European Union Aviation Safety Agency

Notice of Proposed Amendment 2021-01

in accordance with Articles 6(3), 7 and 8 (Standard procedure: public consultation) of MB Decision No 18-2015

Rotorcraft chip detection systems

RMT.0725 — Subtask 1

EXECUTIVE SUMMARY

The objective of this Notice of Proposed Amendment (NPA) is to ensure that the chip detection systems installed in rotorcraft rotor drive systems achieve an acceptable minimum level of effectiveness.

This NPA proposes to introduce new objective-based certification specifications (CSs) for the performance of chip detection systems, and the associated acceptable means of compliance (AMC) and guidance material (GM).

Ultimately, the target is for rotorcraft rotor drive systems to feature systems capable of effectively detecting ferromagnetic particles indicating the incipient failure or degradation of internal gearbox components.

The proposed amendments are expected to increase the safety of rotorcraft rotor drive systems by improving their designs.

Action area:	Design and production of rotorcraft		
Affected rules:	CS-27; CS-29		
Affected stakeholders:	Design organisation approval (DOA) and production organisation approval (POA) holders		
Driver:	Safety	**Rulemaking group:**	Yes
Impact assessment:	Yes	**Rulemaking Procedure:**	Standard

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1. About this NPA

1.1. How this NPA was developed

The European Union Aviation Safety Agency (EASA) developed this NPA in line with Regulation (EU) 2018/1139[1] (the 'Basic Regulation') and the Rulemaking Procedure[2]. This rulemaking activity is included in the European Plan for Aviation Safety (EPAS) for 2020–2024[3] under Rulemaking Task (RMT).0725.

This rulemaking task is carried out in two phases, as follows:

— **Subtask 1:** Introduction of a new objective-based certification requirement for the performance of chip detection systems, and the associated AMC and GM.

— **Subtask 2:** Assessment of whether it is necessary to proportionately and retroactively apply this new certification requirement to the existing fleets and to the future production of type-certified rotorcraft.

This NPA covers only Subtask 1 of RMT.0725. The outcome of this rulemaking task (i.e. the new certification specifications for future products) represents one of the elements to be considered for the assessment envisaged as part of Subtask 2.

The text of this NPA has been developed by EASA with the support of Rulemaking Group (RMG) RMT.0725. It is hereby submitted to all interested parties[4] for consultation.

1.2. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[5].

The deadline for the submission of comments is **15 April 2021**.

1.3. The next steps

Following the closing of the public commenting period, EASA will review all the comments received with the support of the RMT.0725 RMG.

After considering the comments received, EASA will develop a decision that amends the Certification Specifications for Small Rotorcraft (CS-27) and for Large Rotorcraft (CS-29), including the associated AMC and GM.

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

[2] EASA is bound to follow a structured rulemaking process as required by Article 115(1) of Regulation (EU) 2018/1139. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the 'Rulemaking Procedure'. See MB Decision No 18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by EASA for the issuing of opinions, certification specifications and guidance material (http://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-18-2015-rulemaking-procedure).

[3] https://www.easa.europa.eu/document-library/general-publications/european-plan-aviation-safety-2020-2024

[4] In accordance with Article 115 of Regulation (EU) 2018/1139, and Articles 6(3) and 7 of the Rulemaking Procedure.

[5] In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

The comments received on this NPA and the EASA responses to them will be reflected in a comment-response document (CRD). The CRD will be published on the EASA website[6].

[6] https://www.easa.europa.eu/document-library/comment-response-documents

2. In summary — why and what

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

The function of a rotorcraft rotor drive system is to transmit power from the engines to the rotors, whilst at the same time reducing the rotational speed and increasing torque. A typical rotorcraft rotor drive system's main gearbox consists of many highly loaded dynamic components that are essential for continued safe flight and landing. The designs of rotorcraft rotor drive systems usually have single-load-path architectures, and the nature of the types of degradation and failure mechanisms that affect them means that it is difficult to directly and regularly inspect the integrity of the critical components. It is for this reason that these systems have to make use of alternative means of detecting degradation and potential impending failures.

One of these means is to use chip (metal particle) detectors that are located in key areas of the drive system gearboxes to provide an indication to the crew and/or maintenance personnel of the presence of ferromagnetic particles. These particles are typically released by gearbox components when they are worn or damaged, and are therefore considered to be a reliable way of detecting when elements of the system are no longer in a serviceable condition.

The establishment of the effectiveness of a chip detection system is not a simple task, and it typically requires a detailed evaluation through specific testing to ensure reliable and repeatable results.

This issue was included in the Preliminary Impact Assessment (PIA) for Rotorcraft Issue 3 in 2018, which proposed rulemaking as the best approach to address it. The PIA was consulted with the EASA Advisory Bodies, and RMT.0725 was included in the EPAS for 2019–2023.

For additional details regarding the issue, please refer to Section 4.1.

Related safety issues

CS 27/29.1337(e) requires the rotor drive system transmissions and gearboxes of small and large rotorcraft to be equipped with chip detectors that indicate the presence of particles of ferromagnetic material resulting from damage or excessive wear of elements of the systems, and provide a signal that should result in a caution or warning to the crew as specified in CS 29.1305(a)(23) and in CS 27.1305(v). The certification specifications that were introduced in 1988, along with the associated acceptable means of compliance, included the expectation that the chip detector should be easily removable, and that the loss of oil from the gearbox should be prevented in case of a failure of the retention device for the removable portion of the chip detector.

At present, there are no provisions in the current certification specifications or their associated acceptable means of compliance that require a demonstration that the effectiveness of a chip detection system is adequate.

Based on the absence of such provisions, there is a potential for current and future rotorcraft types to feature ineffective chip detection systems that would not be capable of detecting the incipient degradation of drive system components as intended. The findings from recent investigations of accidents and incidents have revealed that this kind of event, which was previously considered to be unlikely, can actually occur[7]. A review conducted by EASA revealed that a number of catastrophic accidents have occurred involving European products, which could have been prevented by having more effective chip detection systems installed on the affected drive system gearboxes. Additionally, this review identified that there have been other incidents on both European and American products in which more effective chip detection systems could have mitigated some of the safety issues.

Based upon the outcome of this analysis, it is considered that there is currently a gap between the assumed safety benefit provided by the installation of chip detectors in rotorcraft rotor drive systems and the actual effectiveness of the current chip detection systems.

The following safety recommendation (SR), addressed to EASA by aircraft safety investigation authorities and published by them in their accident investigation reports according to Commission Regulation (EU) No 996/2010[8], will be considered for this RMT. New SRs related to this task may be considered after the publication of the ToR, where appropriate.

AIB Norway safety recommendation NORW-2018-004:

> 'The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) revise the Certification Specifications for Large Rotorcraft (CS-29) to introduce requirements for MGB chip detection system performance.'

