Certification Memorandum

Determination of an Unsafe Condition for Risk of Rotorcraft Engine In-Flight Shut-Down (IFSD) and Power Loss

EASA CM No.: CM–PIFS-011 Issue 01 issued 30 November 2016

Regulatory requirement(s): **Article 21.A.3A and 21.A.3B of Annex I Part 21 to Commission Regulation (EU) No 748/2012, amended by Commission Regulations (EU) 7/2013 and 69/2014**

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Log of issues

Issue	Issue date	Change description
001	30.11.2016	First issue.

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1. Introduction

1.1. Purpose and scope

This Certification Memorandum describes the methodology to be applied, as part of the Continued Airworthiness (CAW) of the design of engines and rotorcraft, in the process of determination of an unsafe condition related to the risk of engine In-Flight Shut-Down (IFSD) and power loss, for both single and multi-engine rotorcraft.

This Certification Memorandum clarifies the process that the Type Certificate (TC) holders should follow when applying the guidance of AMC and GM 21.A.3B(b) in the determination of an unsafe condition, and also how EASA will use that AMC and GM along with TC holder data to determine the unsafe condition and decide on the issuance of Airworthiness Directives (ADs) for these particular installations.

When referring to helicopter operations, this Certification Memorandum mainly quotes Commercial Air Transport (CAT). However non-commercial helicopter operations should also be taken into consideration by the TC holders, and evaluated with EASA where applicable.

Note: This Certification Memorandum does not directly address the operational contributors to rotorcraft safety. It accounts for operational aspects when determining an unsafe condition related to the risk of IFSD and power loss due to engine or rotorcraft defects.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
-	'Category' (for rotorcraft)	CS-Definitions	Amdt 2	23/12/2010
CS-E 50	Engine Control System	CS-E	Amdt 3	23/12/2010
AMC E 50	Engine Control System	CS-E	Amdt 3	23/12/2010
CS-E 510 (a) and (g)	Safety Analysis	CS-E	Amdt 3	23/12/2010
AMC E 510 (f)	Safety Analysis	CS-E	Amdt 3	23/12/2010
AMC 20-3A	Certification of Engines Equipped with Electronic Engine Control Systems	AMC-20	---	12/09/2013
CS 27.901	Installation	CS-27	Amdt 3	11/12/2012
CS 27.1309	Equipment, systems, and installations	CS-27	Amdt 3	11/12/2012
AC 27.1309	Equipment, systems, and installations	FAA AC 27-1B	Change 4	01/05/2014
CS 29.901	Installation	CS-29	Amdt 3	11/12/2012
CS 29.1309	Equipment, systems, and installations	CS-29	Amdt 3	11/12/2012
AC 29.1309	Equipment, systems, and installations	FAA AC 29-2C	Change 4	01/05/2014
Part 21.A.3A	Failures, malfunctions and defects	Reg (EU) 748/2012[1]	---	08/01/2013

[1] Last amended by Regulation (EU) No 69/2014, dated 27/01/2014

Reference	Title	Code	Issue	Date
CAT.POL.H.225	Operations to/from a Public Interest Site	Reg (EU) 965/2012[2]	---	05/10/2012
CAT.POL.H.305	Operations without an assured safe forced landing capability	Reg (EU) 965/2012[2]	---	05/10/2012
AMC & GM to CAT.POL.H.305	Helicopter operations without an assured safe forced landing capability	ED Decision 2014/015/R[3]	Initial Issue	25/10/2012
CAT.POL.H.420	Helicopter operations over a hostile environment located outside a congested area	Reg (EU) 965/2012[2]	Initial Issue	25/10/2012
AMC & GM to CAT.POL.H.420	Helicopter operations over a hostile environment located outside a congested area	ED Decision 2014/015/R[3]	Initial Issue	25/10/2012
Part 21.A.3A	Failures, malfunctions and defects	Reg (EU) 748/2012	---	08/01/2013
Part 21.A.3B	Airworthiness Directives	Reg (EU) 748/2012	---	08/01/2013
AMC & GM 21.A.3B (b)	Determination of an unsafe condition	ED Decision 2012/020/R[4]	---	30/10/2012
GM 21.A.3B (d)(4)	Defect correction – Sufficiency of proposed corrective action	ED Decision 2012/020/R[4]	---	30/10/2012

