99 ~~%~~ and 99.9 **percent**~~%~~ ~~exceedance probabilities~~ **percentile data for Liquid Water Content (LWC)** were presented ~~for Appendix O icing conditions. Figures 37 through 40 of the referenced report show that the 99 % exceedance limits of Appendix O are consistent with the Newton definition of heavy icing conditions (refer to DOT/FAA/AR-09/10~~**,** ~~section 3.22). Indeed, Appendix O is based on 99 % exceedance limits~~ **based upon the SLD research flight data. For** ~~T~~**t**he 99.9 ~~%~~ **percent** ~~Liquid Water Content (~~LWC~~)~~ analysis**,** ~~contained in this report has significant confidence limits, and~~ there were no SLD observations that exceeded the upper confidence limit**s** ~~of the 99.9 % LWC envelopes~~. Therefore, to provide an additional element of conservatism **for the calculation of number of flights required**, a probability of exceeding **the SLD conditions represented by** Appendix O ~~icing conditions~~ was defined as 0.001. …"

JUSTIFICATION: This comment is the second of two intended to address the issues raised by reference to "heavy" SLD conditions and the use of two different probabilities for the same conditions [one for this "number of flights" calculation, and the second, for the "number of encounters" calculations per section 2.4.2.1.5 (p. 14 of NPA) and Appendix 1]. Also see our comment on paragraph 2.4.2.1.3.1 (pp. 10-11 of the NPA) for the first of these two comments.

In this paragraph, the reference to the FAA report regarding the Newton curve describes it as "heavy." The FAA report, however, states that Newton suggested that curve to be representative of "severe" conditions. We request that the Newton-curve sentence be

	deleted. ● Newton's work was published in 1978. At that time, there was no "heavy" intensity reporting category – there was only trace, light, moderate, and severe. ● In 2003, as a result of an FAA ARAC harmonization working group's task to update icing terminology, new definitions were published. These added the "heavy" intensity category. The definition of "severe" was revised to contain additional description, but the essential guidance remained the same. Thus, Newton's "severe" in 1978 is still "severe," rather than "heavy." Somewhere between Newton's "moderate" and "severe" curves would now be another curve for "heavy" intensity. Our requested deletions following the "Newton curve" sentence are intended to de-emphasize the 99.9 percentile curves (since they were rejected for Appendix O), but still retain their reference for the decision to use a probability for "heavy" SLD conditions of 0.001. Our remaining suggested revisions are editorial: ● Rather than referring to the FAA report by only its publication number, it is appropriate to at least refer to it as the FAA report. ● As noted before in our comments, we highly recommend that percent symbols not be used in this text; "percent" should be spelled out so that there is no chance for misinterpretation. This revision is applicable throughout the document. ● The next item clarifies that the two sets of percentile data are based upon the research data; since the 99.9 percentile curves were rejected for Appendix O, the statement as proposed seems less accurate. ● Our suggested revisions to the final sentence of this paragraph are intended to clarify the effect of the added conservatism and, as noted in other comments, to refer to SLD conditions <u>represented by</u> Appendix O.
response	Accepted.

comment	*90* comment by: *Boeing* Page: 13 Paragraph: *2.4.2.1.4 -- Review of in-service experience* *Editorial Comment* **<u>The proposed text states</u>:** *"… The results of the database search, shown in **Error! Reference source not found.**, indicate that the ccidents and serious icing incidents experienced by the ATR42/72 and Embraer Brasilia occurred prior to each fleet accruing 2.5 million flying hours; yet, the first icing-related incidents occurred within 0.5 million flight hours. Suspected SLD events occurred after 2.5 million and 3.9 million flying hours. …"*

	REQUESTED CHANGE: We recommend revising the text as follows: *"… The results of the database search, shown in ~~Error! Reference source not found~~ Table 1, indicate that the accidents and serious icing incidents experienced by the ATR 42/72 and Embraer Brasilia occurred prior to each fleet accruing 2.5 million flying hours; yet, the first icing-related incidents occurred within 0.5 million flight hours. Suspected SLD events occurred after 2.5 million and 3.9 million flying hours. …"* **JUSTIFICATION:** The *"Error!"* message should be replaced by *"Table 1,"* in accordance with the Rulemaking Group's report. The *"a"* in "accidents" is missing as well.
response	Accepted.

2. Explanatory Note — 2.4. Overview of the proposed amendments — 2.4.3. Proposed amendments to CS-25 Book 1 and Book 2	p. 16-17

comment	*10* comment by: *Transport Canada Civil Aviation Standards Branch*
	As stated in 4.1.3 of NPA 2015-07, one of the main reasons for this regulatory initiative is to ensure harmonization and uniformity in robustness amongst Large aeroplane manufacturers when proposing a MoC for comparative analysis. That being said it is understood from 2.4.2.3. of NPA 2015-07: "The key parameters which will be used to show compliance via comparative analysis will have to be identified, and agreed to with the Agency…" While we agree that there will be variance upon the application of comparative analysis from different OEMs given that there are different approache~~d~~s to attain type certification, this statement does not necessarily espouse a transparent approach to achieve MoC for type certification of a future aeronautical product and falls a bit short of fostering harmonization amongst all future applicant MoCs, as stated in 4.1.3.
response	Not accepted. The intent of the proposed amendment is to provide information to applicants on how a comparative analysis may be accepted and put in place. While it is envisaged that some harmonisation could be reached with regard to the methodology used by applicants, it is also acknowledged that the outcome of the analysis may differ from one applicant to another. Reasons for such differences could be for instance the characteristics of the reference fleet of aircraft which are not the same from one applicant to another one, the variations in term of design rules/specifications as well as means of compliance with certification requirements, nature of the eventual changes brought to the proposed aircraft relative to the reference fleet.

comment	*91* comment by: *Boeing*
	Page: 16 Paragraph: *2.4.3 -- Proposed amendments to CS-25 Book 1 and Book 2* **The proposed text states:**

	"BOOK 1: ***CS 25.1420 Supercooled large drop icing conditions: …"*** **REQUESTED CHANGE:** We recommend revising the text as follows: ***"BOOK 1:*** ***CS 25.21 Proof of Compliance*** **[We propose that a new statement be added to sub-paragraphs (g)(2) and (g)(3) that identifies the potential to use comparative analysis as a means of compliance, as an alternative to the existing means.]** ***CS 25.1420 Supercooled large drop icing conditions****: …"* **JUSTIFICATION:** Since this NPA seeks to establish the potential to use comparative analysis as a means of compliance for the CS-25 requirements related to SLD conditions represented by App. O, this option should be identified as an alternative in both sub-paragraphs CS 25.21(g)(2) and (g)(3). A brief statement of that proposal should be added to this section.
response	Accepted. Please also refer to our replies to comment nrs 54, 55, 93, 26.

comment	*92* comment by: *Boeing* Page: 16 Paragraph: *2.4.3, CS 25.1420* *Editorial comment* **The proposed text states:** *"It is proposed to create a new sub-pragraph (c) which provides …"* **REQUESTED CHANGE:** We recommend revising the text as follows: *"It is proposed to create a new sub-p**a**ragraph (c) which provides …"* **JUSTIFICATION:** Correction of a typographical error.
response	Accepted.

3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — CS 25.1420 Supercooled large drop icing conditions	p. 18-19

comment	*38* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 19, CS 25.1420** Original text "(c) If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to

	establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests may not be required (see AMC 25.1420, paragraph (e))", <u>Proposed text</u> "(c) If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) **<u>and CS 25.1420(d)</u>** to establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests **<u>are not</u>** required (see AMC 25.1420, paragraph (e))" **Reasons for adding "and CS 25.1420(d)":** Pursuant to agreement of the Rulemaking Group, for a new or derivative airplane model, no tests regarding ice detection means for Appendix O are needed and the applicant may show compliance through comparative analysis. Only the icing conditions represented by Appendix C should be considered. Therefore, the change proposed by Embraer to paragraph (c) makes it more clear that comparative analysis, when applicable, may be used to show compliance with ice detection performance in Appendix O. **Reasons for changing *"may not be required"* to *"are not required:*** The intent of the rulemaking activity was to provide an alternative to testing, when seeking certification for flying in the icing conditions introduced through Amendment 16 of CS-25. In this sense, when comparative analysis is applicable and may be adequately performed, there should be no need for SLD ice shape computations and flight tests. Therefore, Embraer believes the words “are not” would be more appropriate than “may not be”.
response	- Proposal to add ‘and CS 25.1420(d)’: (to be replied together with comments 69, 94): Not accepted. The proposal of comments 69 and 94 has been retained. Please refer to our responses to these comments. - Proposal for changing ‘may not be required’ to ‘are not required’ (to be replied together with comments 69, 94): Not accepted. Although it is correct that the intent of the comparative analysis is to show compliance without mandating the tests of CS 25.1420(b), in particular the flight tests, this analysis may also conclude that some kind of test(s) may be needed to validate some aspects of the analysis (e.g. if the comparative analysis identifies areas where full credit cannot be taken from the reference fleet). Paragraph 5.9 on ‘Augmenting Comparative Analysis’ already foresees this possibility. The term ‘may not be required’ is therefore maintained. However, at the beginning of AMC 25.1420(f) (previously AMC 25.1420(e)), the second paragraph has been amended to explain that, when using a comparative analysis, flight testing in natural SLD and/or with simulated ice shapes in accordance with Appendix O Part II is not required. It also states that other types of test may be required.

comment	*54* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 18, 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision)** Notwithstanding this NPA does not amend CS 25.21, Embraer believes that CS 25.21(g)(2) and CS 25.21(g)(3) should be amended as follows.

	Current CS 25.21(g)(2) “(2) If the applicant does not seek certification for flight in all icing conditions defined in Appendix O, each requirement of this subpart, except CS 25.105, 25.107, 25.109, 25.111, 25.113, 25.115, 25.121, 25.123, 25.143(b)(1), (b)(2), and (c)(1), 25.149, 25.201(c)(2), 25.207(c), (d) and (e)(1), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is not sought in order to allow a safe exit from those conditions. Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.” Current CS 25.21(g)(3) "(3) If the applicant seeks certification for flight in any portion of the icing conditions of Appendix O, each requirement of this subpart, except paragraphs CS 25.121(a), 25.123(c), 25.143(b)(1) and (b)(2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is sought. CS 5.207(c) and (d) must be met in the landing configuration in the icing conditions specified in Appendix O for which certification is sought but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. Proposed text for CS 25.21(g)(2) and CS 25.21(g)(3) Add the following sentence at the end of both paragraphs: **“ If applicable, a comparative analysis, as provided in AMC 25.1420 paragraph (e), may be used to show compliance”** Rationale The AMC 25.21(g) has been reviewed in this NPA, where references to the comparative analysis (provided in AMC 25.1420(e)) as a potential means of compliance have been added to several paragraphs. The change proposed by Embraer contributes to the intent of this rulemaking activity, which is providing an alternative to testing, when seeking certification for flying in the icing conditions introduced through Amendment 16 of CS-25. Therefore, Embraer believes that CS 25.21(g)(2) and CS 25.21(g)(3) should also be amended as proposed to make it clear that comparative analysis is a means of compliance to those requirements.
response	Accepted. However, reference is made to the rule providing the option of comparative analysis (CS 25.1420), not to its AMC.

comment	_55_	comment by: _Dassault-Aviation_

Dassault-Aviation comment page 18:

<u>Extract:</u>
CS 25.21 (g)(2) :
“Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.”

<u>Comments and rationales:</u>
If applicable, comparative analysis may be used to show compliance as an alternative to using the ice accretions determined for Appendix O icing conditions.
It is thus proposed to update CS 25.21 (g)(2) to take into account this alternative.

<u>Requested change and propose text:</u>

CS 25.21 (g)(2) :
“Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. If applicable, a comparative analysis (see AMC 25.1420, paragraph (e)), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O"

<u>Extract:</u>
CS 25.21 (g)(3) :
“Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.”

<u>Comments and rationales;</u>
If applicable, comparative analysis may be used to show compliance as an alternative to using the ice accretions determined for Appendix O icing conditions.
It is thus proposed to update CS 25.21 (g)(3) to take into account this alternative.

<u>Requested change and proposed text:</u>

CS 25.21 (g)(3) :
“Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. If applicable, a comparative analysis (see AMC 25.1420, paragraph (e)), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O"

response

Accepted.
However, reference is made to the rule providing the option of comparative analysis

(CS 25.1420), not to its AMC.

comment | _69_ | comment by: _AIRBUS_

1. Amend CS 25.1420 as follows:
CS 25.1420 Supercooled large drop icing conditions

Proposed Text:
"(c) For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419(e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. ~~If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests may not be required (see AMC 25.1420, paragraph (e)).~~

(d) If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the aeroplane can operate safely as required in CS 25.1420(a) and as an alternative to CS 25.1420(c) regarding ice detection methods for timely activation of the ice protection systems as required by CS 25.1419(e), (f), (g), and (h). In this case, tests are not required [see AMC 25.1420(e)]. ~~For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate."~~

Rationale:
The intent of this rulemaking activity is to provide AMC material so that the applicant may use and take credit for similarity to a previous design having proven safe operation in SLD icing conditions and this provide an alternative to ice shape computation and flight testing.

response | Partially accepted.
Paragraph (c) is changed as proposed.
Paragraph (d): The end of first sentence is slightly modified to be consistent with the wording used in CS 25.1419(e) and the quoting of CS 25.1419(e), (f), (g), and (h) is deleted to avoid repeating CS 25.1420(c).
Proposal for changing 'may not be required' to 'are not required' (to be replied together with comments 69, 94): Not accepted. Although it is correct that the intent of the comparative analysis is to show compliance without mandating the tests of CS 25.1420(b), in particular the flight tests, this analysis may also conclude that some kind of test(s) may be needed to validate some aspects of the analysis (e.g. if the comparative analysis identifies areas where full credit cannot be taken from the reference fleet). Paragraph 5.9 on 'Augmenting Comparative Analysis' already foresees this possibility. The term 'may not be required' is' therefore' maintained.
However, at the beginning of AMC 25.1420(f) (previously AMC 25.1420(e)), the second paragraph has been amended to explain that, when using a comparative analysis, flight testing in natural SLD and/or with simulated ice shapes in accordance with Appendix O Part II is not required. It also states that other types of test may be required.