This SR is related to an accident that occurred on 29 April 2016 during an offshore mission in the North Sea, Norway, involving a EUROCOPTER EC225 rotorcraft, registered LN-OJF.

The proposed amendments to CS-27 and CS-29 are considered to properly address the objective of this SR.

Other related considerations

There are no:

— exemptions that are pertinent to the scope of this RMT;

— direct references to the ICAO Standards and Recommended Practices (SARPs); nor

— references to EU regulatory material that is relevant for this RMT.

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 1 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Section 2.1.

The specific objective of this proposal is to ensure that the chip detection systems installed in rotorcraft rotor drive systems achieve an acceptable minimum level of effectiveness. Ultimately, the aim is for rotorcraft rotor drive systems to feature systems that are capable of effectively detecting ferromagnetic particles indicating the incipient failure or degradation of internal gearbox components.

[7] AIB Norway safety recommendation NORW-2018-004 states: 'The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) revise the Certification Specifications for Large Rotorcraft (CS-29) to introduce requirements for MGB chip detection system performance.'

[8] Commission Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC (OJ L 295, 12.11.2010, p. 35) (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1479716039678&uri=CELEX:32010R0996).

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

RMT.0725 will be conducted in two phases to achieve the desired objectives.

These phases are:

Subtask 1: This will address new designs, and will provide improved certification specifications and acceptable means of compliance within CS-27 and CS-29 for the demonstration of chip detection system effectiveness.

Subtask 2: This will address existing designs and in-service rotorcraft, and may require retrospective regulatory activity in Part-/CS-26.

This NPA addresses the objective of Subtask 1, proposing amendments to CS-29 and CS-27 as explained hereinafter.

CS 27/29.1337 Powerplant instruments

Currently, point (e) of CS 27/29.1337 requires rotorcraft rotor drive system transmissions and gearboxes of small and large rotorcraft to be equipped with chip detectors that indicate the presence of particles of ferromagnetic material resulting from damage or excessive wear of elements of the systems, and provide caution/warning signals to the crew.

The proposed amendments to these points introduce the objective to demonstrate that the effectiveness of the chip detection is adequate.

AMC 29.917 Rotor drive system design

It is proposed to amend and supplement this AMC in order to introduce additional considerations for chip detection systems used as compensating provisions in the design assessments performed in accordance with point (b) of CS 29.917, to be taken into account in addition to those detailed in AMC 29.1337.

In order to keep the additional provision well separated from the existing AMC 29.917, it is proposed to restructure this AMC as detailed in Table 1 below:

Table 1

EXISTING AMC	AMENDMENT PROPOSED BY THIS NPA
AMC 29.917 — introductory sentences	AMC 29.917
AMC 29.917 — existing provisions for dedicated safety assessment of the rotor drive system's lubrication system	AMC No 1 to 29.917
—	AMC No 2 to 29.917 — proposed additional considerations regarding chip detection systems

This amendment proposes that the full-scale test described in AMC 29.1337 should be executed when the chip detection system is used as a compensating provision.

AMC 27/29.1337 Powerplant instruments

It is proposed to introduce this new AMC in order to provide further acceptable means of compliance with the amended specification of CS 27/29.1337. This new AMC therefore supplements the existing material in CS-27/-29 Book 2 (referring to FAA AC 29-2C § AC 29.1337). As such, it should be used in conjunction with the FAA AC.

This AMC provides means to demonstrate the effective performance of a chip detection system, including objectives for an acceptable level of performance, as well as acceptable methodologies for using test and analysis means for compliance with the amended certification specifications of point (e) of CS 27/29.1337.

In order to ensure a proportionate approach, the proposed AMC 27.1337 allows a simplified demonstration of compliance for small rotorcraft that are not in CAT-A.

GM 27/29.1337 Powerplant Instruments

New guidance material is proposed, describing design practices that may be considered when using AMC 27/29.1337 in order to demonstrate compliance with the amended certification specifications of point (e) of CS 27/29.1337.

2.4. What are the expected benefits and drawbacks of the proposals

The proposed amendments are expected to provide an appreciable safety benefit, would have no social or environmental impacts, would have a slight impact on certification costs, and would streamline the certification process.

For the full impact assessment of the alternative options, please refer to Chapter 4.

3. Proposed amendments and rationale in detail

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

— deleted text is ~~struck through~~;

— new or amended text is highlighted in blue;

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

3.1. Draft certification specifications

CS 29.1337 Powerplant Instruments

[…]

(e) *Chip detection system*. Rotor drive system transmissions and gearboxes utilising ferromagnetic materials must be equipped with chip ~~detectors~~ detection systems designed and demonstrated to effectively indicate the presence of ferromagnetic particles resulting from damage or excessive wear within the transmission or gearbox. Each chip detector must:

(1) Be designed to provide a signal to the indicator required by point (a)(23) of CS 29.1305~~(a)(23)~~; and

(2) Be provided with a means to allow crew members to check or to be informed of, in flight, whether the electrical circuits and signals of the chip detector(s) are functioning correctly ~~function of each detector electrical circuit and signal~~.

[…]

3.2. Draft acceptable means of compliance and guidance material

AMC 29.917 Rotor drive system design

This AMC provides further guidance and acceptable means of compliance to supplement FAA AC 29-2C § AC 29.917, to meet EASA's interpretation of CS 29.917. As such, it should be used in conjunction with the FAA AC, ~~.~~ but should take precedence over it, where stipulated, in the showing of compliance.

AMC No 1 addresses the dedicated safety assessment of the rotor drive system's lubrication system and details how to use it in support of compliance with point (c) of CS 29.927. It also provides clarification regarding the scope of compliance with CS 29.1465, where vibration health monitoring is used as a compensating provision to meet point (b) of CS 29.917.

AMC No 2 contains additional considerations for each chip detection system used as a compensating provision to meet point (b) of CS 29.917, to be taken into account in addition to those detailed in AMC 29.1337.

AMC No 1 to 29.917 Rotor drive system design

Where ~~V~~vibration ~~H~~health ~~M~~monitoring is used as a compensating provision to meet point (b) of CS 29.917~~(b)~~, the design and performance of the vibration health monitoring system should be approved by requesting compliance with point (a) of CS 29.1465~~(a)~~.

For lubrication systems: a dedicated safety assessment should be performed that addresses all the lubrication systems of rotor drive system gearboxes and, in particular, the following:

(a) Identification of any single failure, malfunction, or reasonably conceivable combinations of failures that may result in a loss of oil pressure, a loss of oil supply to the dynamic components or a loss of the oil scavenge function. This normally takes the form of a failure mode and effects analysis. Compensating provisions should be identified to minimise the likelihood of occurrence of these failures. The safety assessment should also consider potential assembly or maintenance errors that cannot be readily detected during specified functional checks.