1.3. Abbreviations

AD	Airworthiness Directive
AMC	Acceptable Means of Compliance
CAW	Continued Airworthiness
CM	Certification Memorandum
CS	Certification Specification
EASA	European Aviation Safety Agency
EECS	Electronic Engine Control Systems
FH	Flight Hours
GM	Guidance Material
IFSD	In-Flight Shut-Down

[2] Last amended by Regulation (EU) No 2016/1199
[3] Last amended by ED Decision 2014/029/R
[4] Last amended by ED Decision 2014/007/R

LOTC/LOPC	Loss Off Thrust Control / Loss Off Power Control
PC	Performance Class
SIB	Safety Information Bulletin
TC	Type Certificate

2. Background

The risk to rotorcraft safety, following an engine IFSD or power loss, is currently managed through a combination of good design, manufacturing, and maintenance practices and through operational precautions that provide for continued safe flight or a safe landing.

However despite these precautions there remains a residual risk, as engine IFSD and power losses continue to occur on both single- and multi-engine rotorcraft. These incidents, when combined with unfavourable operational conditions, do sometimes result in emergency landings and, in the worst cases, accidents.

2.1. Provisions in Certification Specifications (CS) related to Engine IFSD and Power Loss

Table 1 provides relevant extracts of the Certification Specifications for Engines (CS-E) and of the Certification Specifications for Small/Large Rotorcraft (CS-27/29) where engine IFSD and power losses are addressed or concerned:

Table 1 – Relevant Extracts of CS-E and CS-27/29

Engine Level – CS-E (*)	Rotorcraft Level – CS-27/29
CS-E SUBPART D – TURBINE ENGINES, DESIGN AND CONSTRUCTION CS-E 510 Safety Analysis: *(g) An Engine Failure in which the only consequence is **partial or complete loss of thrust or power** (and associated Engine services) from the Engine must be regarded as a **Minor Engine Effect**.* AMC E 510 Safety Analysis: *(3) Specific means.* *(f) It is generally recognised that **Engine Failures involving complete loss of thrust or power** from the affected Engine can be expected to occur in service, and that **the aircraft should be capable of controlled flight following such an event**. For the purpose of the Engine safety analysis and Engine certification, Engine Failure with no external effect other than loss of thrust and services may be regarded as **a Failure with a minor effect. This assumption may be revisited during aircraft***	CS-27/29 SUBPART E – POWERPLANT For definition of Category A and Category B rotorcraft, refer to CS-Definitions. CS 27/29.901 Installation: *(b) For each powerplant installation:* *(1) **Each component of the installation** must be constructed, arranged, and installed to ensure its **continued safe operation** between normal inspections or overhauls for the range of temperature and altitude for which approval is requested;* CS 29.901 Installation: *(c) For each powerplant and auxiliary power unit installation, it must be established that **no single failure or malfunction or probable combination of failures will jeopardise the safe operation of the rotorcraft** except that the failure of structural elements need not be considered if the probability of any such failure is extremely remote.*

certification**, where installation effects such as Engine redundancy may be fully taken into consideration. **This re-examination applies only to aircraft certification and is not intended to impact Engine certification**.* CS-E SUBPART A – GENERAL CS-E 50 Engine Control System: *(c) **Engine Control System Failures**. The Engine Control System must be designed and constructed so that:* *(1) **The rate for Loss of Thrust (or Power) Control (LOTC/LOPC) events, consistent with the safety objective associated with the intended aircraft application, can be achieved,**…"* *AMC 20-3A Certification of Engines Equipped with Electronic Engine Control Systems* *(7) Integrity of the **Engine Control System *(d) **Acceptable LOTC/LOPC rate*** *The applicant may propose an LOTC/LOPC rate other than those below. Such a proposal should be substantiated in relation to the criticality of the Engine and control system relative to the intended installation. The intent is to show equivalence of the LOTC/LOPC rate to existing systems in comparable installations.* *(i) For turbine Engines* *The **EECS** should not cause more than **one LOTC/LOPC event per 100 000 engine flight hours**."*	

Note (*): "Engine level" provisions include extracts of AMC 20-3A Certification of Engines Equipped with Electronic Engine Control Systems, which is referred in AMC E 50 Engine Control System.

Summary on the review of provisions in CS related to engine IFSD and power losses:

An engine IFSD or power loss is classified as Minor Engine Effect in CS-E 510. AMC E 510 confirms this classification, but requires revisiting this assumption during aircraft certification, while specifying that this re-examination is not intended to impact engine certification.