comment | _75_ | comment by: _Bombardier_

NPA Proposed Text

	BOOK 1 *SUBPART F – EQUIPMENT* *CS 25.1420 Supercooled large drop icing conditions* *(see AMC 25.1420)* *(a) If certification for flight in icing conditions is sought, in addition to the requirements of CS 25.1419, the aeroplane must be capable of operating in accordance with sub-paragraphs (a)(1), (a)(2), or (a)(3) of this paragraph.* *(1) Operating safely after encountering the icing conditions defined in Appendix O:* *….* *(c) If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests may not be required (see AMC 25.1420, paragraph (e)).* *(c) (d) For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.* *…* *4.8.2.2 Normal operating procedures provided in the AFM should reflect the procedures used to certify the aeroplane for flight in icing conditions. This includes configurations, speeds, ice protection system operation, power plant and systems operation, for take-off, climb, cruise, descent, holding, go-around, and landing. For aeroplanes not certified for flight in all of the supercooled large drop atmospheric icing conditions defined in Appendix O to CS-25, procedures should be provided for safely exiting all icing conditions if the aeroplane encounters Appendix O icing conditions that exceed the* *icing conditions the aeroplane is certified for. Information to be provided in the AFM may be based on that which is provided in the reference fleet AFM(s), or other operating manual(s) furnished by the TC holder, when comparative analysis is used as the means of compliance.* **Bombardier Comment** Little data and few analytical or testing tools are available to predict ice accretions associated with flight under all SLD icing conditions as represented in Appendix O. It is recommended that the use of comparative analysis be limited to showing compliance to Para (a)(1). Typical operating procedures for the majority of currently certified aeroplanes may not explicitly address SLD icing conditions and limitations and/or cautionary notes typically direct the flight crew to avoid any 'severe' icing conditions based on pilot judgment.
response	Not accepted. Various certified large aeroplanes are currently flying safely without restriction in term of supercooled liquid icing conditions environment. The TC holders of such aircraft should have the possibility to consider using a comparative analysis for a new project; therefore, it would not be appropriate to limit the scope of the proposed CS 25.1420(c) to the CS 25.1420(a)(1) option.

comment	*93*	comment by: *Boeing*
	Page: 18 Paragraph: *3.1.1*	

<u>The proposed text states</u>:

"BOOK 1

SUBPART F – EQUIPMENT

1. Amend CS 25.1420 as follows: …"

<u>REQUESTED CHANGE</u>: We recommend revising the text as follows:

"BOOK 1

SUBPART B – FLIGHT

1. Amend CS 25.21(g) as follows:

(g) The requirements of this subpart associated with icing conditions apply only if the applicant is seeking certification for flight in icing conditions.

(...)

(2) If the applicant does not seek certification for flight in all icing conditions defined in Appendix O, each requirement of this subpart, except CS 25.105, 25.107, 25.109, 25.111, 25.113, 25.115, 25.121, 25.123, 25.143(b)(1), (b)(2), and (c)(1), 25.149, 25.201(c)(2), 25.207(c), (d) and (e)(1), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is not sought in order to allow a safe exit from those conditions. Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. If applicable, a comparative analysis, as defined in AMC 25.1420(e), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O.

(3) If the applicant seeks certification for flight in any portion of the icing conditions of Appendix O, each requirement of this subpart, except paragraphs CS 25.121(a), 25.123(c), 25.143(b)(1) and (b)(2), 25.149, 25.201(c)(2), and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is sought. CS 25.207(c) and (d) must be met in the landing configuration in the icing conditions specified in Appendix O for which certification is sought but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. If applicable, a comparative analysis, as defined in AMC 25.1420(e), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O.

(...)

SUBPART F – EQUIPMENT

	~~1~~2. Amend CS 25.1420 as follows: …" **JUSTIFICATION:** Since the current CS 25.21(g)(2) and (g)(3) expressly state how compliance must be shown, it is appropriate to add new text explaining that comparative analysis may be used to show compliance. [Note: At the beginning of the second sentence of sub-paragraph (g)(3), the "2" in CS 25.207 is missing.]
response	Accepted. However, reference is made to the rule providing the option of comparative analysis (CS 25.1420), not to its AMC.

comment	_94_ comment by: _Boeing_ Page: 19 Paragraph: _3.1.1_ **The proposed text states:** ***"1. Amend CS 25.1420 as follows:*** _(…)_ _(c) If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests may not be required (see AMC 25.1420, paragraph (e))._ _~~(c)~~ (d) For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate."_ **REQUESTED CHANGE:** We recommend revising this text as follows: ***~~1~~2. Amend CS 25.1420 as follows:*** _(…)_ _(c) ~~If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the aeroplane can operate safely as required in CS 25.1420(a). In this case, tests may not be required (see AMC 25.1420, paragraph (e)).~~_ ***For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419(e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.*** _~~(c)~~ (d) ~~For an aeroplane certified in accordance with sub-paragraph (a)(2) or (a)(3) of this paragraph, the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.~~_ ***If applicable, a comparative analysis may be used as an alternative to CS 25.1420(b) to establish that the***

	<u>aeroplane can operate safely as required in CS 25.1420(a) and as an alternative to CS 25.1420(c) regarding ice detection methods for timely activation of the ice protection systems as required by CS 25.1419(e), (f), (g), and (h). In this case, tests are not required [see AMC 25.1420(e)].</u>" **<u>JUSTIFICATION</u>:** If our suggested addition is made for CS 25.21(g)(3) as No. 3.1.1, then the subsequent paragraph numbers will have to be adjusted accordingly (i.e., "Amend CS 25.1420" will become No. 2). This comment applies to all subsequent paragraphs 3.1.x. Since we are requesting revision of proposed sub-paragraph (c) to include the use of comparative analysis as an alternative to CS 25.1420["current (c)"] [i.e., for CS 25.1419(e), (f), and (g)], it would be more appropriate for current sub-paragraph (c) to remain (c), and proposed new (c) to become new (d).] The noted revision request to include the use of comparative analysis as an alternative to CS 25.1420[current (c)]) is made pursuant to agreement of the Rulemaking Group that the method of ice detection and activation of the ice protection systems for a new airplane model can be evaluated using comparative analysis and need only consider the icing conditions represented by Appendix C (see Example 2 of Appendix 2 to the NPA). The final sentence of proposed sub-paragraph (c) [revised to be "new (d)"] incorporates a revision that was not reviewed and agreed to by the members of the Rulemaking Group. Prior to that revision, this sentence stated that tests <u>are not</u> required. We respectfully submit that the pre-revision statement was and still is the intention of the comparative analysis option; i.e., that testing is not required. This was documented in EASA's notes of the last Rulemaking Group meeting. In the event that the Agency believes that "may not be required" is necessary language, then the AMC should be revised to include clear guidance for applicants regarding when tests might or are likely to be required, as well as what those tests might be.
response	Partially accepted. Paragraph (c) is changed as proposed. Paragraph (d): The end of first sentence is slightly modified to be consistent with the wording used in CS 25.1419(e) and the quoting of CS 25.1419(e), (f), (g), and (h) is deleted to avoid repeating CS 25.1420(c). Proposal for changing 'may not be required' to 'are not required' (to be replied together with comments 69, 94): Not accepted. Although it is correct that the intent of the comparative analysis is to show compliance without mandating the tests of CS 25.1420(b), in particular the flight tests, this analysis may also conclude that some kind of test(s) may be needed to validate some aspects of the analysis (e.g. if the comparative analysis identifies areas where full credit cannot be taken from the reference fleet). Paragraph 5.9 on 'Augmenting Comparative Analysis' already foresees this possibility. The term 'may not be required' is therefore maintained. However, at the beginning of AMC 25.1420(f) (previously AMC 25.1420(e)), the second paragraph has been amended to explain that, when using a comparative analysis, flight testing in natural SLD and/or with simulated ice shapes in accordance with Appendix O Part II is not required. It also states that other types of test may be required.

3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision)	p. 19-21

— AMC 25.21(g) Performance and Handling Characteristics in Icing Conditions

comment	26 comment by: *AIRBUS*
	If applicable, comparative analysis may be used to show compliance as an alternative to using the ice accretions determined for Appendix O icing conditions. It is thus proposed to update CS 25.21 (g)(2) and CS 25.21 (g)(3) in addition to the proposed changes to the AMC to take into account this alternative. Original text: CS 25.21 (g)(2) "*Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual*." Proposed text: CS 25.21 (g)(2) "Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. **If applicable, a comparative analysis (see AMC 25.1420, paragraph (e)), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O"** Original text: CS 25.21 (g)(3) "*Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual.*" Proposed text: CS 25.21 (g)(3) "Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, assuming normal operation of the aeroplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Aeroplane Flight Manual. **If applicable, a comparative analysis (see AMC 25.1420, paragraph (e)), may be used to show compliance as an alternative to using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O"**
response	Accepted. However, reference is made to the rule providing the option of comparative analysis (CS 25.1420), not to its AMC.

3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.1093(b) Powerplant Icing p. 26

comment	67 comment by: *AIRBUS*

	7. Amend AMC 25.1093(b) as follows: **AMC 25.1093(b)** **Powerplant Icing** Comment 1: <u>Original text:</u> "*To certify by analysis the applicant should evaluate the Appendix O drop sizes up to a maximum of 3 000 microns particle size to find a critical condition*." <u>Proposed text:</u> "To certify by analysis the applicant should evaluate the Appendix O drop sizes up to a maximum of 2 228 microns particle size to find a critical condition." <u>Rationale:</u> 2 228 is the max for Appendix O. There is threfore no reason to mention 3 000. Comment 2: The term "particle size" is ambiguous.
response	Not accepted. This text is part of the outcome of rulemaking task RMT.0058 and is out of the scope of RMT.0572. It is also consistent with Table 1 of CS 25.1093(b)(2). The 3 000 microns upper value was added in Table 1 at the request of various airframe and engine manufacturers (including Airbus) during consultation of NPA 2011-03. You can refer to CRD 2011-03; the justification of the comments was 'allow flexibility in test demonstrations' and 'to match the definition proposed by the FAA for 14CFR 33.68 (reference NPRM 10-10)'.

comment	*95*	comment by: *Boeing*
	Page: 26 Paragraph: *3.1.7* **<u>The proposed text states</u>:** ***"AMC 25.1093(b)*** ***Powerplant Icing*** *(…)* ***(b) Compliance with CS 25.1093(b)(2)*** *(…)* *<u>2. Ground taxi exposure to Appendix O conditions.</u>* *The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be addressed. Applicants should include the terminal falling velocity of SLD (for example, freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron*	

	minimum mean effective diameter (MED) is selected as a reasonable achievable condition, given current technology. To certify by analysis the applicant should evaluate the Appendix O drop sizes up to a maximum of 3 000 microns particle size to find a critical condition. For showing compliance with the CS-25 certification specifications relative to SLD icing conditions represented in Appendix O, the applicant may use a comparative analysis. AMC 25.1420 paragraph (e) provides guidance for comparative analysis." **REQUESTED CHANGE:** We recommend the text be revised as follows: *"The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be addressed. Applicants should include the terminal falling velocity of SLD (~~for example,~~ freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron minimum mean effective diameter (MED) is selected as a ~~reasonble~~ **reasonably** achievable condition, given current technology. To certify by analysis the applicant should evaluate the Appendix O drop sizes up to a maximum of ~~3 000~~ **2,228** microns ~~particle size~~ **diameter** to find a critical condition. For showing compliance with the CS-25 certification specifications relative to SLD icing conditions represented in Appendix O, the applicant may use a comparative analysis. AMC 25.1420 ~~paragraph~~ (e) provides guidance for comparative analysis."* **JUSTIFICATION:** Although some of this is existing text that is not currently proposed to be revised, we nonetheless have the following comments: We suggest deleting the words, "for example," because they inaccurately imply that there are additional SLD conditions in addition to freezing drizzle and freezing rain. In the middle of the paragraph, revision of the phrase "reasonable achievable" is needed for grammatical correctness. It is suggested that it be revised to "reasonably achievable," although "reasonable and achievable" is another option. The next sentence refers to evaluating drops up to a maximum of 3,000 microns; however, per Figure 5 of Appendix O, the maximum drop size to be considered is 2,228. We therefore request that the maximum drop size be consistent with the Appendix. This sentence also refers to the drop "particle size," which is ambiguous nomenclature; we suggest that "diameter" be used instead. In the addition, at the end of the paragraph, the word "paragraph" is not needed preceding the "(e)" and should be deleted. This revision is applicable throughout the document.
response	Not accepted. This text is part of the outcome of rulemaking task RMT.0058 and is out of the scope of RMT.0572. It is also consistent with Table 1 of CS 25.1093(b)(2). The 3 000 microns upper value was added in Table 1 at the request of various airframe and engine manufacturers during consultation of NPA 2011-03. You can refer to CRD 2011-03; the justification of the comments was 'allow flexibility in test demonstrations' and 'to match the definition proposed by the FAA for 14CFR 33.68 (reference NPRM 10-10)'. The grammatical correction on 'reasonable' is accepted.

3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) p. 26-27

— AMC 25.1324 Flight instrument external probes

comment *96* comment by: *Boeing*

Page: 26-27
Paragraph: *3.1.8*
Editorial comment

The proposed text states:

"8. Amend AMC 25.1324 as follows:
(...)
11. Supercooled Large Drop Liquid Conditions

Based on the design of the probe, the drop size may not be a significant factor to consider as compared to the other parameters and in particular the Liquid Water Content (LWC). The SLD LWC defined in Appendix O (between 0.18 and 0.44 g/m3) are largely covered by the Appendix C continuous maximum LWC (between 0.2 and 0.8 g/m3) and the Appendix C intermittent maximum LWC (between 0.25 and 2.9 g/m3). …"

REQUESTED CHANGE: We recommend revising the text as follows

"~~8~~9. Amend AMC 25.1324 as follows:
(...)
11. Supercooled Large Drop Liquid Conditions

Based on the design of the probe, the drop size may not be a significant factor to consider as compared to the other parameters and in particular the Liquid Water Content (LWC). The SLD LWC defined in Appendix O (between 0.18 and 0.44 g/m^{3}~~3~~) ~~are~~ is largely covered by the Appendix C continuous maximum LWC (between 0.2 and 0.8 g/m^{3}~~3~~) and the Appendix C intermittent maximum LWC (between 0.25 and 2.9 g/m^{3}~~3~~). …"

JUSTIFICATION: As noted in our previous comments, if the requested addition is made for CS 25.21(g)(3) as No. 3.1.1, then the subsequent paragraph numbers for 3.1.x will need to be adjusted accordingly.