(b) The safety assessment should consider any specific design features which are subject to variability in manufacture or wear/degradation in service and which could have an appreciable effect on the *maximum period of operation following loss of lubrication*. Any features that may have a significant influence on the behaviour of the residual oil or the auxiliary lubrication system should be taken into account when determining the configuration of test articles.

(c) Identification of the *most severe failure mode* that results in the shortest duration of time in which the gearbox should be able to operate following the indication to the flight crew of a *normal-use lubrication system* failure. This should be used for simulating lubrication failure during the loss-of-lubrication test of point (c) of CS 29.927~~(c) loss of lubrication test~~.

(d) *Auxiliary lubrication system:* Where compliance with point (c) of CS 29.927~~(c)~~ is reliant upon the operation of an *auxiliary lubrication system*, sufficient independence between the *normal-use* and *auxiliary lubrication systems* should be substantiated. Common-cause failure analysis, including common-mode, particular-risk, and zonal safety analyses, should be performed. It should be established that no single failure or identified common-cause failure will prevent the operation of both the *normal-use* and the *auxiliary lubrication systems*, apart from any failures that are determined to be *extremely remote lubrication failures*. The effects of inadvertent operation of the *auxiliary lubrication system* should also be considered.

(e) Definitions

(1) *Lubrication ~~S~~system ~~F~~failure:* in the context of point (b) of CS 29.917~~(b)~~, references to a failure of the lubrication system should be interpreted as any failure that results in a loss of pressure and an associated low oil pressure warning, within the duration of one flight.

(2) *Most severe failure mode:* the failure mode *of the normal use lubrication system* that results in the shortest duration of time in which the gearbox is expected to operate following an indication to the flight crew.

(3) *Normal-use lubrication system:* the lubrication system relied upon during normal operation.

(4) *Auxiliary lubrication system:* any lubrication system that is *independent* of the *normal-use lubrication system*.

(5) *Independent:* an *auxiliary lubrication system* should be able to function after a failure of the *normal-use lubrication system*. Failure modes which may result in the subsequent failure of both the *auxiliary and the normal-use lubrication systems* and which may prevent continued safe flight or safe landing should be shown to be *extremely remote lubrication failures*.

(6) *Extremely remote lubrication failure:* a lubrication failure where the likelihood of occurrence has been minimised, either by structural analysis in accordance with CS 29.571 or laboratory testing. Alternatively, in-service experience or other means can be used which indicate a level of reliability comparable with one failure per 10 million hours. Failure modes including failures of external pipes, fittings, coolers, or hoses, and any components that require periodic removal by maintainers, should not be considered *as extremely remote lubrication failures.*

(f) Determination of the *Most Severe Failure Mode*

(1) The objective of the loss-of-lubrication test is to demonstrate the operation of a rotor drive system gearbox following the *most severe failure mode* of the *normal-use lubrication system*. The determination of the *most severe failure mode* may not be immediately obvious, as leakage rates vary, and system performance following leaks from different areas varies as well. Thus, a careful analysis of the potential failure modes should be conducted, taking into account the effects of flight conditions if relevant.

(2) The starting point for the determination of the *most severe failure mode* should be an assessment of all the potential lubrication system failure modes. This should be accomplished as part of the design assessment of point (b) of CS 29.917~~(b) design assessment~~, and should include leaks from any connections between components that are assembled together, such as threaded connections, hydraulic inserts, gaskets, seals, and packing (O-rings). Failure modes, such as failures of external lines, failures of component retention hardware and wall-through cracks that have not been substantiated for CS 29.307, CS 29.571 and point (m) of CS 29.923~~(m)~~ should also be considered. The determination that a failure is an *extremely remote lubrication failure*, when used to eliminate a potential failure mode from being considered as a candidate *most severe failure mode*, should be substantiated. Where leakage rates or the effect of failure modes cannot be easily determined, then a laboratory test should be conducted. Once the *most severe failure mode* has been determined, this should form the basis of the conditions for the start of the test.

(g) Use of an *auxiliary lubrication system*

The use ~~Use~~ of an *auxiliary lubrication system* may be an acceptable means of providing extended operating time after a loss of lubrication. The *auxiliary lubrication system* should be designed to provide sufficient independence from the *normal-use lubrication system*. Since the *auxiliary lubrication system* is by definition integral to the same gearbox as the *normal-use lubrication system*, it may be impractical for it to be completely independent. Therefore, designs should be conceived such that shared components or interfaces between the *normal-use* and *auxiliary lubrication systems* are minimised and comply with the design assessment provisions of point (b) of CS 29.917~~(b)~~. A failure of any common feature shared by both the *normal-use* and *auxiliary lubrication systems* that could result in the failure of both systems, and would consequently reduce the *maximum period of operation following loss of lubrication,* should be shown to be an *extremely remote lubrication failure*. If compliance with point (c) of CS 29.927~~(c)~~ is reliant on the functioning of an *auxiliary lubrication system*, then:

(1) in the unlikely event of a combined failure of both the *normal-use lubrication system* and the *auxiliary lubrication system*, the RFM emergency procedures should instruct the flight crew to 'LAND IMMEDIATELY' unless testing representing this failure mode has been performed in order to substantiate that an increased duration is justified; and

(2) a means of verifying that the *auxiliary lubrication system* is functioning properly should be provided during normal operation of the rotorcraft on either a periodic, pre-flight or continual basis. Following a failure of the normal-use lube system and activation of an auxiliary lubrication system, the flight crew should be alerted in the event of any system malfunction.

(h) Independence of the *auxiliary lubrication system*~~.~~

(1) In order to ensure that the *auxiliary lubrication system* is sufficiently independent:

(i) a failure of any pressurised portion of the *normal-use lubrication system* should not result in a subsequent failure of the *auxiliary lubrication system*;

(ii) common failure modes shown to defeat both the *normal-use* and the *auxiliary lubrication systems* should be shown to be *extremely remote lubrication* failures, unless it is demonstrated by testing conducted to comply with point (c) of CS 29.927~~(c)~~ that the failure mode does not compromise the *'Maximum period of operation following loss of lubrication'*; and

(iii) control systems, logic and health-reporting systems should not be shared; consideration should be given to the design process to ensure appropriate segregation of the control and warning systems in the system architecture.

(2) Methods which should be used to demonstrate that failure modes of common areas are *extremely remote* include:

(i) field experience of the exact design with an exact application;

(ii) field experience with a similar design/application with supporting test data to allow a comparison;

(iii) demonstration by test of extremely low leakage rates;

(iv) redundancy of design;

(v) structural substantiation with a high safety margin for elements of the lubrication systems assessed against CS 29.571; and

(vi) assessment of the potential dormant failure modes of the *auxiliary lubrication system,* and in order to minimise the risk of dormant failures, determination of the health of the *auxiliary lubrication system* prior to each flight.

AMC No 2 to 29.917 Rotor drive system design

For each chip detection system used as a compensating provision for hazardous or catastrophic failures to meet point (b) of CS 29.917, this section introduces acceptable means of compliance to substantiate the chip detection system specified in point (e) of CS 29.1337 as an appropriate compensating provision.

