Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

REASSESSMENT OF THE RESPONSE TO AVIATION SAFETY RECOMMENDATION A11-01

Main gearbox certification: the "extremely remote" provision

Background

On 12 March 2009, at 0917 Newfoundland and Labrador Daylight Time, a Cougar Helicopters' Sikorsky S-92A (registration C-GZCH, serial number 920048), operated as Cougar 91 (CH191), departed St. John's International Airport, Newfoundland and Labrador, with 16 passengers and 2 flight crew, to the Hibernia oil production platform. At approximately 0945, 13 minutes after levelling off at a flight-planned altitude of 9000 feet above sea level (asl), a main gearbox (MGB) oil pressure warning light illuminated. The helicopter was about 54 nautical miles (nm) from the St. John's International Airport. The flight crew declared an emergency, began a descent to 800 feet asl, and diverted back towards St. John's. At 0955, approximately 35 nm from St. John's, the crew reported that they were ditching. Less than 1 minute later, the helicopter struck the water in a slight right-bank, nose-high attitude, with low speed and a high rate of descent. The fuselage was severely compromised and sank quickly in 169 metres of water. One passenger survived with serious injuries and was rescued approximately 1 hour and 20 minutes after the accident. The other 17 occupants of the helicopter died of drowning.

The Board concluded its investigation and released report A09A0016 on 09 February 2011.

Board Recommendation A11-01 (February 2011)

The last major update of rotorcraft airworthiness standards took place in the 1980s. This update flowed from the phenomenal growth of the rotorcraft industry and the recognition by the U.S. government and industry that existing certification rules had been outdated by rapidly advancing rotorcraft technology. The rules specifically recognized the need for a high level of safety in the design requirements for rotorcraft.

The update of the design requirements for large, multiengine transport rotorcraft (Category A) recognized the need for MGB to have a significant capacity to operate following a loss of lubricant in order to optimize eventual landing opportunities. This consideration led directly to the introduction of the 30 minute requirement to operate after a loss of MGB lubricant. However the introduction of the "extremely remote" concept following the comment phase of the rule-making made it possible for a helicopter to be certified without being capable of operating for 30 minutes with only residual lubricant. Category A rotorcraft certified under the "extremely remote" criteria may not be capable of continued operation for 30 minutes with only residual lubrication. These helicopters remain vulnerable to gearbox failures stemming from unforeseen massive losses of MGB lubricant, placing passengers and crew at risk.

Therefore, the Board recommends that:

> The Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency remove the "extremely remote" provision from the rule requiring 30 minutes of safe operation following the loss of main gearbox lubricant for all newly constructed Category A transport helicopters and, after a phase-in period, for all existing ones.
>
> **TSB Recommendation A11-01**

Response of the Federal Aviation Administration to Recommendation A11-01 (April 2011)

In its response, the Federal Aviation Administration (FAA) indicated that:

> Currently, 14 CFR 29.927(c) (effective Amendment 29-26) requires that the MGB must be tested to run satisfactorily for at least 30 minutes with a loss of lubricating oil, unless a lubrication failure resulting in a loss of lubrication is determined to be "extremely remote".
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> All transport Category A helicopters certified (under this rule), including the Sikorsky Model S-92A, have met the 30 minute "loss of lubrication" requirement. The Model S-92A MGB used an oil cooler bypass valve to meet this requirement by eliminating the most likely sources of leakage, which are the cooler and external lines and fittings. Events that have occurred during the operational use of the Model S-92A, such as the MGB oil filter bowl failure associated with the S-92 Cougar accident, have shown that certain failures not considered during certification testing are more likely than "extremely remote". The service history therefore does not support the method of compliance that was originally accepted by the FAA at the time of the Model S-92A type certification. Because of this very tragic and regrettable experience, the FAA will propose a rule change to either clarify or eliminate the "extremely remote" provision in this regulation. In the interim, the FAA will revise the guidance material associated with the rule to prevent confusion and to achieve a more robust and standardized method of compliance with the loss of lubrication requirements.

The FAA is participating in a coordinated formal review of the rules related to the "extremely remote" provision and the 30 minute requirement, with Transport Canada (TC) and the European Aviation Safety Agency (EASA).