Although this is existing text that is not currently proposed to be revised, we nonetheless have the following comments: The expression of "cubic metre" as "m3" is incorrect; the "3" should be an exponent/superscript. *"The SLD LWC"* phrase is singular, so the verb *"are"* should be *"is"* to be in agreement.

response Accepted.

3. Proposed amendments — 3.1. Draft Certification Specifications — CS-25 (Draft EASA Decision) — AMC 25.1420 Supercooled large drop icing conditions p. 28-38

comment *6* comment by: *CAA-NL*

Comment on (e) CS 25.1420(c) Comparative analysis, section 1 Definitions (page 32/33 of

53)
In other regulations like (EU) 376/2014 the definitions of 'Accident', 'Serious incident' and 'Event' are given by reverence to (EU) 996/2010 in stead of ICAO. Please use for concistency in the European legal framework the same references for these definitions here.

response

Not accepted.
The definitions provided in Regulation (EU) No 996/2010 have been harmonised with ICAO Annex 13.
We could indeed refer to Regulation (EU) No 996/2010 definitions in CS-25, however, in doing that there is a risk that the reference becomes obsolete in the future when the regulation in question is either amended, consolidated or repealed. In addition, the Annex 13 definitions may be updated although the update of the corresponding definitions in Regulation (EU) No 996/2010 may be performed afterward with a time delay.
Therefore, it is deemed better to refer to Annex 13, without specifying an Edition number.

comment *12* comment by: *Transport Canada Civil Aviation Standards Branch*

Transport Canada believes that it is in the public interest for EASA to provide within their rule a '*Minimum Key Parameters List in Comparative Analysis*'. In addition to increasing public transparency, this will at a minimum, ensure a baseline level of harmonization amongst all OEMs when setting out a comparative analysis while acknowledging differences in approaches and eventual improvements in certification processes.

Therefore, propose for page 34 of the NPA to modify the wording as follows (grey is proposed wording):

5. Conducting Comparative Analysis

If a safe fleet history in icing conditions can be substantiated, and compliance with the CS-25 certification specifications for safe flight in Appendix C icing conditions can be shown, then the reference fleet can be used for comparative analysis.

The substantiation of the reference fleet's design features and/or margins which have contributed to the safe fleet history can be used for a new or derivative model having comparable design features and/or margins, to show compliance with the CS-25 certification specifications relative to flight in SLD icing conditions. When conducting a comparative analysis, the effects of the minimum key parameters for the given individual components or systems shall~~must~~ be considered at the aeroplane level. The following aspects shall ~~must~~ be addressed:

(Examples given)
Minimum Key Parameters List in Comparative Analysis

Aspect	**Minimum key parameter**
Ice protection systems	Manoeuvrability
	Controllability
	Performance
Ice or icing conditions detection	Reference fleet versus proposed fleet/model

In addition to the above, the applicant may define and provide supplementary key parameters for each of the topics addressed in the comparative analysis. They should be agreed with the Agency. The topics include:

a. Ice protection systems,
b. Unprotected components,
c. Ice or icing conditions detection,
d. Ice accretion and ice shedding sources,
e. Performance and handling characteristics,
f. Aeroplane flight manual information,
g. Additional considerations — Augmenting comparative analysis

response Not accepted.
A list of key parameters is not deemed required. The applicable key parameters will depend on the application, and there can be substantial differences from one project to another one. Proving a minimum list could create some concerns on some project where this minimum list would need to be amended and therefore create a burden for both the applicant and the Agency. Please note that the list of topics to be considered is maintained.

comment *21* comment by: *FAA*

Comment: Para 3.3: Add “ directions to exit severe icing” to examples of AFM Limitations

Rationale: ADs issued against airplanes that experienced accidents or incidents in icing conditions, or had similar designs, did not explicitly prohibit flight in FZDZ or FZRA. Rather, they used the term severe icing.

response Accepted.

comment *22* comment by: *FAA*

Comment: Para 3.3: Delete 25.1420(a)(2) as option for which comparative analysis may be used. All existing airplanes with an AFM limitation or procedures on flight in SLD do not distinguish a portion of SLD.

Rationale: Many if not all airplanes with designs similar to those that have had previous accidents in severe icing conditions contain limitations in the AFM intended to prevent continued flight in such conditions. Such limitations have likely prevented continued operations in SLD conditions so it should not be assumed that previous flight in icing contained any continued operations in SLD conditions, even a portion.

response Not accepted.
If the reference fleet of an applicant has demonstrated a safe in-service history while using

limitations or restrictions applicable to SLD (represented by Appendix O), the applicant should be able to apply for a comparative analysis taking credit of this safe fleet history. The scope of the comparative analysis will then be limited either to a portion of Appendix O which cannot exceed the conditions prescribed in the reference fleet's limitations or restrictions (CS 25.1420(a)(2) option), or to the detection and exit of any Appendix O condition (CS 25.1420(a)(1) option).
Please note that, in terms of reference fleet, the AMC text in question has to be usable either by reference to already certified aeroplanes or to future new designs which could be certified for operation in a portion of Appendix O.

comment *27* comment by: *AIRBUS*

AMC 25.1420
Supercooled large drop icing conditions

Original Text:
"*When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II may not be required*."

The intent of this rulemaking activity is to provide AMC material so that the applicant may use and take credit for similarity to a previous design having proven safe operation in SLD icing conditions and this provide an alternative to ice shape computation and flight testing.

Proposed Text:
"When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II **is** not required."

response Accepted.

comment *28* comment by: *AIRBUS*

AMC 25.1420
Supercooled large drop icing conditions

Paragraph 3.4 Safe Fleet History Requirements

This section defines 2 million flights as an acceptable in-service history. The analysis indicates that a fleet history of 1 million or 1.5 million flights would be acceptable.

The threshold of 2 million flights is acceptable but is extremely conservative and could be reduced to, for example, 1.2 million flights.

In computing the probability of flying in "heavy" SLD icing conditions, conservative assumptions have been adopted. It would therefore be reasonable to maintain the required number of flights as 1.2 million without adding an additional factor.

response Not accepted.

As explained in the NPA, the 2-million-flights threshold was set-up in order to add a margin against uncertainties from statistics, but also to capture aeroplanes which experienced events in supercooled icing conditions although it was not confirmed to include SLD conditions. For these aircraft, events have occurred after up to an estimated 1.7 million flights (case of the Saab 340).

comment 29 comment by: *AIRBUS*

AMC 25.1420
Supercooled large drop icing conditions
Paragraph 5 Conducting Comparative Analysis

Original Text:
"*When conducting a comparative analysis, the effects of key parameters for individual components or systems should be considered at the aeroplane level*."

The intention of this paragraph is to highlight that dissimilarity in design margins for one component or system can be compensated for at aircraft level by considering the overall margin at aircraft level.
The proposed text below clarifies the intent of this paragraph.

Proposed Text:
"When conducting a comparative analysis, the effects of key parameters for individual components or systems should be considered at the aeroplane level. **A different design feature or margin may be shown to be acceptable when considered at the aircraft level taking into account the other aircraft design features and margins that are deemed to contribute to safe flight in icing conditions.**"

response Accepted.

comment 30 comment by: *AIRBUS*

AMC 25.1420
Supercooled large drop icing conditions
Paragraph 5.7 Aeroplane Performance and Handling Characteristics

Original text:
"*The comparative analysis should substantiate that the effects of ice accretion and the agreed key parameters of the new or derivative model are comparable to those of the reference fleet. The applicant should substantiate by analysis, test, or a combination of both, that the new or derivative aeroplane will have similar margins to those of the reference fleet for flight in the icing conditions of Appendix C*."

When showing compliance to subpart B requirements through Comparative Analysis, certification ice shapes/ice data determined for Appendix C icing conditions are acceptable without additional Appendix O considerations.
It is proposed to state this point precisely in §5.7 introduction.

Proposed text:
"The comparative analysis should substantiate that the effects of ice accretion and the

	agreed key parameters of the new or derivative model are comparable to those of the reference fleet. The applicant should substantiate by analysis, test, or a combination of both, that the new or derivative aeroplane will have similar margins to those of the reference fleet for flight in the icing conditions of Appendix C. **<u>Certification ice shapes/ice data determined for Appendix C icing conditions are acceptable without additional Appendix O considerations".</u>**
response	Not accepted. The paragraph subject to the comment is already clear because it only refers to Appendix C icing conditions. Furthermore, the relief from flight testing with Appendix O ice shapes is already mentioned in other paragraphs of CS 25.1420, AMC 25.21(g), AMC 25.1420.

comment	*31* comment by: *AIRBUS* **AMC 25.1420** **Supercooled large drop icing conditions** **Paragraph 5.7.2 Controllability and Manoeuvrability** It is acceptable for Appendix C ice shapes to affect controllability and maneuverability in a different manner to that of the reference fleet. Use of the word "restored" might imply a degradation of margin whereas the objective here is to retain comparable controllability and maneuverability to those of the reference fleet. It is proposed to use the word "retained" instead of "restored". <u>Proposed text:</u> "If critical Appendix C ice shapes affect maneuverability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are ~~restored~~ **retained** (speed increase, etc.)".
response	Accepted. The same change is made at the end of the paragraph just above dealing with 'control effectiveness and forces'.

comment	*32* comment by: *AIRBUS* **AMC 25.1420** **Supercooled large drop icing conditions** **Paragraph 5.7.4 Stability** It is acceptable for Appendix C ice shapes to affect stability in a different manner to that of the reference fleet. Use of the word "restored" might imply a degradation of margin whereas the objective here is to retain comparable stability to those of the reference fleet. It is proposed to use the word "retained" instead of "restored". <u>Proposed text:</u> "If critical Appendix C ice shapes affect maneuverability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are ~~restored~~ **<u>retained</u>** (speed increase, etc.)".
response	Accepted.

comment	*33* comment by: *AIRBUS*
	Original text: *"~~(e)~~ (f) CS 25.1420 ~~(c)~~ (d)* *CS 25.1420~~(c)~~(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.* *Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply*." AMC 25.1420(e) provides guidance on how to apply comparative analysis to ice detection systems. The proposed text is required to make the link between the CS 25.1420(d) requirement and the associated comparative analysis means of compliance described in AMC 25.1420(e). Proposed text: "~~(e)~~ (f) CS 25.1420 ~~(c)~~ (d) CS 25.1420(c)(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply. **If applicable, a comparative analysis, as defined in AMC 25.1420 paragraph (e), may be used to show compliance"**
response	Accepted.

comment	*39* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*
	Page 38 AMC 25.1420 Original text "~~(e)~~ (f) CS 25.1420 ~~(c)~~ (d) CS 25.1420~~(c)~~(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply." Proposed text "~~(e)~~ (f) CS 25.1420 ~~(c)~~ (d) CS 25.1420(c)(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply. If applicable, a comparative analysis, as provided in AMC 25.1420 paragraph (e), may be used to show compliance" Rationale: Embraer believes the proposed text makes it more clear that comparative analysis is also a means of compliance for CS 25.1420(d), according to the guidance described in AMC

	25.1420(e).
response	Accepted.

comment	*40* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 31 AMC 25.1420(e) Comparative Analysis** <u>Original Text</u> “When using this comparative analysis as a means of compliance,flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II may not be required." <u>Proposed Text</u> “When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II <u>**is**</u> not required.” <u>Rationale</u> The intent of the rulemaking activity was to provide an alternative to testing, when seeking certification for flying in the icing conditions introduced through Amendment 16 of CS-25. In this sense, when comparative analysis is applicable and may be adequately performed, there should be no need for SLD ice shape computations and flight tests. Therefore, Embraer believes the word “is” would be more appropriate than “may”.
response	Accepted.

comment	*41* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 33 AMC 25.1420(e) Paragraph 3.1 “Fleet History Composition”** <u>Original Text</u> “The reference fleet should include the previous aeroplane model(s) sharing the design features and/or margins that will be used to substantiate the comparative analysis. The applicant should present to the Agency any known supercooled-liquid-water-icing-related accidents or serious incidents of the reference fleet.” <u>Proposed Text</u> “The reference fleet should include the previous aeroplane model(s) sharing the design features and/or margins that will be used to substantiate the comparative analysis. <u>**Various aeroplane models, including models from different aeroplane families, may be included in the reference fleet if the design features and/or margins are comparable to the new/derivative aeroplanes.**</u> The applicant should present to the Agency any known supercooled-liquid-water-icing-related accidents or serious incidents of the reference fleet” <u>Rationale</u>

	The addition of the proposed text aims to include in the reference fleet, all aircraft that share Comparable features and/or design margins (Key Parameters.)
response	Not accepted. The proposed text introduces redundancy to the existing text. Furthermore, guidance on the substantiation of the reference fleet is already provided in AMC 25.1420(e) paragraph 5. 'Conducting Comparative Analysis'.

comment	*42* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 34, 3.4 Safe Fleet History** This section defines 2 million flights as an acceptable in-service history. The analysis indicates that a fleet history of 1 million to 1.5 million flights would be acceptable. Embraer believes that 2 million flights seem to be a very conservative threshold to define an acceptable in-service history. Therefore, Embraer suggests reducing it to a figure between 1 and 1.5 million flights.
response	Not accepted. As explained in the NPA, the 2-million-flights threshold was set-up in order to add a margin against uncertainties from statistics, but also to capture aeroplanes which experienced events in supercooled icing conditions although it was not confirmed to include SLD conditions. For these aircraft, events have occurred after up to an estimated 1.7 million flights (case of the Saab 340).

comment	*43* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 34 AMC 25.1420(e) paragraph 3.4 Safe Fleet History Requirements** Original Text The reference fleet should have accumulated two million or more flights, in total, with no accidents or serious incidents in supercooled liquid water icing conditions aloft. Proposed Text The reference fleet should have accumulated two million or more flights, in total, with no accidents or serious incidents in supercooled liquid water icing conditions aloft. **With the agreement of the Agency, if the reference fleet has not accumulated sufficient flights the applicant may elect to augment comparative analysis with additional SLD assessments as described in section 5.9 of this AMC.** Rationale The inclusion of the proposed text would allow, with the agreement of the agency, comparative analysis to be augmented with additional methods. It would be especially useful for some applicants, which may not be able to demonstrate the defined number of flights.