(1) A chip detection system installed on a rotor drive system transmission or gearbox for compliance with point (e) of CS 29.1337 is typically identified as a compensating provision in the rotor drive system design assessment. As a compensating provision, it is intended to minimise the likelihood of occurrence of certain failures in transmissions and gearboxes, including some hazardous and catastrophic failures.

(2) In order to be accepted as an appropriate compensating provision, the chip detection system must effectively indicate the presence of particles released due to degradation that could lead to the failure modes whose occurrence the chip detection system is intended to minimise. As a result, when demonstrating compliance with point (b) of CS 29.917, the effectiveness of the chip detection system for all the relevant hazardous and catastrophic failure modes should be substantiated by full-scale testing.

(3) The test(s) performed for this demonstration should address all the areas of the rotor drive system associated with the failure modes for which the chip detection system is identified as a compensating provision. Point (3)(a) of AMC 29.1337 provides further guidance on full-scale testing means for compliance demonstration for the chip detection system and performance objectives to be met in order to demonstrate the general level of effectiveness of the system. In addition, the specific characteristics of the failure modes for which the chip detection system is identified as a compensating provision should be evaluated to ensure that the detection effectiveness of point (2) of AMC 29.1337 is sufficient. For cases where the failure modes being analysed cannot be identified by the chip detection effectiveness prescribed in point (2) of AMC 29.1337 with a sufficient margin before hazardous or catastrophic consequences, enhanced objectives for the demonstration of the chip detection effectiveness should replace those of point (2) of AMC 29.1337.

Note: The demonstration of the effectiveness of a chip detection system performed in support of the demonstration of compliance with point (b) of CS 29.917 and point (e) of CS 29.1337 should not be considered as a means to obtain credit towards compliance with other certification specifications. Robust design should still be considered as the primary mitigation means for rotor drive system failures.

AMC 29.1337 Powerplant Instruments

This AMC provides further guidance and acceptable means of compliance to supplement FAA AC 29-2C § AC 29.1337 to meet EASA's interpretation of CS 29.1337. As such, it should be used in conjunction with the FAA AC.

For chip detection systems, the following aspects should be taken into consideration in order to demonstrate compliance with point (e) of CS 29.1337:

(1) Chip detection effectiveness. The effectiveness of a chip detection system should be understood as its capability to indicate the presence of ferromagnetic particles within a transmission or a gearbox. Because of the nature of a chip detection system, which requires these ferromagnetic particles to move to the vicinity of its sensing element(s) (chip detector(s)), the effectiveness of the chip detection system is dependent upon:

— the design of the rotor drive system's transmission or gearbox;

— the location of the chip detector; and

— the design of the chip detector.

(2) Demonstration of effectiveness. A chip detection system installed in a rotor drive system's transmission or gearbox must be demonstrated to effectively perform its function of indicating the presence of ferromagnetic particles resulting from damage or excessive wear within the transmission or gearbox.

As previously mentioned, the effectiveness of a chip detection system is also affected by the design of the transmission or gearbox in question and the location of the chip detectors within them. As a result, when evaluating the effectiveness of the chip detection system, the characteristics of the complete transmission or gearbox should be taken into account. Hence, the demonstration of the effectiveness of the chip detection system should show that the capability of the system is adequate to consistently generate a caution/warning signal within an acceptable period of time of a limited amount of ferromagnetic material in the form of representative particles being released, considering the characteristics of the corresponding transmission or gearbox, such as oil ways and flow paths towards the chip detectors.

Concerning the level of effectiveness that is considered adequate to fulfil this certification specification, it is considered acceptable to show that a caution/warning signal is generated by the chip detection system following the release of 60 mg of ferromagnetic material from any relevant area of the transmission or gearbox. The amount of 60 mg should be used, unless it can be substantiated that a greater amount is acceptable, based on the characteristics of the failure modes associated with the specific area of the transmission or gearbox under evaluation. In addition, no more than 20 minutes should elapse between the introduction of the first particles of ferromagnetic material and the generation of the caution/warning signal by the chip detection system.

The applicant should consider particles with characteristics (shapes, sizes, densities and magnetic properties) representative of the damage or wear associated with the areas being tested. In addition, it should be ensured that the chip detection system performs its intended function under the range of expected operating conditions. Therefore, the applicant should take into consideration by means of design analysis and/or dedicated testing any aspects of the chip detection system and the gearboxes and transmissions in which it is installed that could affect the effectiveness of the system. These aspects should include the:

— attitude of the rotorcraft,

— temperature and viscosity of the oil,

— exact location from which the ferromagnetic particles are released, and the vicinity of potential retention features.

(3) Means used for the demonstration of effectiveness. As an initial step, a preliminary design assessment should be performed. This evaluation should address all the areas of the transmission or gearbox from which ferromagnetic particles could be released and the expected paths by which the particles will reach the chip detectors. The assessment should identify those design features that might impede particles from reaching a chip detector. In general, the areas of the transmission or gearbox to be considered for this evaluation should include those on the main and/or tail rotor drive path (or those which could affect the correct transmission of torque to those), including the contact locations of the bearings, gears and shafts that are internal to the transmission or gearbox.

The outcome of the preliminary design assessment should be used to determine the need for testing of each relevant area of rotor drive system transmissions and gearboxes. This could take into consideration that, in cases where a location can be justified to provide a conservative result relative to other locations, the number of areas tested could be optimised. The preliminary design assessment should also establish those areas for which sufficient information exists, based on the available data from representative tests and in-service experience from previous designs.

Based on the conclusions of the preliminary design assessment, the effectiveness of a chip detection system should be established by a combination of the following:

(a) A full-scale certification test of the transmission or gearbox by artificially introducing particles of ferromagnetic material. This test should be run in a series of phases, with measured amounts of ferromagnetic material to establish the quantity of material and the time needed to generate the caution/warning signal specified by point (a)(23) of CS 29.1305 for each relevant area of the transmission or gearbox. This compliance method should be used for those areas of transmissions or gearboxes for which the effectiveness cannot be confidently established by a detailed design assessment as described in (b) below.

In addition:

— The test should be performed in a fully representative gearbox, including its lubrication system. For gearboxes with pressurised lubrication, some external elements of the lubrication system, which can be justified to have no impact on the results, may be replaced by test equipment.

— The full-scale certification test should be performed at a fixed attitude, rotational speed and lubricating oil temperature corresponding to those in which the gearbox is expected to spend the most time while in operation. The torque transmitted by the gearbox is not considered a relevant parameter for this test.

— The measured amount of ferromagnetic material should be introduced while the gearbox is rotating in stabilised conditions, wherever possible. Each introduction should be performed in a way that represents as closely as possible the expected behaviour of particles produced by the damage or wear mechanism.