Within CS-E there are no requirements or guidance for prediction of occurrence rates of failures resulting in Minor Engine Effects. For comparison the guidance for failures resulting in Major Engine Effects is no more than 10^{-5} per FH. It is also to be noted that the guidance of AMC 20-3A for LOTC/LOPC events caused by the EECS happens to be 10^{-5} per FH as well.

Category B rotorcraft have no guaranteed capability to continue safe flight in the event of an engine failure, and unscheduled landing is assumed.

CS 27/29.901 (b)(1) requires that each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation. CS 29.901 (c) requires that no single failure or malfunction or probable combination of failures will jeopardise the safe operation of the rotorcraft. For information,

compliance with CS 27/29.901 is usually carried out with the use of techniques applied in accordance with the requirements of CS 27/29.1309 Equipment, systems and installations.

2.2. Accounting for Helicopter Operating Conditions

Following the provision of CS 27/29.901, a review of helicopter operating conditions has been performed within Commission Regulation (EU) 965/2012 related to air operations. In particular for operations defined in Annex I of this regulation as **'performance class 2'** (PC2) applicable to multi-engine helicopters, and **'performance class 3'** (PC3) applicable to single- or multi-engine helicopters, the failure of an engine during certain manoeuvres may not enable the helicopter to safely continue its flight.

Furthermore, a review of Annex IV [PART-CAT], Subpart C Aircraft Performance and Operating Limitations, Section 2 Helicopters, Chapters 2, 3 and 4, has identified the following specific operations where a safe forced landing capability is not assured during the take-off and landing phases in case of engine failure:

- **CAT.POL.H.225** Operations to/from a Public Interest Site
- **CAT.POL.H.305** Operations without an assured safe forced landing capability (#)
- **CAT.POL.H.420** Helicopter operations over a hostile environment located outside a congested area (##)

Note (#): during take-off and landing phases, as referenced in CAT.POL.H310/325 for PC2 operations and in CAT.POL.H.400/405/415 for PC3 operations

Note (##): where an en-route alleviation is provided for PC3 operations

These operations may be approved by the competent authorities under certain provisions. Those require the operator to conduct a risk assessment, which includes among other provisions of AMC1 CAT.POL.H.305(b) *(extract)*:

*(a) As part of the risk assessment prior to granting an approval under CAT.POL.H.305, the operator should provide appropriate **engine reliability statistics** available for the **helicopter type** and the **engine type**.*

*(b) Except in the case of new engines, such data should show sudden power loss from the set of in-flight shutdown (IFSD) events not exceeding **1 per 100 000 engine hours** in a 5 year moving window. However, a rate in excess of this value, but not exceeding **3 per 100 000 engine hours**, may be accepted by the competent authority after an assessment showing an **improving trend**.*

Summary of the review of helicopter operations:

The review has identified that for helicopter operating in 'performance class 2' and 'performance class 3', the failure of an engine during certain manoeuvres may not enable the helicopter to safely continue its flight. In certain specific operations under 'performance class 2' such as, but not limited to, CAT.POL.H.305 or CAT.POL.H.420, a safe forced landing capability is not assured in case of engine failure during the take-off or landing phases. To gain approval for these specific operations, the operator conducts a risk assessment which includes the provision of engine reliability statistics.

2.3. Requirements of Part 21 for Occurrences, Determination of an Unsafe Condition and Airworthiness Directives (ADs)

21.A.3A Failures, malfunctions and defects requires *(extract)*:

"(a) System for Collection, Investigation and Analysis of Data

*The holder of a type-certificate, restricted type-certificate, supplemental type-certificate, European Technical Standard Order (ETSO) authorisation, major repair design approval or any other relevant approval deemed to have been issued under this Regulation shall **have a system for collecting, investigating and analysing reports** of and information related to **failures, malfunctions, defects** or other occurrences which cause or*

*might cause **adverse effects on the continuing airworthiness of the product**, part or appliance covered by the type-certificate, restricted type-certificate, supplemental type-certificate, ETSO authorisation, major repair design approval or any other relevant approval deemed to have been issued under this Regulation. **Information about this system shall be made available to all known operators of the product**, part or appliance and, on request, to any person authorised under other associated implementing Regulations.*

(b) Reporting to the Agency

> *1. The holder of a type-certificate, restricted type-certificate, supplemental type-certificate, ETSO authorisation, major repair design approval or any other relevant approval deemed to have been issued under this Regulation shall **report to the Agency** any **failure, malfunction, defect** or other occurrence of which it is aware related to a product, part, or appliance covered by the type-certificate, restricted type-certificate, supplemental type-certificate, ETSO authorisation, major repair design approval or any other relevant approval deemed to have been issued under this Regulation, and **which has resulted in or may result in an unsafe condition**."*