response	Not accepted. The comparative analysis augmentation is not foreseen to be used to compensate for an insufficient reference fleet number of flights. The minimum flights criterion is a threshold to be considered for eligibility to the comparative analysis.

comment	_44_ comment by: _Embraer - Indústria Brasileira de Aeronáutica - S.A._ **Page 33, AMC 25.1420(e) Paragraph 3** Change "Determining Adequately Safe Fleet History" to "Determining Adequate~~ly~~ Safe Fleet History".
response	Not accepted. The proposed wording does not appear to be better that the current one.

comment	_45_ comment by: _Embraer - Indústria Brasileira de Aeronáutica - S.A._ **AMC 25.1420(e) paragraph 5** <u>Original Text</u> "When conducting a comparative analysis, the effects of key parameters for individual components or systems should be considered at the aeroplane level." <u>Proposed Text</u> "When conducting a comparative analysis, the effects of key parameters for individual components or systems should be considered at the aeroplane level. **<u>A different design feature or margin may be shown to be acceptable when considered at the aircraft level taking into account the other aircraft design features and margins that are deemed to contribute to safe flight in icing conditions</u>"** <u>Rationale</u> The proposed text highlights that a different design feature or margin for one component or system can be compensated by other component or system features that contribute to safe flight in icing conditions. Furthermore, the proposed text aims to encourage improvements and innovations that might provide safety and environmental benefits.
response	Accepted.

comment	_46_ comment by: _Embraer - Indústria Brasileira de Aeronáutica - S.A._ **Page 38, AMC 25.1420(e) paragraph 5.9** <u>Original Text</u> 5.9 Additional Considerations — Augmenting Comparative Analysis In addition to the use of design features and/or margins, to substantiate a new or derivative design by comparative analysis, the applicant may augment the comparative analysis with

	other methodologies (e.g. test, analysis or combination thereof). The new methodologies should be agreed with the Agency. <ins>Proposed Text</ins> 5.9 Additional Considerations — Augmenting Comparative Analysis In addition to the use of design features and/or margins, to substantiate a new or derivative design by comparative analysis, the applicant may augment the comparative analysis with other methodologies (e.g. test, analysis or combination thereof). The new methodologies should be agreed with the Agency. **<ins>For example comparative analysis may be augmented by additional SLD studies (e.g. back to back design comparisons) for aspects of the design that cannot be shown to retain similar design features or margins to the reference fleet.</ins>** <ins>Rationale</ins> The inclusion of the proposed text would allow, with the agreement of the agency, comparative analysis to be augmented with additional methods. It would be especially useful for some applicants, which may not be able to demonstrate the defined number of flights.
response	Not accepted. The comparative analysis augmentation is not foreseen to be used to compensate for an insufficient reference fleet number of flights. The minimum flights criterion is a threshold to be considered for eligibility to the comparative analysis.

comment	_48_ comment by: _Embraer - Indústria Brasileira de Aeronáutica - S.A._ **Page 37 AMC 25.1420(e) 5.7.2 Controllability and Maneuverability** <ins>Original Text</ins> “If critical Appendix C ice shapes affect maneuverability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are restored (speed increase, etc.)” <ins>Proposed Text</ins> “If critical Appendix C ice shapes affect maneuverability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are **<ins>retained</ins>** (speed increase, etc.)” <ins>Rationale</ins> The proposed change seems to be more appropriate for this context. If critical Appendix C ice shapes affect maneuverability in a different manner than that of the reference fleet, the margins must be retained. This same comment applies to paragraph 5.7.3 “Trim”.
response	Partially accepted.

	In 5.7.2, the proposed change is adopted and the same change is made at the end of the paragraph dealing with ‘control effectiveness and forces’. In 5.7.3, the change is not applicable. You probably intended to refer to 5.7.4 instead.

comment	*50* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 38** Minor typographical error: Paragraph 5.7.5.b should be started as a new paragraph.
response	Accepted. The numbering error has been corrected.

comment	*53* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 32, AMC 25.1420, (e) CS 25.1420(c) Comparative Analysis, Key elements** <u>Original Text</u> “– Key elements: o The new model is certifiable for Appendix C icing conditions, o Aeroplane models previously certified for Appendix C icing conditions are used to establish a reference fleet, o The new model has similar design features and/or margins for key parameters relative to the reference fleet, o The reference fleet has a safe fleet history in supercooled liquid water icing conditions”. <u>Proposed Text</u> “– Key elements: o The new <u>**or derivative**</u> model is certifiable for Appendix C icing conditions, o Aeroplane models previously certified for Appendix C icing conditions are used to establish a reference fleet, o The new <u>**or derivative**</u> model has similar design features and/or margins for key parameters relative to the reference fleet, o The reference fleet has a safe fleet history in supercooled liquid water icing conditions”. <u>Rationale</u> In the key elements section, there is no mention to derivative models, only new ones.
response	Accepted.

comment	*56* comment by: *Dassault-Aviation* <u>**Dassault-Aviation comment**</u> <u>**NPA 2015-07 - Page 31: Book 2 AMC - Subpart F**</u>

	(e) CS 25.1420(c) Comparative analysis **Introduction** "For showing compliance with the CS-25 certification specifications relative to SLD icing conditions as represented in Appendix O, the applicant may use a comparative analysis to show similarity of a new or derivative aeroplane model to existing model(s) with features and/or margins which are deemed to have contributed to a safe fleet history in all icing conditions. When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II may not be required." Comment & Rationale: The intent of this rulemaking activity is to provide an AMC material so that the applicant may use and take credit for similarity to a previous design having proven safe operation in SLD icing conditions. When applicable, Comparative Analysis guidance provides material in order to show compliance without performing testing in natural or simulated SLD conditions, or without using SLD ice shapes. The use of the word "may" is contrary to the objective of this AMC. The word "is" should be used instead. **Requested change and proposed text:** For showing compliance with the CS-25 certification specifications relative to SLD icing conditions as represented in Appendix O, the applicant may use a comparative analysis to show similarity of a new or derivative aeroplane model to existing model(s) with features and/or margins which are deemed to have contributed to a safe fleet history in all icing conditions. When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II is not required."
response	Accepted.

comment	*57* comment by: *Dassault-Aviation* **Dassault-Aviation comment:** **NPA 2015-07 - Page 34: Book 2 AMC - Subpart F** **(e) CS 25.1420(c) Comparative analysis** **3.4 Safe Fleet History Requirements** "The reference fleet should have accumulated two million or more flights, in total, with no accidents or serious incidents in supercooled liquid water icing conditions aloft." **Comment & Rationale:** This section defines that 2 million or more flights are an acceptable threshold. The analysis provided in §2.4.2.1 of the NPA explains that, based on probability of heavy SLD icing conditions, a fleet history of around 1.2 million flights would be acceptable. This value also captures in service experience events presented in §2.4.2.1.4. That means that the retained criterion of 2 million contains an unnecessary conservatism. It is thus proposed to retain 1.2 million. **Requested change and proposed text:** The reference fleet should have accumulated 1.2 million or more flights, in total, with no

	accidents or serious incidents in supercooled liquid water icing conditions aloft.”
response	Not accepted. As explained in the NPA, the 2-million-flights threshold was set-up in order to add a margin against uncertainties from statistics, but also to capture aeroplanes which experienced events in supercooled icing conditions although it was not confirmed to include SLD conditions. For these aircraft, events have occurred after up to an estimated 1.7 million flights (case of the Saab 340).

comment	*58* comment by: *Dassault-Aviation* **<u>Dassault-Aviation comment:</u>** **<u>NPA 2015-07 - Page 36/37: Book 2 AMC - Subpart F</u>** **(e) CS 25.1420(c) Comparative analysis** **5.7 Aeroplane Performance and Handling Characteristics** “The comparative analysis should substantiate that the effects of ice accretion and the agreed key parameters of the new or derivative model are comparable to those of the reference fleet. The applicant should substantiate by analysis, test, or a combination of both, that the new or derivative aeroplane will have similar margins to those of the reference fleet for flight in the icing conditions of Appendix C.” **<u>Comment & Rationale:</u>** When showing compliance to subpart B requirements by the use of Comparative Analysis, certification ice shapes/ice data determined for Appendix C icing conditions are acceptable without additional Appendix O considerations. It is proposed to state this point precisely in §5.7 introduction. **<u>Requested change and proposed text:</u>** “The comparative analysis should substantiate that the effects of ice accretion and the agreed key parameters of the new or derivative model are comparable to those of the reference fleet. The applicant should substantiate by analysis, test, or a combination of both, that the new or derivative aeroplane will have similar margins to those of the reference fleet for flight in the icing conditions of Appendix C. Certification ice shapes/ice data determined for appendix C icing confitions are acceptable without additional Appendix O considerations"
response	Not accepted. The paragraph subject to the comment is already clear because it only refers to Appendix C icing conditions. Furthermore, the relief from flight testing with Appendix O ice shapes is already mentioned in other paragraphs of CS 25.1420, AMC 25.21(g), AMC 25.1420.

comment	*59* comment by: *Dassault-Aviation* **<u>NPA 2015-07 - Page 37: Book 2 AMC - Subpart F</u>** **(e) CS 25.1420(c) Comparative analysis** **5.7.2 Controllability and Manoeuvrability** “The manoeuvrability associated with the certification ice shapes/ice shape data determined for the icing conditions of Appendix C should be comparable to those of the aeroplanes which comprise the reference fleet. If critical Appendix C ice shapes affect manoeuvrability in

	a manner which may be different to that of the reference fleet, then the applicant should show how the margins are restored (speed increase, etc.)" **Comment & Rationale:** It is acceptable for Appendix C ice shapes to affect manoeuvrability in a different manner to that of the reference fleet. The word "restored" might be understood as if the objective was to restore margins to compensate degradation. But, the objective here is to retain comparable manoeuvrability to those of the reference fleet. It is thus proposed to use the word "retained" instead of "restored". **Requested change and proposed text:** "If critical Appendix C ice shapes affect maneuverability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are retained (speed increase, etc.)"
response	Accepted. The same change is made at the end of the paragraph just above dealing with 'control effectiveness and forces'.

comment	*60*	comment by: *Dassault-Aviation*
	Dassault-Aviation comment **NPA 2015-07 - Page 37/38: Book 2 AMC - Subpart F** **(e) CS 25.1420(c) Comparative analysis** **5.7.4 Stability** "The aeroplane stability associated with the certification ice shapes/ice shape data determined for the icing conditions of Appendix C should be comparable to those of the reference fleet. If this cannot shown, then the applicant should show how similar stability margins are restored (speed increase, sizing criteria, other aircraft limitations, etc)." **Comment & Rationale:** Same comment as comment#6: the word "restored" might be understood as if the objective was to restore margins to compensate degradation. But, the objective here is to retain comparable stability to those of the reference fleet. It is thus proposed to use the word "retained" instead of "restored". **Requested change and proposed text:** "If this cannot shown, then the applicant should show how similar stability margins are retained (speed increase, sizing criteria, other aircraft limitations, etc)."	
response	Accepted.	

comment	*61*	comment by: *Dassault-Aviation*
	Dassault-Aviation comment:	

	NPA 2015-07 - Page 38: Book 2 AMC - Subpart F **~~(e)~~(f) CS 25.1420~~(c)~~(d)** "CS 25.1420~~(c)~~(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply." **Comment:** AMC 25.1420 paragraph (e) provides guidance on how to use comparative analysis to show compliance to CS 25.1420 (d) requirements. That means that, if applicable, comparative analysis may be used to show compliance as an alternative to using AMC 25.1419. It is thus required to update AMC 25.1420 paragraph (f) to take into account this alternative. **Requested change and proposed text:** "CS 25.1420~~(c)~~(d) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), and (g) of AMC 25.1419 apply. If applicable, a comparative analysis (see AMC 25.1420, paragraph (e)), may be used to show compliance"
response	Accepted.

comment	*65* comment by: *AIRBUS*
	Original Text: "*Comparative analysis:* *The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in the icing environment of Appendix C with a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been certified for operation in the icing environment of Appendix O*." Proposed Text: "The use of analyses to show that an aeroplane is comparable to models that have previously been certified for operation in all icing conditions via the environment represented by Appendix C and have a proven safe operating history in supercooled liquid water icing conditions, but that may not have already been explicitly certified for operation in the icing environment represented by Appendix. Rationale: Existing Aircraft that are already certified to the icing conditions represented by Appendix C are certified for all icing conditions without restriction. These aircraft (originally certified prior to the SLD icing requirements) are still approved for flight in all icing conditions even after the adoption of the new requirements.
response	Partially accepted. The proposed text is accepted, except that the word 'all' is removed. The previous certification were based on Appendix C. However, Appendix C was not deemed to represent all icing conditions. 'Any' is added before 'supercooled liquid water icing conditions'.

comment	*76* comment by: *Bombardier*

NPA Proposed Text
3.2 Use of Fleet History Data Not Owned by the Applicant
The use of fleet history data from the fleets of other certificate holders for Supplemental Type Certificate, new Type Certificate, or Major change to Type Certificate applications may be accepted by the Agency when formal agreements between the applicant and the certificate holder permitting the use of the relevant fleet history are in place. The Agency will determine the acceptability and the applicability of the data.

Bombardier Comment
When competitive reasoning prevails it may not be possible to reach an agreement between the applicant and the certificate holder permitting the use of the relevant fleet history. Similar to our comment on 2.4.2.1, it is recommended that the authorities review and consider ways to ensure a level playing field for all OEMs prior to release of this NPA.

response Noted.
The concept of allowing a comparative analysis was discussed in the frame of RMT.0058. It is acknowledged that not all applicants may be eligible to use it.

comment *77* comment by: *Bombardier*

NPA Proposed Text
3.3 Applicability of Fleet History for the Certification Options of CS 25.1420(a)
If the aeroplane model(s) proposed to be included in the applicant's reference fleet has (have) limitations or restrictions applicable to SLD, the certification options for which comparative analysis could be used are limited to CS 25.1420(a)(1) or (a)(2). The applicant should demonstrate within the comparative analysis that the means of ice and/or icing conditions detection for the reference fleet remain valid and are applicable to the new or derivative aeroplane.