— Each area identified for testing should be the subject of a dedicated test phase, unless it can be justified that testing more than one area at the same time will still render representative results for each area.

— The test procedure should ensure that there is no contamination between the test phases. This will often require disassembly and detail cleaning of the gearbox being tested after each test phase.

(b) Detailed design analyses, combined with test data supporting the performance of the relevant chip detectors in their local environments. This evaluation should be used to demonstrate that adequate design provisions are in place to ensure that the ferromagnetic particles released as a result of damage or excessive wear in the relevant locations will reach at least one chip detector. Test data should be available to show that, based upon the performance of the relevant chip detectors in representative environments, the caution/warning signal specified by point (v) of CS 27.1305 will be generated. When evaluating the available test data, the applicant should consider that, depending on the area of the transmissions or gearboxes where the particles originate, additional test points may be needed, depending on the design of the chip detectors and the areas around them. In general, if questionable features exist that may trap particles or impede their progress, representative test data or in-service experience substantiating the impact of those details should be available to support the evaluation.

Supporting test data may be obtained from representative full-scale tests, previous similar designs and/or components or sub-assembly tests, as appropriate.

GM 29.1337 Powerplant Instruments

This GM provides guidance to complement AMC 29.1337.

(1) <u>Design considerations.</u>

(a) Flat oil sumps can significantly limit the capability of particles coming from different locations in the transmission or gearbox to move and reach a chip detector. Therefore, substantiating test data will normally be necessary to support the certification of this type of design feature.

Note: If tests were successfully performed in accordance with point (3)(a) of AMC 29.1337, no further test data would be necessary.

(b) When designing rotor drive system transmissions and gearboxes, the flow path for the lubricating oil intended to carry particles should be designed to ensure it is directed to the locations of the chip detectors. The location, orientation and flow of oil jets may affect the movement of the particles subject to their influence.

(c) Specific features such as cavities or pockets that could act as retention features for particles should be avoided wherever possible.

(d) Particles may be drawn into the lubrication circuit at the pump intake. This can be advantageous for locating chip detectors, but careful consideration is required with respect to the acquisition and retention* of particles in areas of strong oil flow.

*Or the final location for recovery when analysis of the particles is required.

CS 27.1337 Powerplant Instruments

[…]

(e) Chip detection system. Rotor drive system transmissions and gearboxes utilising ferromagnetic materials must be equipped with chip ~~detectors~~ detection systems designed and demonstrated to effectively indicate the presence of ferromagnetic particles resulting from damage or excessive wear within the transmissions or gearboxes. Each ~~C~~chip detector must:

(1) be designed to provide a signal to the indicator required by point (v) of CS 27.1305~~(v)~~; and

(2) be provided with a means to allow crew members to check, in flight, whether the electrical circuits and signals of the chip detector(s) are functioning correctly. ~~the function of each detector electrical circuit and signal.~~

CS-27 BOOK 1 — Appendix C — Criteria for Category A

[…]

29.1337(e)

[…]

AMC 27.1337 Powerplant Instruments

This AMC provides further guidance and acceptable means of compliance to supplement FAA AC 27-1B § AC 27.1337 to meet EASA's interpretation of CS 27.1337. As such, it should be used in conjunction with the FAA AC.

For chip detection systems, the following aspects should be taken into consideration in order to meet the certification specifications of point (e) of CS 27.1337:

(1) Chip detection effectiveness. The effectiveness of the chip detection system should be understood as its capability to indicate the presence of ferromagnetic particles within a transmission or a gearbox. Because of the nature of a chip detection system, which requires these ferromagnetic particles to move to the vicinity of its sensing element(s) (chip detector(s)), the effectiveness of the chip detection system is dependent upon:

— the design of the rotor drive system's transmission or gearbox;

— the location of the chip detector; and

— the design of the chip detector.

(2) Demonstration of effectiveness. A chip detection system installed in a rotor drive system transmission or gearbox shall be demonstrated to effectively perform its function of indicating the presence of ferromagnetic particles resulting from damage or excessive wear within the transmission or gearbox.

The effectiveness of a chip detection system is also affected by the design of the transmission or gearbox in question, and the location of the chip detectors within them. As a result, when evaluating the effectiveness of the chip detection system, the characteristics of the complete transmission or gearbox should be taken into account. Hence, the demonstration of the effectiveness of the chip detection system should show that the capability of the system is adequate to consistently generate a caution/warning signal within an acceptable period of time of a limited amount of ferromagnetic material in the form of representative particles being released, considering the characteristics of the corresponding transmission or gearbox, such as oil ways and flow paths towards the chip detectors.

Concerning the level of effectiveness that is considered adequate to fulfil this requirement, it is considered acceptable to show that a caution/warning signal is generated by the chip detection system following the release of 60 mg of ferromagnetic material from any relevant area of the transmission or gearbox. The amount of 60 mg should be used, unless it can be substantiated that a greater amount is acceptable, based on the characteristics of the failure modes associated with the specific area of the transmission or gearbox under evaluation. In addition, no more than 20 minutes should elapse between the introduction of the first particles of ferromagnetic material and the generation of the caution/warning signal by the chip detection system.

The applicant should consider particles with characteristics (shapes, sizes, densities and magnetic properties) representative of the damage or wear associated with the areas being tested. In addition, it should be ensured that the chip detection system performs its intended function under the range of expected operating conditions. Therefore, the applicant should take into consideration by means of design analysis and/or dedicated testing any aspects of the chip detection system and the gearboxes and transmissions in which it is installed that could affect the effectiveness of the system. This should include:

— the attitude of the rotorcraft;

— the temperature and viscosity of the oil;

— the exact location from which the ferromagnetic particles are released and the vicinity of potential retention features.

(3) Means used for the demonstration of effectiveness. Due to the lower complexity and power density of the gearboxes featured in single-engined CS-27 small rotorcraft, it is acceptable to comply with point (e) of CS 27.1337 by means of a detailed design assessment supported by representative test data supporting the performance of the relevant chip detectors in their local environments. This evaluation should be used to demonstrate that adequate design provisions are in place to ensure that the ferromagnetic particles released as a result of damage or excessive wear in the relevant locations will reach at least one chip detector. Test data should be available to show that, based upon the performance of the relevant chip detectors in representative environments, the caution/warning signal specified by point (v) of CS 27.1305 will be generated.

When evaluating the available test data, the applicant should consider that depending on the area of the transmissions or gearboxes where the particles originate, additional test points may be needed depending on the design of the chip detectors and the areas around them. In general, if questionable features exist that may trap particles or impede their progress, representative test data or in-service experience substantiating the impact of those details should be available to support the evaluation.

Supporting test data may be obtained from representative full-scale tests, previous similar designs and/or components or sub-assembly tests, as appropriate.

GM 27.1337 Powerplant Instruments

This GM provides guidance to complement AMC 27.1337.

(1) Design considerations.