21.A.3B Airworthiness directives requires *(extract)*:

*"(b) The Agency shall issue an **airworthiness directive** when:*

> *1. an **unsafe condition** has been determined by the Agency to exist in an aircraft, as a result of a deficiency in the aircraft, or an engine, propeller, part or appliance installed on this aircraft; and*
>
> *2. that condition is likely to exist or develop in other aircraft."*

GM 21.A.3B(b) Determination of an unsafe condition provides guidance for the determination of an unsafe condition, and in particular attempts to address engine installation *(extract)*:

> *"2.2 Engines*
>
> > *The **consequences and probabilities of engine failures** have to be assessed **at the aircraft level** in accordance with paragraph 2.1, and **also at the engine level** for those failures considered as Hazardous in **CS E-510**.*
> >
> > *The latter will be assumed to constitute unsafe conditions, unless it can be shown that the consequences at the aircraft level do not constitute an unsafe condition for a particular aircraft installation."*

Summary of the review of the requirements of Part 21 for Occurrences, Determination of an Unsafe Condition and Airworthiness Directives:

Part 21.A.3A requires the TC holder to have a system for collecting, investigating and analysing failures, malfunctions and defects, and reports those which has resulted in or may result in an unsafe condition.

GM 21.A.3B(b) requires an assessment of the consequences and probabilities of engine failures at aircraft level, in addition to those at engine level. However there is no detailed guidance on how to perform this assessment.

3. EASA Certification Policy

3.1. EASA Policy

In accordance with Part 21 requirements listed in paragraph 2.3 of this CM, and having regard to the provisions of CS and conditions listed in paragraphs 2.1 and 2.2 of this CM, the following EASA policy clarifies the relevant tasks and activities performed by:

- The TC holders of an engine installed, or intended to be installed, on single- or multi-engine rotorcraft
- The TC holder of a rotorcraft
- EASA

The following definitions apply to the content of this policy:

Engine IFSD and power loss

For engine IFSD or power loss, it is appropriate to use the definition of 'sudden in-service power loss' of AMC1 CAT.POL.H.305(b) Helicopter operations without an assured safe forced landing capability, paragraph (e)(3):

Sudden in-service power loss is an engine power loss:

(i) larger than 30 % of the take-off power;

(ii) occurring during operation; and

(iii) without the occurrence of an early intelligible warning to inform and give sufficient time for the pilot to take any appropriate action.

However IFSD and power losses not matching this definition, such as, but not limited to, IFSD commanded by the pilot (e.g. following a warning), should also be monitored and assessed.

'Defects' (or deficiencies):

They are referred to in Part 21, paragraphs 21.A.3A, 21.A.3B and GM 21.A.3B(d)(4). They encompass issues for which the TC holder has obligations for collecting, reporting, investigating and correcting. For the purpose of this policy, 'engine defects' or 'rotorcraft defects' refer to defects of part or system which belong respectively to the engine or rotorcraft type design. They typically include design issues, or production issues (such as manufacturing or assembly). Maintenance issues or errors would not normally be the responsibility of the TC holder, unless it has been found that maintenance instructions are unclear or not sufficient, and need to be corrected by the TC holder.

Rates:

- 'Global rates': They are the actual rates of IFSD and power loss across the whole fleet, or sub-fleets if appropriate.
  For the rotorcraft TC holder, rates of IFSD and power loss including all events, as well as events attributed to the rotorcraft, should be assessed.
  For the engine TC holder, rates of IFSD and power loss including events attributed to the engine should be assessed.

- 'Individual rates': They are the rates or probabilities of IFSD and power loss caused by an identified engine or rotorcraft defect(s). These may be actual rates of occurrences, or estimated probabilities based on the assessment of the issue and further analysis, or a combination thereof.
  The following aspects should be taken into account in the calculation of the individual rates:
  - The fleet that is affected by the defect(s) may be limited to a subset of the fleet.
  - The probability of failure may be higher during certain phase(s) of flight (e.g. take-off, hovering, landing…).

- 'Watch rates': They are rates of IFSD and power loss where focussed attention is typically brought when reached or exceeded. They are indicative and set for monitoring purpose, and are not to be considered as recommended rate limits.