Bombardier Comment
Typical operating procedures for the majority of currently certified aeroplane models may not explicitly address SLD icing conditions and limitations. Cautionary notes mainly direct the flight crew to avoid 'severe' icing conditions based on pilot judgment. Similar to comment 3, it is recommended that the use of comparative analysis be limited to showing compliance to CS-25.1420 (a)(1).

response Noted.
Please refer to our response to comment nr 75.

comment *78* comment by: *Bombardier*

NPA Proposed Text
5.2 Ice Protection Systems
The applicant should demonstrate similar levels of protection against the effects of ice accretion at the aeroplane level in the icing conditions of Appendix C. In doing so, the applicant should consider the ice protection system performance, modes of operation and the other factors identified by the applicant that contribute to the overall safety of the aeroplane for flight in the icing conditions of Appendix C. The assessment could include but is not necessarily limited to an analysis of the protection limits relative to supercooled liquid water impingement limits, runback and residual ice, as applicable.

Bombardier Comment
For aeroplane models equipped with de-icing systems where ice is shed or removed by destroying the bond between the ice and the protected surface, ice may accrete on the upper wing surface behind the protected surfaces under Appendix O conditions. It is assumed that the reference fleet had demonstrated acceptable handling characteristics with such ice accretions. Unless substantiated by the comparative analysis, the applicant must show the aircraft has acceptable handling characteristics under these conditions. Flight testing with ¼ round 1 inch forward facing artificial ice shapes installed on the upper wing surface behind the protected surfaces is a satisfactory method of simulating these accretions.

response Noted.
Paragraph 5.2 is provided in the frame of comparative analysis. Therefore, Appendix C icing conditions are considered for the comparison of ice protection systems.

comment *79* comment by: *Bombardier*

NPA Proposed Text
5.7.2 Controllability and Manoeuvrability
The effectiveness of the control surfaces and the control forces for the new or derivative model, with the certification ice shapes/ice shape data for flight in the icing conditions of Appendix C, should be comparable to those of the reference fleet. If critical Appendix C ice shapes affect the control surface effectiveness or control forces in a manner which may be different to that of the reference fleet, then the applicant should show how the control effectiveness and forces are restored. The manoeuvrability associated with the certification ice shapes/ice shape data determined for the icing conditions of Appendix C should be comparable to those of the aeroplanes which comprise the reference fleet. If critical Appendix C ice shapes affect manoeuvrability in a manner which may be different to that of the reference fleet, then the applicant should show how the margins are restored (speed increase, etc.).

Bombardier Comment
For aeroplane models equipped with manual flight control surfaces, ice may accrete ahead of the control surfaces under Appendix O conditions. This may result in changes to the surfaces' hinge moment characteristics. It is assumed that the reference fleet had demonstrated acceptable handling characteristics with such ice accretions. Unless substantiated by the comparative analysis, additional analysis and/or flight testing may be required.

response Noted.
Paragraph 5.7.2 is provided in the frame of comparative analysis. Therefore, Appendix C icing conditions are considered for the comparison of controllability and manoeuvrability.

comment *97* comment by: *Boeing*

Page: 29
Paragraph*: 3.1.11.d.1.2.2.2 -- Service history*

The proposed text states:

	"… Service history data are limited to the fleet of aeroplane type(s) owned by the applicant." **REQUESTED CHANGE:** We recommend revising the text as follows. "… Service history data are limited to the fleet of aeroplane type(s) ~~owned by~~ ***for which*** the applicant ***is the holder of the Type Certificate(s) ("TC's"), or the owner of the data, or if accepted by the Agency, has an agreement in place with the owner of the data that permits its use by the applicant for this purpose (see paragraph 3.1.11.e.3.2)***." **JUSTIFICATION:** Although this is existing text that is not proposed to be revised, we nonetheless have the following comment: In general, the applicants do not own the airplanes that will be used to establish an adequately safe service history; rather, the airplanes are owned by airlines, leasing companies, etc. Our suggestion is to revise this sentence such that the applicant is the holder of the TC(s), or the owner of the data, or has an agreement in place with the owner of the data as discussed in paragraph 3.1.11.e.3.2.
response	Accepted.

comment	*98* comment by: *Boeing* Page: 29-30 Paragraph: *3.1.11.d.1.2.2.4* **The proposed text states:** *"**1.2.2.4** Icing event history of conventionally designed aeroplanes certificated before the introduction of CS 25.1420* *Given the volume of aeroplane operations and the number of reported incidents that did not result in a catastrophe, a factor of around 1 in 100 is a reasonable assumption of probability for a catastrophic event if an aeroplane encounters Appendix O conditions in which it has not been shown capable of safely operating. An applicant may assume that the hazard classification for an unannunciated encounter with Appendix O conditions while the ice protection system is activated is Hazardous in accordance with AMC 25.1309, provided that the following are true:* • *The aeroplane is similar to previous designs with respect to Appendix O icing effects, and* • *The applicant can show that the icing event history of all conventionally designed aeroplanes is relevant to the aeroplane being considered for certification."* **REQUESTED CHANGE:** We request revising the text as follows: *"1.2.2.4 Icing event history of ~~conventionally designed~~ aeroplanes **of conventional design** certificated before the introduction of CS 25.1420* *Given the volume of aeroplane operations and the number of reported incidents that did not*

result in a catastrophe, a factor of around 1 in 100 is a reasonable assumption of probability for a catastrophic event if an aeroplane encounters ***the icing conditions represented by*** *Appendix O ~~conditions~~ in which it has not been shown capable of safely operating****, while the aeroplane's ice protection systems are operating normally (in accordance with approved procedures for the icing conditions represented by Appendix C)****. An applicant may assume that the hazard classification for an unannunciated encounter with* ***the icing conditions represented by*** *Appendix O****,*** *~~conditions~~ while the****se*** *ice protection system****s are operating normally,*** *~~is activated~~ is Hazardous in accordance with AMC 25.1309, provided that the following are true:*

• The aeroplane is similar to previous designs with respect to ***icing effects in the conditions represented by*** *Appendix O ~~icing effects~~, and*

• The applicant can show that the icing event history of all ~~conventionally designed~~ aeroplanes ***of conventional design*** *is relevant to the aeroplane being considered for certification."*

JUSTIFICATION: Although this is existing text that is not currently proposed to be revised, we nonetheless have the following comments:

In both the title and the last bullet of this sub-paragraph, we assume that the intention is not to use the verb to refer to the manner in which the airplanes were designed (i.e., using conventional methods, such as computing tools) but rather, as a noun to describe the physical design or configuration characteristics. Our suggested revision will clarify this and is applicable throughout the document.

Beginning with *"while"* in the middle of the paragraph, our revisions relative to operation of the ice protection systems are suggested to clarify the intention regarding operation of those systems relative to Appendix O. If we have not captured the intention correctly, we respectfully request appropriate clarification and explanation.

The remaining revisions request reference to icing conditions represented by the appendices and are commensurate with our prior comments regarding such references.

response	Accepted.

comment	*99* comment by: *Boeing*

Page: 30
Paragraph: *3.1.11.d.1.2.3*

The proposed text states:

"1.2.3 Probability of encountering Appendix O icing conditions

Appendix C was designed to include 99 percent of icing conditions. Therefore, the probability of encountering icing outside of Appendix C drop conditions is on the order of 10-2. The applicant may assume that the average probability for encountering Appendix O icing conditions is 1 x 10-2 per flight hour. This probability should not be reduced based on phase of flight."

	REQUESTED CHANGE: *"1.2.3 Probability of encountering **the icing conditions represented by** Appendix O ~~icing conditions~~* *Appendix C was designed to include 99 percent of icing conditions. Therefore, the probability of encountering icing outside of **the icing conditions represented by** Appendix C ~~drop conditions~~ is on the order of 10-2. The applicant may assume that the average probability for encountering **the icing conditions represented by** Appendix O ~~icing conditions~~ is 1 x 10-2 per flight hour. This probability should not be reduced based on phase of flight**, except for aeroplanes that cruise at altitudes above the maximum altitudes specified in Appendix O for the freezing drizzle and/or freezing rain regimes, as applicable; for those aeroplanes, the probability for the cruise phase of flight may be reduced to zero**."* **JUSTIFICATION:** Although this is existing text that is not currently proposed to be revised, we nonetheless have the following comments: In the title and the text, the revisions requesting reference to the icing conditions represented by the appendices are commensurate with our other comments on this issue. For aeroplanes that cruise above the maximum altitudes for encountering freezing drizzle and freezing rain, per the Appendix O engineering standards, we respectfully request revision of the last sentence to reflect that it is appropriate to eliminate the probability of encountering SLD icing conditions during the cruise phase of flight.
response	Partially accepted. The last part of the proposal concerning the probability aspect is not accepted. This aspect was introduced by RMT.0058 and it is out of the scope of this NPA which is dedicated to comparative analysis.

comment	*100* comment by: *Boeing* Page: 31 Paragraph: *3.1.11.(e)* **The proposed text states:** ***"(e) CS 25.1420(c) Comparative analysis*** *(...)* *When using this comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II may not be required."* ***REQUESTED CHANGE:*** *We recommend revising the text as follows:* ***"(e) CS 25.1420(~~c~~d) Comparative analysis*** *(...)*

*When using ~~this~~ comparative analysis as a means of compliance, flight testing in measured natural SLD icing conditions and/or flight testing with simulated ice shapes defined in accordance with Appendix O - Part II ~~may~~ **is** not ~~be~~ required."*

JUSTIFICATION: In accordance with our previous comment, changing the order of proposed CS 25.1420(c) and (d) will require that this section refer to (d).

In the subject sentence, we request that the word "this" be deleted as it is unnecessary and potentially confusing.

The final phrase of the sentence proposed in the NPA incorporates a revision that was not reviewed and agreed to by the members of the Rulemaking Group. Prior to the revision, this sentence stated that testing is not required. We respectfully submit that the pre-revision statement was and still is the intention of the comparative analysis option; i.e., flight testing is not required. Concurrence with this position is documented in the Agency's notes for the last meeting of the Rulemaking Group.

response Accepted.

comment *101* comment by: *Boeing*

Page: 35
Paragraph*: 3.1.11.e.5.4 -- Ice or Icing Conditions Detection*

The proposed text states:

"… If the applicant chooses to introduce a new ice and/or icing conditions detection technology and show compliance at the aeroplane level based on a reference fleet with unrestricted operations (CS 25.1420(a)(3)) by comparative analysis, the new ice and/or icing conditions detection technology may require additional analysis, testing, or qualification data to demonstrate the capability to detect supercooled liquid water conditions when exposed to the SLD conditions represented in Appendix O. …"

REQUESTED CHANGE: We recommend revising the text as follows:

*"… If the applicant chooses to introduce a new ice and/or icing conditions detection technology and show compliance at the aeroplane level based on a reference fleet with unrestricted operations**, and the applicant is seeking certification by comparative analysis for unrestricted operations in SLD icing conditions for the new or derivative model per** ~~(~~CS 25.1420(a)(3)~~) by comparative analysis~~, the new ice and/or icing conditions detection technology ~~may require additional analysis, testing, or qualification data to demonstrate the capability to detect supercooled liquid water conditions when exposed to the SLD conditions represented in Appendix O.~~ **should be installed and operate in a manner that results in equivalent ice and/or icing conditions detection performance. This may include additional qualification to the icing conditions represented by Appendix C. See Example 2 of Appendix 2 to this NPA**. …"*

JUSTIFICATION: In the first half of this paragraph, the phrase, *"based on a reference fleet with unrestricted operations (CS 25.1420(a)(3)),"* seems to imply that the reference fleet

	model(s) have already been certified to CS 25.1420(a)(3). Our recommended revision will clarify that the reference fleet has no restrictions for operating in SLD icing conditions and that the applicant is seeking certification to CS 25.1420(a)(3) for the new or derivative model. This avoids specifying that the reference fleet has already been certified to CS 25.1420(a)(3), which it might or might not have been. We believe that including either scenario is more helpful for both near-future and longer-term applicants. The requested revisions for the second half of this paragraph align with the agreement of the Rulemaking Group that, when comparative analysis is used as the MoC, ice or icing conditions detectors for the new or derivative model need only provide the same level of functionality and performance as those of the adequately safe reference fleet. It would be appropriate and helpful to reference Example 2 of Appendix 2 as well, as we have suggested.
response	Accepted. However, the reference to the NPA Appendix 2 is not adopted in the CS-25 text.

4. Regulatory Impact Assessment (RIA) p. 39-41

comment	*51* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* **Page 41, 4.4.4 Economic Impact** Embraer believes that the RIA does not address the potential impact upon the introduction of new technologies. Currently, the only acceptable means of compliance to the full envelope of Appendix O is comparative analysis. It means that some aircraft may not be certified to operate in SLD conditions although the majority of large aircraft have demonstrated good in service experience in those conditions. It is assumed that future aircraft designs will achieve certification by comparative analysis whilst continuing to improve the efficiency of the aircraft to achieve continued improvement in noise and emissions whilst providing at the same time improved efficiency to the aircraft operators. Therefore, this should be reflected in the practical application of the SLD rules and comparative analysis. Otherwise the RIA should be updated to record the economic impact of constraining future developments.
response	Noted. It is agreed that the comparative analysis should be usable in such a way that new technologies can be introduced on new or derivative aeroplanes. It is not to be used for similar designs only as explained in AMC 25.1420.

comment	*68* comment by: *AIRBUS* 4. Regulatory Impact Assessment (RIA) *4.1. Issues to be addressed* Original text: This would facilitate the demonstration of compliance with the specifications and it may eliminate the need for performing testing in natural or simulated SLD conditions. Proposed text:

	This would facilitate the demonstration of compliance with the specifications and it will eliminate the need for performing testing in natural or simulated SLD conditions. Rationale: Comparative analysis is intended to be an alternative to flight testing and computation of SLD ice shapes.
response	Accepted.

comment	*102* comment by: *Boeing* Page: 39 Paragraph: *4.1 -- Issues to be addressed* **The proposed text states:** *"… For this reason, the Agency created some provisions in the AMC 25.1420 (refer to NPA 2012-22) so that the applicant may use and take credit for similarity to a previous design having proven safe operation in SLD icing conditions. This would facilitate the demonstration of compliance with the specifications and it may eliminate the need for performing testing in natural or simulated SLD conditions. …"* **REQUESTED CHANGE:** We recommend revising the text as follows: *"… For this reason, the Agency created some provisions in the AMC 25.1420 (refer to NPA 2012-22) so that the applicant may use and take credit for similarity to a previous design having proven safe operation in SLD icing conditions. This would facilitate the demonstration of compliance with the specifications and it ~~may~~ **will** eliminate the need for performing testing in natural or simulated SLD conditions. …"* **JUSTIFICATION:** In accordance with our requested change to CS 25.1420(c), a similar revision is appropriate for this explanatory sentence. The agreement among the members of the Rulemaking Group, including the Agency, is that flight testing will not be required when comparative analysis is used as the means of compliance. This was documented in EASA's notes of the last meeting of the group.
response	Accepted.