(a) Flat oil sumps can significantly limit the capability of particles coming from different locations in the transmission or gearbox to move and reach a chip detector. Therefore, substantiating test data will normally be necessary to support the certification of this type of design feature.

Note: If tests were successfully performed in accordance with point (3)(a) of AMC 29.1337, no further test data would be necessary.

(b) When designing rotor drive system transmissions and gearboxes, the flow path for the lubricating oil intended to carry particles should be designed to ensure it is directed to the locations of the chip detectors. The location, orientation and flow of oil jets may affect the movement of the particles subject to their influence.

(c) Specific features such as cavities or pockets that could act as retention features for particles should be avoided wherever possible.

(d) Particles may be drawn into the lubrication circuit at the pump intake. This can be advantageous for locating chip detectors, but careful consideration is required with respect to the acquisition and retention* of particles in areas of strong oil flow.

*Or the final location for recovery when analysis of the particles is required.

4. Impact assessment (IA)

4.1. What is the issue

Typically, chip detectors, when installed on pressure-lubricated transmissions or gearboxes, are located in areas where ferromagnetic particles being carried by the lubricating oil will be detectable, which includes locations such as gearbox oil sumps and oil pump intakes. Therefore, the chip detection systems of rotorcraft certified against this requirement typically rely on the lubrication system to drive any ferromagnetic particles resulting from wear or damage to drive system components to the areas monitored by these chip detectors. As a result, the actual capability of the chip detectors fitted on drive system gearboxes to indicate the presence of ferromagnetic particles (hereinafter referred to as 'chip detection effectiveness') is dependent not only on the designs of the chip detectors themselves, but also on the designs of the gearbox housings and lubrication systems.

Additionally, it is worth highlighting that chip detectors are normally identified and accepted as compensating provisions in the design assessment requested by point (b) of CS 29.917 (for large rotorcraft only). These compensating provisions are described in the acceptable means of compliance as means to minimise the occurrence of hazardous and catastrophic failures.

However, regardless of all the considerations described in the paragraphs above, at the moment, there is no provision in the current certification specifications or their associated acceptable means of compliance or guidance material requiring a demonstration of adequate chip detection effectiveness.

Based on the absence of provisions in the current certification specifications regarding the demonstration of adequate chip detection effectiveness, there is a potential for current and future rotorcraft types to feature systems with low chip detection effectiveness. Such systems would not be capable of performing as means of detection of incipient degradation of drive system components. Proof of this is now available to EASA, thanks to recent findings on past accidents and incidents and their associated investigations. Based on the events reviewed by EASA, a number of catastrophic accidents have occurred involving European products, which may have been prevented by more effective chip detection systems on the affected drive system gearboxes. Additionally, other incidents have been recorded for both European and American products in which more effective chip detection systems would have been beneficial. Further information is provided in Section 4.1.1 below.

Therefore, it is considered that there is a risk of a gap existing between the assumed safety provided by the installation of chip detectors in rotorcraft rotor drive systems and the actual chip detection effectiveness delivered by today's systems.

For these reasons, EASA has raised a certification review item (CRI) on recent projects to address the issue, and has initiated this rulemaking task. Furthermore, in addition to the detailed investigations being conducted on Airbus Helicopters' products, EASA is investigating whether an unsafe condition may exist in the rest of the in-service large rotorcraft fleet through a continued airworthiness review item (CARI).

4.1.1. Safety risk assessment

The function of a rotorcraft rotor drive system is to transmit power from the engines to the rotors, whilst at the same time reducing rotational speed and increasing torque. A typical rotorcraft rotor drive system's main gearbox consists of many highly loaded dynamic components that are essential for safe flight and landing. Due to the single-load-path architecture of rotorcraft rotor drive system designs, the nature of the degradation and failure mechanisms that affect them and the difficulty to directly and regularly inspect the integrity of the critical components, these systems have to make use of alternative means of detection. One of these means is chip detection, which uses chip detectors located in key areas of rotorcraft rotor drive system gearboxes to provide an indication to the crew and/or maintenance personnel of the presence of ferromagnetic particles. These chip detection systems, which provide indications of the presence of the ferromagnetic particles that are typically released by gearbox components when worn or damaged, are considered a reliable way of detecting when elements of the system are no longer in serviceable condition.

The chip detection effectiveness is dependent on a number of factors, including:

— the capability of the ferromagnetic particles released by any critical component to reach the chip detector location;

— the capability of the chip detector to detect or collect and detect these particles; and

— the amount of ferromagnetic material needed to raise a caution/warning signal.

Therefore, establishing the effectiveness of a chip detection system is not a simple task, and it typically requires a detailed evaluation through specific testing to ensure reliable results. However, no guidance currently exists to support the definition and evaluation of the effectiveness of a chip detection system.

By not defining the objectives to be achieved in terms of the effectiveness of a chip detection system at the time of certification, the level of safety obtained is uncertain and dependent on the design procedures of each manufacturer. In conclusion, it is considered that without defining such means in the certification specifications and the associated acceptable means of compliance and guidance material, failures of rotorcraft rotor drive systems, which could lead to catastrophic consequences and that could be prevented through the detection of ferromagnetic particles, could occur in both the currently certified rotorcraft types and those to be certified in the future.

In order to evaluate the safety risk related to chip detection, the safety occurrence database of EASA has been interrogated to identify the accidents and incidents over a period of 11 years (from 2009 till 2019) related to rotorcraft rotor drive system malfunctions. This database contains accidents and serious incidents within the scope of EASA — namely occurrences involving European products operating worldwide, plus other occurrences involving an EASA Member State, either as the State of occurrence, State of operator or State of registry. In addition, the database includes all the accidents involving large commercial aeroplanes and rotorcraft worldwide.

The analysis of the events involving failures or malfunctions of the main and/or tail rotor drive systems and related to CS-27 and CS-29 rotorcraft showed the following:

— 11 fatal accidents, causing 31 casualties in total;

— 46 non-fatal accidents;

— 13 serious incidents; and

— 260 incidents.

Regarding the identification of those events in which chip detection could have played a relevant role, it is worth noting that it is complex to establish a proven link between a rotorcraft accident/incident caused by some kind of drive system malfunction and ineffective chip detection. A detailed evaluation of the findings and a root cause investigation is needed in order to be able to conclude that ferromagnetic particles were present in the affected drive system gearbox sufficiently in advance to provide an indication to the crew or maintenance personnel and prevent the event from occurring. As a result, for a number of the events, it is not possible to establish a clear link due to the absence of sufficient information.

Nevertheless, for 3 fatal accidents over the mentioned period of 11 years, it has been established that ineffective chip detection of the affected gearbox was a contributing factor to the events. It is, therefore, considered that if the chip detection effectiveness objectives for rotorcraft rotor drive system gearboxes had been applicable to the affected types, these 3 fatal accidents may have been prevented.