Typically rates per engine/rotorcraft Flight Hour (FH) are used. The definition of how FH are counted should be provided.

It is recognised that for small fleets, (e.g. at the early stages of entry into service) the limited number of engine and rotorcraft flight hours may result in less representative IFSD rates. This should be taken into account in the risk assessment.

Table 2 lists the tasks of both engine and rotorcraft TC holders, which should be shared with EASA. Engine and rotorcraft TC holders should regularly share and agree on their respective data.

When joint reviews are specifically recommended, a **[J]** is added to the task.

Table 2 – Tasks of Engine TC Holder and Rotorcraft TC Holder, to be shared with EASA (@)
1. Collect engine IFSD and power loss data (@@)
2. Monitor engine IFSD and power loss data trends (@@)
3. Identify engine or rotorcraft 'Defect(s)' that have caused or contributed to engine IFSD or power losses
4. Conduct joint (engine/rotorcraft) reviews of above data, and agree on the allocation of events to either the engine or the rotorcraft type design for further analysis **[J]**
5. Perform a risk assessment consisting of :
a) Assessing the rates of engine IFSD or power loss for the in-service fleet(s), which should include : ▪ Actual 'Global rates'; yearly and 5-year rolling average rates. ▪ 'Individual rates'.
b) Evaluating the potential consequences of the engine IFSD and power losses at rotorcraft level. For this the following may be used : ▪ Safety assessment of the rotorcraft/engine combination, including actual flight profiles. ▪ Return of service experience from operational or maintenance networks, such as, but not limited to, when they are aware of operations where a safe forced landing capability is not assured in case of engine failure. **[J]**
c) Proposing rate limits above which a potential unsafe condition may exist : The proposed rate limits should depend on the potential consequences of the engine IFSD and power losses at rotorcraft level, for - single event, and - multiple event on more than one engine of the same rotorcraft (common cause) Watch rates may be set below rate limits for monitoring purposes : see note (@@@)
6. Propose corrective actions to the respective engine and rotorcraft defect(s) which include the following steps :
a) Definition of the corrective actions which may be, as examples, in the form of inspections (one-time or repetitive), rework or repair, replacement, modification, testing or limitations.
b) Propose applicability and compliance time(s) associated with the defined corrective actions. ▪ The proposed applicability and compliance times should be commensurate with an appropriate combination of 'global' and 'individual' rates, and their consequences. They may apply to, depending on the criticality of consequences: - Engines installed on single- and/or multiple-engine rotorcraft, - Engines/rotorcraft operated under certain performance class as defined in Commission Regulation (EU) 965/2012 related to air operations. Figure 1 depicts, as an example, the trend of risk and compliance time typically considered when accounting for engine installation (single- or multi-) and certain known helicopter operations. ▪ If the affected fleet(s) include engine installed on both single- and multiple-engine rotorcraft, engines installed on single-engine rotorcraft should normally be corrected within a shorter compliance time, unless the consequences on the multiple-engine rotorcraft would justify otherwise. ▪ The method described in GM 21.A.3B(d)(4) Defect correction – Sufficiency of proposed corrective action may be used in performing these tasks.

7. Intervals for sharing data with EASA (@):	
	a) For 'Global rates' and trends, at regular intervals, normally not to exceed every 12 months, unless justified otherwise e.g. by the characteristics of the fleets.
	b) For 'Individual rates', as soon as the rate limits for potential unsafe conditions are reached, or show a trend indicating that these limits may be reached in the future, unless justified otherwise by the characteristics of the data.

Notes:

(@) The respective TC holder of the engine or the rotorcraft that is responsible for the defect should report relevant data to its assigned EASA oversight section.

(@@) It is recognised that TC holders may face difficulties in data collection; whilst making their best efforts, they should inform EASA of the assumptions and limitations associated with the collection of data.

(@@@) 'Watch rates' may be set below rate limits for monitoring purposes. They should depend on the characteristics of the fleets, but alternatively the following default values may be used:

- ⇨ 10^{-5} per FH for 'Global rates'
- ⇨ 10^{-6} per FH for 'Individual rates'