6. Appendices — 6.1. Appendix 1 — Explanation of the method used to determine the number of SLD encounters experienced by an aircraft fleet during a defined number of flights	p. 44-49

comment	*23* comment by: *FAA* **Comment: Appendix I:** "Considering probabilities determined in paragraph 2.4.2.1.3: — 5 % of flights encounter icing conditions; — 1.7 % of the icing conditions are in SLD; and — 1 % of the SLD are considered heavy.

As explained in paragraph 2.4.2.1.3.3, a probability of exceeding Appendix O icing conditions of 0.1% has been retained to provide an additional element of conservatism to calculate the probability of heavy SLD icing conditions. However, in determining the number of encounters associated with operational conditions, it has been considered that such a conservatism was too severe for this calculation; therefore, as Appendix O is based on 99 % exceedance limits, the 1 % probability of heavy SLD has been selected.

Thus, the number of flight hours in heavy SLD is:

1 000 000 x 0.05 x 0.017 x 0.01 = 8.5 hours"

In paragraph 2.4.2.1.3, it is argued that a reasonable estimate is that an icing encounter will occur during 5% of flights. Thus:
P(Icing encounter) = .05

At this point in Appendix 1, the probability of encountering icing conditions is being used as an estimate of the probability of being in icing conditions based on the proportion of time in icing conditions to the time in flight for a collection of flights.

These two probabilities are not conceptually the same. It is possible that they are numerically the same, but highly unlikely. As a result, the example should be revised with the recognition that the probability of encountering icing conditions during a flight is significantly different than the probability of being in icing conditions as a function of flight hours.

Example.
Consider 100 flights of 1 hour each, 4 of which encounter icing for 15 minutes.

Then proportion of flights encountering icing = .04 but the proportion of time in icing = 1 hr/100 hr = .01.

Rationale: The proposal does not clearly distinguish between the proportion of flights which encounter icing and the proportion of time in icing relative to the time in flight. This is an important distinction and we strongly recommended that it be made consistently to avoid inaccurate estimates of in-service experience.

response Accepted.
The comment on the inconsistency of our calculation is considered valid. This led the rulemaking group to fully review the Appendix 1 methodology, and we came to the conclusion that our exposure time calculations are misleading and do not necessarily reflect the reality. Dr Cober's methodology is not challenged, but the input to the methodology provided by the rulemaking group was not correct; indeed, to perform a correct calculation, data on average flight duration in SLD conditions is missing. Appendix 1 to the NPA attempted to go around this issue but provided a misleading calculation.
Furthermore, Appendix 1 calculated the number of exposures to extreme SLD conditions (designated 'heavy SLD' in Appendix 1 but without the conservatism that was used in the calculation of the minimum reference fleet flights), which are beyond Appendix O and outside of the requirements of CS 25.1420. It has, therefore, been decided to limit our assessment to the number of SLD encounters experienced by the reference fleet considering the two-million-flights criterion. Appendix 1 has, therefore, been deleted, as well as

	paragraph 2.4.2.1.5 of the NPA explanatory note. The number of SLD encounters is now provided at the end of the conclusion providing the two-million-flights criterion, now re-numbered 2.4.2.1.5 (previously 2.4.2.1.6).

comment	*24* comment by: *FAA* **Comment: Appendix I:** In several instances it is assumed that the airplane in question is flying at a holding speed of 100 m/s. It should be made clear in the proposal that actual speeds should be used for comparative analysis since speed is a significant factor in estimating the time in icing conditions. **Rationale:** Editorial change for clarity
response	Not accepted. Appendix 1 of the NPA explained the method used to determine the number of SLD encounters that was used to compute the minimum number of flights the reference fleet must have gathered. The purpose was not that an applicant compute its own minimum number of flights. Nevertheless, as explained in our reply to comment 23 above, Appendix 1 has been deleted.

6. Appendices — 6.2. Appendix 2— Application of the comparative analysis — Examples p. 50-53

comment	*25* comment by: *FAA* **Comment: Section 6.2, Appendix 2, example 1**: This example, if adopted, would allow the use of a comparative analysis and in-service experience of an airplane with an anti-ice system to install a de-icing system. The FAA disagrees with this example because the intent of using a comparative analysis should be to substantiate similar designs based on in-service experience. The FAA does not generally consider anti-ice systems and de-ice systems to be similar. As a result, Example 1 should be an example of when comparative analysis should not be used, or simply removed from the document. **Rationale:** De-icing systems generally exhibit runback ice in appendix C conditions at temperatures near freezing. Anti-ice systems generally only exhibit limited runback, if any at all, under low power conditions. As a result, runback ice with a de-icing system is typically more critical compared to runback with an anti-ice system and the potential for more severe runback ice accretions is greatly increased in SLD conditions because of water impingements further aft and higher water contents compared to appendix C conditions.
response	Not accepted. The example 1 explains that such case may not always be acceptable for a comparative analysis: 'If there are significant differences in the amount of runback ice produced in Appendix C icing conditions by the de-icing system when compared to reference fleet ice shapes/ice data, then an analysis must show that the effects can be accurately or conservatively addressed in SLD. If this cannot be shown, then comparative analysis may not be applicable.'

comment	*35* comment by: *AIRBUS*

Appendix 2 – Application of the Comparative Analysis – Examples

The AMC provides guidance on how to apply comparative analysis and the examples provide valid examples that illustrate how to apply CA.
These examples should be included in the AMC.
This will facilitate the consistent application of CA.

response

Not accepted.
The examples were provided in an Appendix of the NPA to illustrate how a comparative analysis could be applied to some specific situations. However, the Agency does not consider that these approaches should be used in a standardised manner; therefore these examples are not introduced in the AMC material. Note that the updated explanatory note, including the examples, will be published in the CRD to NPA 2015-07.

comment

47 comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

Appendix 2 – Application of the Comparative Analysis – Examples

These examples provide valuable guidance on how to apply comparative analysis. Thefore, Embraer suggests including examples of appendix 2 in the advisory material, and not only in the appendices. This will facilitate the consistent application of comparative analysis.

response

Not accepted.
The examples were provided in an Appendix of the NPA to illustrate how a comparative analysis could be applied to some specific situations. However, the Agency does not consider that these approaches should be used in a standardised manner; therefore these examples are not introduced in the AMC material. Note that the updated explanatory note, including the examples, will be published in the CRD to NPA 2015-07.

comment

62 comment by: *Dassault-Aviation*

Dassault-Aviation comment:

NPA 2015-07 - §6.2 Appendix 2 — Application of the comparative analysis — Examples

Comment:
These examples illustrate how to use Comparative Analysis and provide valuable guidance to help applicants when using this MOC. These examples should be included in the AMC material.

response

Not accepted.
The examples were provided in an Appendix of the NPA to illustrate how a comparative analysis could be applied to some specific situations. However, the Agency does not consider that these approaches should be used in a standardised manner; therefore these examples are not introduced in the AMC material. Note that the updated explanatory note, including the examples, will be published in the CRD to NPA 2015-07.

comment

80 comment by: *Bombardier*

Bombardier Comment - NPA Appendix 2

	A review of existing issue papers related to SLD icing encounter shows that safety concerns identified were specific to aeroplane models equipped with de-icing system and/or manual control surfaces. It is recommended to add additional examples for these specific aeroplane models.
response	Not accepted. The examples provided intend to illustrate the principles of how to conduct a comparative analysis which are applicable to any category of large aeroplane. It was not our intent to focus particularly on some design specificities. Furthermore, the examples are not standardised acceptable means of compliance and are not part of the AMC.

4. Appendix 1: Updated Explanatory Note to NPA 2015-07

2. Explanatory Note

2.1. Overview of the issues to be addressed

Within the frame of rulemaking task RMT.0058, new certification specifications (CS) and acceptable means of compliance (AMC) have been created for certification of large aeroplanes for flight in icing conditions. These new provisions, introduced through Amendment 16 of CS-25, include the introduction of Supercooled Large Drop (SLD) icing conditions in various paragraphs of Book 1.

Some provisions have been included in AMC 25.1420 so that the applicant may use and take credit for similarity to a previous type design having proven to safely operate in SLD icing conditions. However, the details of the method and the acceptance criteria to be used when conducting a comparative analysis are not provided; therefore, the Agency decided to create a new rulemaking task to further develop the application of comparative analysis.

For more detailed analysis of the issues addressed by this proposal, please refer to the RIA Section **Error! Reference source not found.**. '**Error! Reference source not found.**'.

2.2. Objectives

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

The specific objective of this proposal is to introduce an acceptable means of compliance based on comparative analysis when showing compliance with SLD-related specifications.

2.3. Summary of the Regulatory Impact Assessment (RIA)

Option 1 (see Section **Error! Reference source not found.**) is recommended, i.e. amend CS-25 to introduce an acceptable means of compliance based on comparative analysis when showing compliance with SLD-related specifications. This would provide a benefit in terms of safety level harmonisation and would facilitate the certification process for both the applicants and the Agency when eligible to utilize the comparative analysis, with an overall economic benefit. It would also meet the request made by several large aeroplane manufacturers within the frame of the development of the new icing certification specifications (RMT.0058).

2.4. Overview of the proposed amendments

Changes to CS-25 Book 1 and Book 2 are proposed in order to enable the use of a means of compliance based on comparative analysis when showing compliance with SLD-related specifications.

This section provides the background and the methodology used to develop the proposed changes.

2.4.1 Definitions

2.4.1.1 Key definitions

Similarity analysis

— The direct comparison of a new or derivative aeroplane model to models already certified for operation in the icing environment of Appendix C and/or Appendix O. Similarity can be established for aircraft, system and/or components.

— Key elements:

- Similar design features
- Similar performance and functionality

Comparative analysis

— The use of analyses to show that an aircraft is comparable to models that have previously been certified for operation in icing conditions via the icing environment represented by Appendix C and have a proven safe operating history in any supercooled liquid water icing conditions, but that may not have already been explicitly certified for operation in the icing environment represented by Appendix O, which did not exist at that time.

— Key elements:

- The new model is certifiable for Appendix C icing conditions
- Aircraft models previously certified for Appendix C icing conditions are used to establish a reference fleet
- The new model has similar design features and/or margins for key parameters relative to the reference fleet
- The reference fleet has a safe fleet history in supercooled liquid water icing conditions

Events

For the purposes of this document, the word 'event' means 'accident and/or serious incident' as defined in ICAO Annex 13, Chapter 1. For the purpose of identifying serious incidents with respect to the in-service history used for the comparative analysis, this should include reports where the flight crew encountered difficulties controlling the aeroplane, or temporarily lost its control, when flying in icing conditions.

Reference fleet

The fleet of previously certified aeroplanes used to establish safe fleet history in order to enable the use of comparative analysis as a means of compliance.

Certification ice shapes/ice shape data

Ice shapes or ice shape data used to show compliance with certification specifications for flight in icing conditions. As used in this document, these are the ice shapes or data used to represent the critical ice shapes with the intent that they convey the ice that represents the most adverse effect on performance and flight characteristics. The data which is used to represent these shapes may be comprised of flight test data (artificial or natural ice), wind tunnel data, analytical data, or combinations of the above as allowed during previous certification efforts.

Key parameters

Parameters that contributed to the safe operation in icing conditions of the reference fleet. These parameters should be defined and provided by the applicant for each of the topics addressed using the comparative analysis. They should be agreed with the Agency.

2.4.1.2 Additional definitions

Anti-icing

The prevention of ice accumulation on a protected surface.

CPR

The Changed Product Rule (CPR) is the process used to determine the applicable certification specifications for an aircraft as determined under Subpart D of Annex I (‘Part 21’) to Commission Regulation (EU) Regulation No 748/2012[4] as amended by Commission Regulation (EU) Regulation No 69/2014[5] (please see 21.A.101).

De-icing

The periodic shedding or removal of ice accretions from a surface by destroying the bond between the ice and the protected surface.

Freezing drizzle

Liquid precipitation in the form of water drops with diameters between 50 and 500 µm that fall in liquid form, but freeze upon impact with the ground or exposed objects.

Freezing rain

Precipitation near the ground or aloft in the form of liquid water drops which have diameters >0.5 mm (500 µm) that fall in liquid form, but freeze upon impact with the ground or exposed objects.

Heavy SLD icing conditions

For the purpose of this analysis, SLD icing conditions beyond those represented by Appendix O are termed ‘Heavy’.

Ice accretion

A growth, build-up, or formation of ice on an aircraft surface.

---

4 Commission Regulation (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 224, 21.8.2012, p. 1).

5 Commission Regulation (EU) No 69/2014 of 27 January 2014 amending Regulation (EU) No 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 23, 28.1.2014, p. 12).

Impingement limits

The farthest aft location on a body on which water droplets impact. This applies to both the upper or lower surface for a body such as an airfoil. This distance can be measured either as the x distance from the leading edge or as the surface distance from the stagnation point (attachment line).***Liquid Water Content (LWC)***

The total mass of water contained in liquid drops within a unit volume or mass of cloud or precipitation, usually given in units of grams of water per cubic metre or kilogram of dry air (g/m^3, g/kg).

MoC

Means of Compliance

Residual ice

Ice remaining immediately after an actuation cycle of a de-icing type of ice protection system.

Runback ice

Ice formed from the freezing or refreezing of water leaving an area on an aircraft surface that is above freezing and flowing downwind to an area that is sufficiently cooled for freezing to take place. This ice type is frequently associated as an unwanted product of thermal anti-icing or de-icing systems.

Supercooled Large Drop (SLD)

Supercooled liquid water drop with diameter >50 µm; this includes freezing rain and freezing drizzle.

Supercooled liquid water

Liquid water at a temperature below the freezing point.