In conclusion, EASA is of the opinion that the current certification specifications and associated acceptable means of compliance and guidance material should be amended to consolidate and improve the level of safety being achieved through the implementation of the CRI addressing the effectiveness of the chip detection system. This is based on the consideration of the number of events described above, the consequences of undetected degradation in gearboxes of rotorcraft rotor drive systems, and the potential for achieving a significant safety benefit levelled across the various rotorcraft manufacturers through the proposed rulemaking task. This is also supported by the statistics reported in the 2019 Annual Safety Review, which establishes system reliability as one of the key safety issues involved in helicopter commercial and non-commercial operation accidents. In fact, due to the fact that 2 of the 3 accidents mentioned above correspond to offshore commercial air transport, and that these were the only fatal accidents in this type of helicopter operation in the last 5 years, system reliability is identified as the priority 1 risk area for helicopter offshore commercial air transport.

4.1.2. Who is affected

This NPA affects CS-27 and CS-29 rotorcraft manufacturers.

4.1.3. How the issue/problem could evolve

Taking into consideration the current accident rates of CS-27 and CS-29 rotorcraft, the industry and regulators should endeavour to reduce the airworthiness risks associated with rotorcraft rotor drive system failures. Noting that these failures typically result in hazardous or catastrophic consequences for the rotorcraft, the capability to detect potential malfunctions in advance is considered critical to prevent such events from occurring. Based on the nature of the degradation and failure mechanisms that typically affect drive system components, effective chip detection is considered to be a reliable means for early detection of an incipient failure of these elements. Thus, not addressing the potential ineffectiveness of chip detection in rotorcraft rotor drive systems through rulemaking could result in a number of accidents not being prevented.

At the moment, EASA addresses this topic in ongoing certification projects through a CRI, which requests an evaluation of the effectiveness of the chip detection system. In addition, it is considered that additional guidance needs to be developed in order to improve the level of safety achieved by compliance with this item. Thus, it is considered necessary to consolidate these requirements and means of compliance in the certification specifications.

In addition, EASA is currently trying to address the situation for current fleets through a detailed investigation of Airbus Helicopters' products, and a CARI for other CS-29 rotorcraft TC holders. The intention of this CARI is to gather service data that supports adequate chip detection effectiveness, which may be extended to CS-27 rotorcraft in the near future. This initiative is currently in progress, and is taken into consideration in the options considered below in Section 4.3.

4.2. What we want to achieve — objectives

Refer to Section 2.2.

4.3. How it could be achieved — options

In order to achieve the above objectives, and limited to **Subtask 1**, the options in Table 2 below have been identified.

Table 1: Selected policy options

Option No	*Short title*	**Description**
0	Do nothing	No policy change (no change to the rules; risks remain as outlined in the issue analysis).
1	Amend CS-27 and CS-29	Amend the current certification specifications and associated acceptable means of compliance and guidance material in order to introduce a new objective-based certification specification for the performance of a chip detection system. The related means of compliance will involve the testing of a gearbox to verify the performance of the chip detection system, as has been done on a current certification project.

Option 1 involves rulemaking to provide enhanced certification specifications and acceptable means of compliance and guidance material within CS-27 and CS-29 regarding demonstrating the effectiveness of a chip detection system. The intent of this rulemaking task is to establish the minimum objectives to be achieved by a chip detection system in terms of its effectiveness, taking into consideration the level of reliance placed on the system to prevent the catastrophic and hazardous failure modes of the drive system. Additionally, this rulemaking task describes the means to demonstrate that these objectives have been achieved. At this stage, it is considered that these acceptable means of compliance should include test evidence to support the demonstration of adequate chip detection effectiveness. This proposed acceptable means of compliance should be complemented by guidance material describing the design considerations that can influence the effectiveness of a chip detection system.

Subtask 2:

As anticipated in the related ToR[9], at the current stage, it is not possible to conduct the impact assessment for Subtask 2, as it is first necessary to evaluate the responses provided by the TC holders to the CARI initiative from EASA in order to understand the current state of play with the in-service fleet. Indeed, it has to be assessed whether retroactive actions will be supported by the outcomes of this CARI. After this evaluation has been concluded, it will be possible to consider the extent and the associated impact of the retroactive action that is necessary. EASA will complete the evaluation of the need for retroactive action and conduct the impact assessment to determine whether the retroactive action is justified.

4.4. Methodology and data

4.4.1. Methodology applied

The methodology applied for this impact assessment is the multi-criteria analysis (MCA), which allows all the options to be compared by scoring them against a set of criteria.

The MCA covers a wide range of techniques and combines a range of positive and negative impacts into a single framework to allow scenarios to more easily be compared. Essentially, it applies a cost–benefit assessment (CBA) to cases where there is a need to present multiple impacts that represent a mixture of qualitative, quantitative and monetary data, and where there are varying degrees of certainty. The key steps of an MCA generally include:

establishing the criteria to be used to compare the options (these criteria must be measurable, or at least comparable in qualitative terms); and

scoring how well each option meets the criteria; the scoring needs to be relative to the baseline scenario.

The criteria used to compare the options were derived from the Basic Regulation, and the guidelines for the impact assessment were developed by the European Commission. The principal objective of EASA is to 'establish and maintain a high uniform level of safety' (as per Article 2(1) of the Basic Regulation). As additional objectives, the Basic Regulation identifies environmental, economic, proportionality and harmonisation aspects, which are reflected below.

The scoring of the impacts uses a scale of –10 to +10 to indicate the negative and positive impacts of each option (i.e. from 'very low' to 'very high' negative/positive impacts). Intermediate levels of benefit are termed 'low', 'medium', and 'high', with also a 'no impact' score possible.

4.4.2. Data collection

The data used for this impact assessment includes the following:

The list of incidents and accidents involving failures of either the tail or the main rotor drive system available in the safety occurrence database of EASA.

The financial information used to assess Option 1, which is based on the publicly available annual reports of the largest affected rotorcraft manufacturers, as well as on the development cost estimates provided to EASA for the purposes of this rulemaking task.

[9] https://www.easa.europa.eu/document-library/terms-of-reference-and-group-compositions/tor-rmt0725

4.5. What are the impacts

4.5.1. Safety impact

The safety impact of the options proposed has been determined to be the following:

Option 0: This option will have no impact on safety, since no changes would be made to the current applicable policies.

Option 1: Based on the expected safety benefit from ensuring that the effectiveness of the chip detection system is adequate through the amendments to the certification specifications and the associated acceptable means of compliance and guidance material of CS-27 and CS-29, a low positive safety impact (score of +4) is considered for Option 1. This is based on the number of accidents and incidents identified in Section 4.1.1 above, and the high level of effectiveness expected from the amended certification specifications in preventing similar events from occurring in the future. For this assessment, it was considered that the proposed amendments to the certification specifications could have prevented the 3 fatal accidents mentioned in Section 4.1.1. In addition, this option will fully address the safety recommendation cited in Section 4.1. However, since this option will only impact on the new rotorcraft types certified after the publication of this NPA, the safety impact was not considered to be greater.