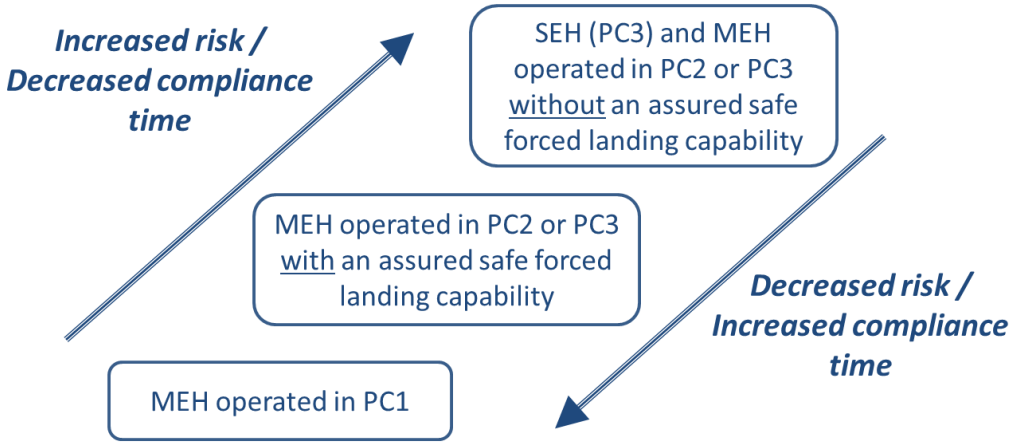

Figure 1

Example: Risk for CAT Operations (as defined in Reg (EU) 965/2012 Air Operations)

Note: SEH = Single-Engine Helicopter ; MEH = Multi-Engine Helicopter ; PC = Performance Class

EASA activities

In accordance with Part 21.A.3A(c)(2) and 21.A.3B, EASA reviews the data submitted by the engine and rotorcraft TC holders, including the assessment of potential unsafe condition, and determines if an unsafe condition exists in relation to the risks of engine IFSD or power loss.

If an unsafe condition has been determined, in accordance with Part 21.A.3B, EASA actions include:

- Approval of the corrective actions and of the applicable compliance times, following the proposals made by the engine and/or the rotorcraft TC holder(s).
- Development of an Airworthiness Directive (AD) to mandate those corrective actions. Normally an AD should be established against the product (engine or rotorcraft) on which the corrective action is directed. Particular cases justifying a different approach (e.g. at interface between the engine and rotorcraft), or for reasons of feasibility or practicality, would be reviewed with both TC holders before the final decision is made by EASA.
- Taking into account the proposals and the justifications provided by the engine and/or the rotorcraft TC holder(s) as defined above, determination of the applicability of the AD and the establishment of the associated compliance times for implementing the corrective actions.
- Issuance of the associated AD.

If an unsafe condition has not been determined but corrective actions are deemed to improve the level of safety, EASA may consider recommending the implementation of these corrective actions through a Safety Information Bulletin (SIB), either at engine or rotorcraft level.

Figure 2 below illustrates the principle of EASA action(AD or SIB) in regards to the determination of unsafe condition based on agreed IFSD / power loss rate limit. The “shaded” zone represents an area where specific aspects of the related case may be taken into account, along with engineering judgement, to decide which action should be taken.

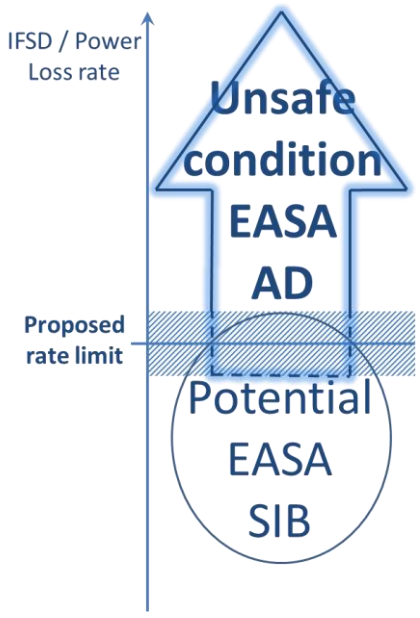

Figure 2

3.2. Who this Certification Memorandum affects

- Type Certificate (TC) holders of turbine engines installed on rotorcraft.
- TC holders of rotorcraft equipped with turbine engine(s).

The principles of this Certification Memorandum should also be applied by TC holders of non-turbine engine installed on rotorcraft, and associated rotorcraft TC holders. They should consult EASA when assessing risks of IFSD and power loss in the course of CAW activities.

When EASA is not the State of Design of a TC holder, and where a Bilateral Agreement (BA) is in place between the European Union and the State of the Certifying Authority (CA) of that TC holder, the provisions of the BA, where applicable, take precedence over the guidance of this CM.

4. Remarks

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu.
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