2.4.2 Comparative analysis as a means of compliance — Explanatory note

This paragraph provides the rationale and explanation of the development of comparative analysis as a MoC for certification against the CS-25 certification specifications addressing Supercooled Large Drop (SLD) icing conditions as represented in Appendix O. The Agency acknowledges that there are a significant number of aeroplane models that have an exemplary record of safe operation in all icing conditions, which inherently include SLD icing conditions. The proposed use of comparative analysis as MoC provides an analytical certification path for new aeroplane models and derivatives by allowing the applicant to substantiate that a new or derivative model will have at least the same level of safety in all supercooled liquid water icing conditions that previous models have achieved.

For derivative models, the applicable certification specifications are determined through application of the CPR. Rather than demonstrating compliance with the certification specifications in effect at the date of application, an applicant may demonstrate compliance with an earlier amendment of the certification specifications when meeting one of the conditions provided in paragraph 21.A.101(b). After application of the CPR, if the derivative model must comply with an amendment that includes the SLD-related requirements of the certification specifications, compliance by comparative analysis may be used.

To use a comparative analysis as a MoC for a new or derivative aeroplane model, four main elements should be established:

1. A reference fleet with an adequately safe history in icing conditions;
2. Accepted analysis of aeroplane features and/or margins that are deemed to contribute to the safe reference fleet history;
3. Comparison showing that the new or derivative aeroplane model shares the comparable design features and/or margins with the reference fleet; and
4. Compliance of the new or derivative aeroplane model with the applicable CS-25 certification specifications relative to flight in the icing conditions defined by Appendix C.

The AMC material will provide guidance for showing compliance by using comparative analysis. It includes specific discussion of:

— ice protection systems;

— unprotected components;

— ice or icing conditions detection;

— ice accretion and ice shedding sources;

— aeroplane performance and handling characteristics;

— aeroplane flight manual information; and

— additional considerations — augmenting comparative analysis.

To ensure consistency, proposed changes to Book 1 and Book 2 to CS-25 are included in this NPA.

2.4.2.1 Definition of 'adequately safe fleet history'

2.4.2.1.1 Objective

The objective is to define the number of flights that the reference fleet must have accumulated without any accidents or serious incidents whilst operating in the supercooled liquid water icing conditions represented in CS-25 Appendix C and Appendix O, to allow the reference fleet history to be used in a demonstration of compliance with the SLD specifications by comparative analysis.

Most aircraft accidents associated with SLD icing are caused by a chain of events in which the aircraft design is only one factor. When considering fleet history, these accidents have also typically resulted from crew reaction and response during times of high workload. Additionally, when reviewing the service history of the aircraft that have had accidents or serious incidents with SLD icing conditions listed as a contributing factor, it was noted that all of the models had precursor events in icing conditions which were not described as SLD.

2.4.2.1.2 Methodology

Safe in-service experience is defined in terms of flights accrued by a fleet without an accident or serious incident while operating in supercooled liquid water icing conditions aloft. Based upon the following definitions, a fleet that has accrued the defined number of flights will have encountered sufficient SLD icing conditions to provide a high level of confidence that the aircraft can operate safely in SLD conditions.

To determine the number of flights required to provide this level of confidence, two approaches are used. A check is also made by computing the number of SLD encounters a fleet would have accrued after the defined number of flights. The process therefore consists of the following three steps:

1. Computation of the number of flights required based on the probability of a heavy SLD icing encounter;
2. Review of the in-service record of aircraft that have experienced serious in-service incidents or accidents to determine the number of flights accrued by the fleets prior to serious icing incidents and accidents; and
3. Final Check: determination of the number of SLD exposures a fleet would have encountered, on average, after accruing the specified number of flights.

The second step was used as a 'common-sense' check. This was considered necessary to compensate for any uncertainty in the probability of SLD icing conditions and to validate that the number of flights selected would have addressed those models. Whilst the first step could be determined either in terms of the number of flights or flight hours, using the number of flights is a better means of comparing various types and sizes of aircraft which fly different route lengths and spend different proportions of their flight times at altitudes where CS-25 Appendix O icing conditions are encountered. The database of in-service events was originally calculated in terms of flight hours. It was then converted to an equivalent number of flights by dividing by the average flight times of the aircraft. The objective therefore was to check that the required number of flights determined by the two different approaches were of a similar order of magnitude.

The third step was used to add another check of consistency by determining the number of SLD exposures within the number of flights required to establish the safe fleet history.

2.4.2.1.3 Computation of adequate number of flights based on probability

2.4.2.1.3.1 Introduction

This paragraph describes how the required number of flights was determined based on the probability of a heavy SLD icing encounter (P(Heavy SLD encounter)). It is first necessary to define an appropriately conservative icing scenario and the associated probability.

It was considered that the scenario must include the severity of the SLD conditions in order to ensure that a fleet of aircraft had encountered sufficiently conservative exposure. To ensure this, the probability computations are based on heavy SLD icing conditions which reduces the probability of the scenario; this is conservative because it increases the number of flights that the reference fleet must have accumulated. Therefore, it was necessary to determine the probability of encountering icing in flight (P(Icing encounter)), the probability of encountering SLD icing conditions while encountering in-flight icing conditions (P(SLD encounter | Icing encounter)) and finally the probability of encountering heavy SLD icing conditions while encountering SLD icing conditions (P(Heavy SLD encounter | SLD icing encounter)).

The overall probability of the scenario can be computed as follows:

P(Heavy SLD encounter) = P(Icing encounter) x P(SLD encounter | Icing encounter) x P(Heavy SLD encounter | SLD icing encounter)

And the required number of flights is:

Required Fleet Number of Flights = 1/P(Heavy SLD encounter)

2.4.2.1.3.2 Probability of SLD icing conditions

Based on the service history of the aeroplane manufacturers represented in the rulemaking group RMT.0572, the probability of encountering supercooled liquid water on any given flight is estimated to be between 5 % and 10 %, with 6% to 7 % per flight being more typical. This is based on manufacturers' test data and airline in-service reports of icing conditions. The required fleet exposure time is inversely proportional to this probability and therefore a lower probability will lead to a longer required fleet exposure. A conservative value of 5 % per flight was therefore used.

Next, the probability of encountering SLD icing conditions aloft at altitudes up to 22,000 feet, whilst in icing conditions, was derived from the FAA report on the development of an SLD engineering standard to be used for certification [which became Appendix O to CS-25], DOT/FAA/AR-09/10[6].

The report states in section 4.2 that ‚determining the actual occurrence of SLD in the atmosphere is difficult using the data sets available. It is recognized that there are large geographical differences and changes with season. However, to a first approximation, the probability of occurrence of SLD for any particular location in North America, representing the altitude ranges between 0 and 15,000 ft (5km), which aircraft normally encounter upon takeoff and landing, is typically 0.5% to 5% over a winter season for a large portion of the continent.‚

According to page 25 of the referenced report, the ratio of SLD icing to normal icing conditions for the research encounters was 17 percent (P of 0.17)[7]. This ratio being based on numbers of 30-second data points, additional ratio calculations were performed in order to check how the ratio changes as a function of the duration of the averaging interval. The following table provides the result:

Averaging interval	30-second	60-second	120-second	300-second
SLD encounters	2444	1432	850	460
Supercooled liquid water icing encounters	14199	7629	4162	1904
Ratio	0.17	0.19	0.20	0.24

This shows that the ratio increases slightly when the averaging interval increases. It is also concluded that a ratio of 0.17 can be retained in our calculation, because it is the most conservative one.

The report also states, however, that because the intent of the testing conducted to gather that data was to fly in SLD conditions, the ratio of SLD icing to non-SLD icing found during the research flight

6 http://www.tc.faa.gov/its/worldpac/techrpt/ar0910.pdf

7 0.17 = (2,444 observations (30-second data points) with an average static temperature ≤0 °C, an average LWC >0.005 g m^{-3}, an ice crystal concentration <1 L^{-1}, an assessment of either liquid or mixed-phase, and drops >100 µm in diameter)/(14,199 observations (30-second data points) (29 % of in-flight) where supercooled liquid water was assessed to exist)

tests was higher than would be for commercial flights. Therefore, a conservative ratio of 0.017 was used for this analysis.

Hence, P(Icing encounter) = 0.05 per flight

and, P(SLD encounter | Icing encounter) = 0.017

2.4.2.1.3.3 Probability of heavy SLD icing conditions

The final term in the SLD scenario probability equation is the probability of encountering heavy SLD conditions while encountering SLD icing conditions. Based on the data contained in FAA report DOT/FAA/AR-09/10, 99 and 99.9 percent percentile data for LWC were presented based upon the SLD research flight data. For the 99.9 percent LWC analysis, there were no SLD observations that exceeded the upper confidence limits of Appendix O. Therefore, to provide an additional element of conservatism for the calculation of number of flights required, a probability of exceeding the SLD conditions represented by Appendix O was defined as 0.001.

Hence, P(Heavy SLD encounter | SLD icing encounter) = 0.001

2.4.2.1.3.4 Explanations relative to the choice of criteria associated with a number of flights

Because aeroplanes of different size and design fly different missions, the amount of time during a typical flight that the aeroplane is within icing altitude limits, particularly for SLD icing conditions, cannot be compared directly. Therefore, it is more appropriate to compare only the number of flights, since almost all flights by all aeroplane types spend an hour or less for the take-off, climb, descent, approach and landing phases, within the altitude envelope of SLD icing conditions. This eliminates consideration of flight hours in cruise, for example, that were completely clear of any icing conditions.

Hence, the resulting fleet history associated with P(Heavy SLD encounter) will be defined in terms of total flights by the reference aeroplane fleet.

2.4.2.1.3.5 Overall probability of the defined SLD icing scenario

The overall probability of the defined SLD icing scenario is obtained by multiplying the individual probabilities:

P(Heavy SLD encounter) = P(Icing encounter) x P(SLD encounter | Icing encounter) x P(Heavy SLD encounter | SLD icing encounter)

P(Heavy SLD encounter) = 0.05 per flight x 0.017 x 0.001 = 8.5×10^{-7} per flight.

The number of flights required to demonstrate a safe fleet service history is determined by taking the inverse of the probability of the SLD icing scenario.

Required Fleet Number of Flights = 1/ P(Heavy SLD encounter)

= $1 / 8.5 \times 10^{-7}$

= 1,200,000 flights

Based on this method, a fleet history of 1.2 million flights would be required. To validate the order of magnitude and the method, this value was checked against the service history of aircraft which have experienced accidents or serious incidents with SLD listed as a contributing factor.

2.4.2.1.4 Review of in-service experience

To provide a common-sense check of the probability computations, the RMT.0572 Rulemaking Group reviewed the accident and incident history of aircraft that have experienced events in SLD conditions. To identify aircraft that have experienced such events, all of the supercooled liquid water icing incidents and accidents recorded in the National Transportation Safety Board (NTSB), Australian Transport Safety Bureau (ATSB), Transport Canada (Civil Aviation Daily Occurrence Report System (CADORS)), FAA (Accident/Incident Data Systems (AIDS)), and NASA accident and incident databases were reviewed. The Ice Protection Harmonization Working Group (IPHWG) Task 2 Working Group Report[8] was also taken into account as it includes a compilation of relevant icing incidents and accidents between 1940 and 2002.

From this review, the following transport category regional turbo-propeller aircraft were identified as having experienced serious incidents and/or accidents due to SLD conditions:

— ATR 42/72; and

— Embraer EMB-120 Brasilia.

The review of these databases also showed that other aeroplane types experienced icing-related events. Cessna 560 aircraft suffered accidents while operating in icing conditions in 1995 and 2005, and a Saab 340 experienced an in-flight icing incident in 2006. In these cases, however, there was no consensus on whether SLD icing conditions were a cause of the events. Therefore, those aeroplane types are not shown in tables 1 and 2 below. Nevertheless, a check of the in-service history of the Cessna 560 and Saab 340 aircraft was performed to ensure that the selected threshold would cover those aircraft types. The flight hours that these aircraft fleets had accrued prior to a supercooled liquid water icing accident or incident (not limited to SLD) were determined, converted to an equivalent number of flights, and compared to the proposed acceptable fleet history to determine whether the accidents and/or serious incidents occurred before the fleet achieved the threshold computed by the probability method.

Table 1: Summary of fleets' in-service history in terms of Flight Hours (FH)

Aircraft Fleet	FH before Icing Serious Incident	FH before Icing Accident	FH before suspected SLD-related Accident/Incident
ATR 42/72	N/A	150,000	3,900,000
EMB-120	450,000	2,500,000	2,500,000

Note 1: ATR 42 Lake Como, Italy, non-SLD icing accident, 1987
Note 2: Pine Bluff, Arkansas, SLD accident, 1993 (pilot error identified as main cause)

The results of the database search, shown in Table 1, indicate that the accidents and serious icing incidents experienced by the ATR42/72 and the EMB-120 occurred prior to each fleet accruing 2.5 million flying hours; yet, the first icing-related incidents occurred within 0.5 million flight hours. Suspected SLD events occurred after 2.5 million and 3.9 million flying hours. To convert from flight

8 Report available on www.regulations.gov, in the docket FAA-2010-0636

hours to the number of flights, the flight hours accumulated prior to the incidents or accidents were divided by the average flight time for each aeroplane type. An analysis of the in-service data showed that the average flight time for the EMB-120 aircraft is 50 minutes. Other turboprops of this type and size range also have an average flight time of approximately 50 minutes. The ATR average flight time is assumed to be of a similar order of magnitude. Using this average flight time yields the data in Table 2.

Table 2: Summary of fleets' in-service histories in terms of number of flights

Aircraft Fleet	Flights before Icing Serious Incident	Flights before Icing Accident	Flights before suspected SLD-related Accident/Incident
ATR 42/72	N/A	180,000	4,680,000
EMB-120	540,000	3,000,000	3,000,000

Table2 shows that the first recorded icing incident occurred for the EMB-120 after 540 000 flights. The first icing accident for the ATR occurred after 180 000 flights with the first SLD related accident or incident at nearly 4.7 million flights.

Using the in-service history of these aircraft indicates that 600 000 flights would be sufficient to reveal any aeroplane, system, or procedural deficiencies that would occur due to icing conditions, even those less severe than SLD. Comparing this value against the number of flights determined using the probability method validates that using 1.2 million flights as the fleet history requirement captures the models listed in table 2.