Table 3: Safety impact assessment of policy options (on a scale of –10 to +10)

Assessment	**Option 0** Do nothing	**Option 1** Amend CS-27 and CS-29
Safety impact	0	+4, i.e. low positive: 3 fatal accidents could have been prevented based on historical events; this option applies only to new TCs

Stakeholders are invited to provide quantified justification elements on the possible safety impacts of the options proposed, or alternatively to propose another justified solution to the issue.

4.5.2. Environmental impact

No environmental impacts have been identified.

4.5.3. Social impact

No social impacts have been identified.

4.5.4. Economic impact

In order to assess the economic impact of the options described above, an estimation of the cost of the development and completion of one test, as well as additional computational analyses to evaluate and demonstrate the adequate effectiveness of the chip detection of a drive system gearbox, have been used. Regarding the test itself, the estimation takes into consideration the costs of the following:

— The test specimen: one development standard main gearbox, conservatively assuming that it cannot be reused after the test.

— The test installation and equipment: no specific bench requirements are foreseen for this kind of test. Any monitoring or test equipment required is considered relatively inexpensive in comparison with the total cost of such a test, and it should be reusable for future tests.

— Test preparation and execution: the manpower used to prepare and execute the test.

— Analysis of the test results: the manpower used to evaluate the findings of the test and draft the test report.

The total estimated cost corresponds to EUR 1 300 000 for a CS-29 rotorcraft and EUR 500 000 for a CS-27 rotorcraft, as provided by a European rotorcraft TC holder with experience in this kind of test.

The economic impact for the options proposed is determined to be the following:

— Option 0: there is no economic impact associated with this option, since there is no change to the policies currently applicable.

— Option 1: the estimation described at the beginning of this section (the cost of the evaluation of the chip detection effectiveness) is compared with the annual revenue of the main CS-27 and CS-29 rotorcraft manufacturers. For this comparison, it is considered that the total cost of the additional testing required for compliance demonstration is divided by the number of years taken for the development of the new helicopter type being developed. The number of years for the development of a new type is estimated as 5 years.

As part of Subtask 1, the requirement to ensure that the chip detection effectiveness is demonstrated by test will only be mandatory for future applicants for CS-29 and CS-27 Category A rotorcraft. Therefore, the economic impact assessment has only taken into consideration the impact on those rotorcraft manufacturers that have certified at least one of these products in the last 20 years.

The economic impact has been considered 'very low'.

Table 4 below summarises the economic impact of the two options considered for this impact assessment.

Table 4: Economic impact assessment results (on a scale of –10 to +10)

Assessment	**Option 0** Do nothing	**Option 1** Amend CS-27 and CS-29
Economic impact	0	–2, i.e. very low negative: the development and certification costs are conservatively estimated at a one-off cost of maximum 1.3M€ per CS-29 rotorcraft type certificate or €0,5M per CS-27 rotorcraft type certificate; no additional production and installation costs.

Stakeholders are invited to provide quantified justification elements on the possible economic impacts of the options proposed, or alternatively to propose another justified solution to the issue.

4.5.5. General aviation and proportionality issues

At this stage of RMT.0725, it has been established that a different approach is needed for Category A CS-27 rotorcraft than for other CS-27 rotorcraft.

Given the simpler drive system configurations, the lack of a clear indication of an associated safety risk, and the lower stress conditions to which the drive system components of non-Category A CS-27 rotorcraft are typically subjected, it has been determined that the implementation of the certification specifications to establish the effectiveness of the chip detection system by test shall be limited to CS-29 and CS-27 Category A rotorcraft.

Nevertheless, it is proposed to amend the certifications specifications and the associated acceptable means of compliance and guidance material for CS-27 rotorcraft to include an evaluation of the chip detection effectiveness for non-Category A rotorcraft. The acceptable means of compliance for this evaluation are proposed in this NPA, and include the use of a detailed design assessment, supported by limited testing, as a means of demonstrating the effectiveness of a chip detection system. This is complemented by newly proposed guidance material describing the design considerations that can influence the effectiveness of a chip detection system.

4.6. Conclusion

Based on the evaluation of the safety and economic impacts of the options proposed, as presented in the sections above and summarised in Table 5 below, it is concluded that Option 1 is the most appropriate one to pursue.

Table 5: Impact assessment results (on a scale of –10 to +10)

Assessment	**Option 0** Do nothing	**Option 1** Amend CS-27 and CS-29
Safety impact	0	+4 (low positive)
Economic impact	0	–2 (very low negative)
Total score	0	+2 (very low positive)

Option 1 is expected to ensure an adequate effectiveness of the chip detection system, which, in turn, would allow early detection of incipient degradation of the drive system components. Based on this, a number of accidents could be prevented, while the certification costs to be sustained by manufacturers of new rotorcraft will slightly increase in order to execute the additional demonstration of compliance with CS 27/29.1337.

Stakeholders are also invited to provide any other quantitative information they may find necessary to bring to the attention of EASA.

As a result, the relevant parts of the IA might be adjusted on a case-by-case basis.

4.7. Monitoring and evaluation

The effectiveness of the proposed amendments to CS-27 and CS-29 will be evaluated as part of the standard process of monitoring the occurrences reported to EASA. As the chip detection systems of rotorcraft certified in accordance with the new requirements are expected to effectively detect the ferromagnetic particles indicating an incipient failure or degradation of internal gearbox components, it is expected that the number of undetected failures of internal gearbox components will be reduced.

Data regarding the effectiveness of chip detection systems in service will also be acquired by TCHs using a continued integrity verification programme for critical parts, including their monitoring systems, when chip detection is part of these systems.

5. Proposed actions to support implementation

EASA is considering organising an information session after the publication of the decision related to this rulemaking task. The ultimate objective of this event would be to present the amended certification specifications, and to provide clear guidance and best practices on how to implement them in future certification projects.

6. References

6.1. Related regulations

n/a

6.2. Related decisions

— Decision No. 2003/15/RM of the Executive Director of the Agency of 14 November 2003 on certification specifications for small rotorcraft (« CS-27 »), as amended

— Decision No. 2003/16/RM of the Executive Director of the Agency of 14 November 2003 on certification specifications for large rotorcraft (« CS-29 »), as amended

7. Quality of the document

If you are not satisfied with the quality of this document, please indicate the areas which you believe could be improved, and provide a short justification/explanation:

— the **technical quality** of the draft proposed rules and/or regulations and/or the draft proposed amendments to them;

— the clarity and readability of the text;

— the quality of the impact assessment (IA);

— application of the 'better regulation' principles[10]; and/or

— others (please specify).

Note: Your replies and/or comments in reply to this section will be considered for internal quality assurance and management purposes only and will not be published in the related CRD.

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