2.4.2.1.5 Conclusions

For aircraft types known to have experienced problems in SLD icing conditions, the data of paragraph 2.4.2.1.4 indicates that serious in-service incidents in supercooled liquid icing conditions have occurred after those aircraft fleets had accumulated 540 000 flights. It is appropriate to consider the first icing incidents as noted in paragraph 2.4.2.1.1 since the fleet history requirement states that the fleet must not have experienced any accidents or serious incidents in any supercooled liquid water icing conditions aloft. These incidents would have preceded any of the SLD-related events which occurred later in the service history.

While the probability analyses presented in this document are considered to be conservative and are validated through a common-sense check against aeroplane models with known SLD incidents, <u>a fleet history criterion of two million flights is recommended</u>. This recommendation adds conservatism to account for the uncertainty in the statistics. In addition, this value also captures the events of the other aircraft models (Cessna 560 and Saab 340) which are not listed in Tables 1 and 2 but have been considered in other reports. For these aircraft, events have occurred after up to an estimated 1.7 million flights (case of the Saab 340).

Finally, the following calculation illustrates how many SLD encounters can be expected from the reference fleet after two million flights:

2,000,000 x 0.05 x 0.017 = 1,700 SLD encounters.

This number of SLD encounters is considered consistent and confirms the robustness of the retained criterion for the fleet history ensuring sufficient exposure to SLD icing conditions.

2.4.2.2 Compliance with CS-25 Certification Specifications relative to flight in the icing conditions defined by Appendix C

The new or derivative aeroplane model should comply with the CS-25 certification specifications relative to the Appendix C icing conditions. Comparative analysis is an acceptable MoC only for the CS-25 certification specifications relative to the Appendix O icing conditions.

2.4.2.3 Analysis of aeroplane design features or margins that are deemed to contribute to the safe fleet history

Upon establishment of the reference fleet that has demonstrated safe operation in all supercooled liquid water icing conditions aloft, a collection of design features and/or margins, deemed to contribute to that history, can be identified. Demonstrating that the new or derivative aeroplane model maintains comparable design features and/or margins, along with flight-in icing compliance using the icing conditions defined in CS-25 Appendix C, will provide confidence that the new or derivative aeroplane model is safe in all supercooled liquid water icing conditions. These include the SLD icing conditions represented in Appendix O.

The key parameters which will be used to show compliance via comparative analysis will have to be identified, and agreed to with the Agency. Examples are included in Appendix 2 to this NPA in order to help clarify the identification and use of key parameters in comparative analysis.

The current CS-25 specifications envisage conventional aeroplane designs. Electronic Flight Control Systems (EFCS) with design features like flight envelope protection functions are not fully addressed by the current CS-25 certification specifications. Nevertheless, aeroplane types with such features have been certified for many years using Special Conditions.

Therefore, the reference fleet for comparative analysis may include aeroplanes that feature EFCS or other design features that are not fully addressed by the current CS-25. However, these design features may contribute to the safe fleet history and therefore they should be eligible to be included in the comparative analysis.

The material described in paragraph (e)5.7 (Aeroplane Performance and Handling Characteristics) of the proposed amendment to AMC 25.1420 is intended to be used for conventional aeroplane designs envisaged in the existing CS-25 text and also for aeroplane designs with EFCS that provide flight envelope protection functions.

2.4.2.4 Additional considerations — Augmenting comparative analysis

At the time of this rulemaking task, the SLD tools required to design and certify new or derivative aeroplane model are not adequately mature. For example, little data and few analysis and test tools are available for use in predicting the ice accretions associated with flight in all SLD icing conditions as represented in Appendix O. However, various organisations are working towards generating more information on SLD ice accretions and improving the associated tools. In the future, this additional information can be expected to lead to improved knowledge leading to alternative types of analyses.

The comparative analysis may be used in combination with new methodologies (test or analysis) at the applicant's discretion in order to establish a comparison between the new or derivative model and the reference fleet. The use of any new methodologies should be agreed by the Agency. The applicant may then substantiate that the new or derivative model has comparable key parameters using the new methodologies.

2.4.3 Proposed amendments to CS-25 Book 1 and Book 2

BOOK 1:

CS 25.21 Proof of compliance

It is proposed to amend CS 25.21(g)(2) and (g)(3) by adding a statement at the end of these two subparagraphs, such that if applicable, a comparative analysis may be used to show compliance as an alternative to using the ice accretions defined in part II of Appendix O.

CS 25.1420 Supercooled large drop icing conditions:

It is proposed to create a new subparagraph (d) which provides for the possibility to use a comparative analysis as a means of compliance, as an alternative to what is required in subparagraphs (b) and (c).

BOOK 2:

AMC 25.21(g) Performance and Handling Characteristics in Icing Conditions

References to the comparative analysis (provided in AMC 25.1420(f)) as a potential means of compliance have been added in several paragraphs of the AMC.

When comparative analysis is used, the AFM information may be based on the reference fleet AFM(s) or operating manual(s) content.

AMC 25.629 Aeroelastic stability requirements

At the end of the subparagraph dealing with ice accumulation, a reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created.

AMC 25.773(b)(1)(ii) Pilot compartment view in icing conditions

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created.

AMC 25.773(b)(4) Pilot compartment non-openable windows

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created in paragraph 1. Ice and heavy rain.

AMC 25.929(a) Propeller De-icing

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created in paragraph 1. Analysis.

AMC 25.1093(b) Powerplant Icing

References to the comparative analysis of AMC 25.1420(f) as a potential means of compliance are created in paragraphs (a) Compliance with CS 25.1093(b)(1) and (b) Compliance with CS 25.1093(b)(2).

AMC 25.1324 Flight instrument external probes

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created in paragraph 11. Supercooled Large Drop Liquid Conditions.

AMC No 1 to CS 25.1329 Flight Guidance System

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created in paragraph 10.1. Normal Performance (bullet 'Icing').

AMC 25.1403 Wing icing detection lights

A reference to the comparative analysis of AMC 25.1420(f) as a potential means of compliance is created at the end of the introductory paragraph.

AMC 25.1420 Supercooled large drop icing conditions

A new subparagraph (f) Comparative analysis, is created to introduce this alternative means of compliance. Different elements must be established in order to be able to use this means of compliance, i.e. a reference fleet with adequately safe history in icing conditions, an analysis of aeroplane features and/or margins contributing to the reference fleet safe history, an analysis showing comparable design features and/or margins between the new or derivative aeroplane model and the reference fleet, and the compliance of the new or derivative aeroplane with certification specifications relative to Appendix C icing conditions.

Additionally, the reference to a comparative analysis is added at various parts of the text in AMC 25.1420.

5. Appendix 2: Application of the comparative analysis — Examples

The following examples are provided to illustrate the application of comparative analysis and its limits. The examples are provided for guidance only. They do not constitute the only method for utilising comparative analysis and they do not define specific requirements that must be applied by all applicants. The specific application of comparative analysis will differ among applicants as it will depend upon the design and certification approaches the applicants have applied to the reference fleet. The illustrations below are not intended to be exhaustive or prescriptive.

The examples illustrate that geometry or configuration similarities are not the only focus for understanding the application of comparative analysis. When using comparative analysis, the physics and aeroplane design characteristics which govern the margins associated with the identified key parameters are a primary consideration. Aeroplane systems or configurations may not always be equivalent. Nevertheless, the effects of configuration similarities or differences are evaluated to compare aerodynamic and/or other aeroplane margins that affect the overall aeroplane safety, which in turn is directly related to the safe in-service history of flight in icing conditions.

Example 1: Wing ice protection system change

(a) Reference fleet ice protection system: anti-icing system

(b) New product ice protection system: de-icing system

The safe in-service experience of the reference fleet is associated with models that have a wing anti-icing system whose features, efficiency and margins are well known by the applicant.

The reference fleet design results in no ice accretion on the wing leading edges (or if any, some runback ice) during normal operation. Changing from an anti-icing system to a de-icing system will result in intercycle ice accretions on the wing leading edges.

How comparative analysis could be applied?

The applicant has already shown that the existing chordwise extent of wing ice protection is adequate to provide the required safety level in Appendix C icing conditions for anti-icing systems. The safe in-service record shows that these protection limits are also adequate in SLD icing conditions. If the de-icing system on the new model is such that there is no appreciable difference in runback ice (e.g. electro-mechanical), it is reasonable to expect that the applicant can also conservatively predict the effects of intercycle ice and compensate accordingly. The behaviour of the aeroplane with intercycle ice shapes must be demonstrated to meet the certification requirements with the icing conditions of Appendix C.

If the de-icing system on the new model produces runback ice, an analysis comparing the runback ice of the new de-icing system to that of the reference fleet with the anti-icing system in Appendix C on icing conditions would be required to show that the system performance and resulting impacts are predictable. This may require specific identified compensating features, like redistributed or additional heat, to be identified. The amount of runback ice produced in Appendix C icing conditions by the de-icing system when compared to reference fleet ice shapes/ice data should be analysed. If there are significant differences in the amount of runback ice produced in Appendix C icing conditions by the de-icing system when compared to reference fleet ice shapes/ice data, then an analysis must show that the effects can be accurately or conservatively addressed in SLD. If this cannot be shown, then comparative analysis may not be applicable.

While a de-icing system will result in ice accretion on the protected parts of the wing, comparative analysis could be applied if similar margins are provided through the application of compensating factors as described below. If the applicant decides not to restore similar margins to those of the reference fleet, then comparative analysis will not be applicable.

<u>Key parameters</u>

Manoeuvrability, performance and stall

Intercycle ice on the new aeroplane with the same spanwise ice protection coverage as that of the reference fleet would result in increased lift loss and drag. The applicant should implement compensating features to maintain similar ice effects as those of the reference fleet relative to the overall lift and drag. Compensating features could include but are not limited to:

— increased spanwise extent of protection to address both lift and drag;

— increased wing area to address lift;

— increased aircraft operating speeds to address lift and drag;

— increased slat chords and/or deflection to address lift; and

— increased thrust to address drag and potentially aid manoeuvring capability.

<u>Controllability</u>

Intercycle ice may impact on the controllability of the aeroplane. In order to maintain lateral controllability margins the following compensating features could be applied:

— Increased aileron size;

— Increased spoiler size and/or deflection;

— Addition of an aileron tab or flaperon; and

— If the reference fleet has powered flight controls, then the derivative or new aeroplane would be expected to also have powered flight controls.

The list of above factors is not exhaustive and other compensatory factors could be proposed by the applicant.

<u>Other considerations</u>

Ice shedding

For aeroplanes with aft mounted engines: a demonstration should be performed in the icing conditions of CS-25 Appendix C to show that shedding of intercycle ice from the inboard part of the wing that could enter the engine is addressed.

Aeroelastic analysis

The mass of ice accreted should be computed in Appendix C icing conditions using methods equivalent to those applied to the reference fleet as required.

Example 2: Ice detector technology change

(a) Reference fleet ice detection system: magnetostrictive probe-type ice detector design

(b) New product ice detection system: optical ice detection technology, unrestricted operation in Appendix O

The key parameter in this example is the capability of the ice detection system to detect the icing conditions in which the aeroplane is operating, i.e. Appendix C and/or Appendix O. Other related design parameters which affect ice detection capability are the locations on the aeroplane where ice detectors are installed, and flight deck indications and procedures used by the pilots to react or reconfigure the aeroplane during icing conditions.

The new optical system must be qualified to work in Appendix C icing conditions. If the new optical system is installed in a location determined using the same methodologies to the magnetostrictive probe installations on the reference fleet, or the sensing area is the same, then it can be assumed, by comparative analysis, that the optical probe will be subjected to the same icing conditions exposure as the reference fleet. Since, by definition, Appendix O contains droplet sizes included in Appendix C, the new aeroplane model will have similar ice detection capability as the reference fleet.

Example 3: Change from an ice protected to unprotected horizontal tail plane

(a) Reference fleet: ice protection system on the horizontal tail plane

(b) New product: no ice protection system on the horizontal tail plane

The safe in-service experience of the reference fleet is associated with models that have anti-icing system protection for the horizontal tail plane leading edge.

Changing from a protected to an unprotected horizontal tail plane results in the new model having ice accretions on the horizontal tail plane leading edges while the reference fleet was certified with no ice accretions. Through establishment of the reference fleet, the applicant has already shown that the existing chordwise extent of tail leading edge ice protection is adequate to provide the required safety level in Appendix C icing conditions for anti-icing systems. The safe in-service record shows that these protection limits are also adequate in SLD icing conditions. This implies that the ice protection limits on the tail planes of the reference fleet were adequately determined. Comparative analysis can be used to establish the validity of the methodologies used on the reference fleet to determine the impingement limits and ice shape footprint range and may be used on the new model for similar analysis based on Appendix C icing conditions.

While the ice extent may be understood, the ice shape details in SLD may not be. This may present some challenges for applying comparative analysis without being augmented with other analysis.

In this case, the applicant would have to be able to show that the assumed ice shape for analysing the aerodynamic impact on the tail plane can be conservatively accounted for. Since the impingement limits, and essentially the ice shape footprint range, are known through comparative analysis, other engineering analysis can potentially be used to show that the margins of the new aeroplane are comparable to the reference fleet. This essentially amounts to utilising some of the provisions of 'Additional considerations — Augmenting comparative analysis'. For example, knowing the ice footprint range, a conservative shape may be used to estimate the aerodynamic impact as long as the

Agency agrees with the shape and manner in which the aerodynamic impacts are being assessed. Once the aerodynamic impacts are determined, comparative analysis may be used to show that margins similar to the reference fleet have been restored.

If other methods or conservative assumptions cannot be argued as compensating features, comparative analysis likely cannot be applied.

If the methods for determining the impacts of the ice on the aerodynamic performance of the horizontal tail plane are agreed with the Agency, then some of the features that may be used to augment comparative analysis by showing that the new model has similar or improved longitudinal trim and manoeuvrability margins relative to those of the reference fleet are:

— increased horizontal tail plane area;

— increased horizontal tail plane chord;

— modification of the tail plane configuration/profile to reduce sensitivity to ice accretion;

— increased tail arm;

— addition of canards;

— adjusted centre of gravity range;

— resized elevator;

— adjusted elevator deflections; and

— decreased pitch moment due to thrust line.

Example 4: Reduction of chordwise extent of ice protection for the wing, horizontal or vertical tail plane without any other changes to the aeroplane

In this case, the margins between impingement limits and protection limits are changed without any compensating features being added to the aeroplane. Therefore, similar margins in Appendix C icing conditions relative to the reference fleet could not be shown. Consequently, comparative analysis could not be used as means of compliance in this case.