It added:

> The FAA does not believe it is practical or necessary to require that all existing and newly- manufactured transport Category A helicopters be equipped with MGBs that meet the 30-minute "loss of lubrication" requirement under 14 CFR 29.927(c), (Amendment 29-26). The cumulative flight hours on these helicopters are well into the millions, and their service history supports that they are

> operating at a satisfactory level of safety. Furthermore, modifying these helicopters to be equipped with new MGBs would have a significant economic impact on the aviation community, and the costs would outweigh any improvements in safety.

Transport Canada's response to Recommendation A11-01 (June 2011)

Transport Canada's response indicated that:

> Transport Canada (TC) has initiated, through a meeting in June (2011), a coordinated formal review with the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) of the rules related to the extremely remote provision and the 30 minute requirements. The objective of the review is to reach an international agreement on what changes may be required to the rules.
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> While the recommendation to assess the complete loss of lubricant in Category A helicopters is not directed to TC (A11-02), it deals with the same part of the rules and will form part of the review. Any amendments to the airworthiness rules would follow the regulatory process in each jurisdiction.
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> TC is accelerating a review of the guidance material relating to the application of standards referred to in these recommendations to identify, by early fall of 2011, additional direction or clarification for the Canadian certification of Category A helicopters.

In addition, the newly appointed Minister of Transport indicated that he has instructed officials to modify the consultation process to accelerate the action required as a result of the recommendations contained in this report.

Response of the European Aviation Safety Agency to Recommendation A11-01 (June 2011)

EASA's response, dated 22 March 2011 was provided to the TSB on 10 June 2011. In its response, EASA acknowledges receipt of Recommendation A11-01 and indicates that the issue is under investigation and a review of the certification guidance material is on-going with the FAA and TC. EASA will keep the recommendation open until a final opinion is published. The conclusion will be provided to the TSB.

Board assessment of the Federal Aviation Administration's response to Recommendation A11-01 (June 2011)

The FAA has indicated that it will propose a rule change to either clarify or eliminate the "extremely remote" provision in this regulation. This statement acknowledges the deficiency. In addition, one proposed course of action, eliminating the "extremely remote" provision, follows A11-01's recommended course of action. However, no timeframe to complete this process is specified. The FAA has proposed action which, if implemented in full, will substantially reduce or eliminate the deficiency for newly certified Category A helicopters.

The review of the certification guidance material initiated by the FAA, TC and EASA may result in changes in the application of the rules related to the "extremely remote" provision and the 30 minute requirement for newly certified Category A helicopters.

However, the FAA goes on to say it "does not believe it is practical or necessary to require that all existing and newly- manufactured transport Category A helicopters be equipped with MGBs that meet the 30-minute "loss of lubrication" requirement under 14 CFR 29.927(c), (Amendment 29-26)". This suggests that Sikorsky, having already certified the S-92A under the existing "extremely remote" criteria, may not be required to redesign and refit its S-92A MGB, which would not be in keeping with the Board's recommendation. The Board will be seeking clarification from the FAA on this point.

Board assessment of Transport Canada's response to Recommendation A11-01 (June 2011)

In its response, TC did not indicate that it was in agreement with the recommendation. However, it indicated that, following a formal review of the rules with the FAA and EASA, there may be a need to change the rules related to the "extremely remote" provision and the 30 minute requirement. This is a logical step considering the certification rules are harmonized between the 3 regulatory bodies.

TC has also indicated that it will accelerate the review of the guidance material relating to the application of the standards referred to in the recommendation, to identify any additional direction or clarification that might be required for the Canadian certification of Category A helicopters. TC plans on completing this review early in the fall of 2011. However, TC does not indicate that the "extremely remote" provision will be removed from the certification rules, eliminating this deficiency. Instead, it suggests that the "extremely remote" provision will remain in the meantime, with possibly additional direction and clarification being provided for its application in future certification of Category A helicopters.

There is no indication in the response as to what TC's position is on the future certification of Category A helicopters or with respect to the approximately 125 S-92A helicopters that fly today or those that will be manufactured in the coming years. Specifically, TC has not said whether it will eliminate the "extremely remote" provision nor has it said whether it will require all Category A helicopters to meet a 30 minute run dry requirement. However, TC is participating in the review of the certification requirements with the FAA and EASA which may result in changes to the rules related to the "extremely remote" provision and the 30 minute requirement for helicopters certified in the future.

Board assessment of the European Aviation Safety Agency's response to Recommendation A11-01 (June 2011)

EASA's response does not indicate agreement with the identified deficiency. However, it has indicated that it is completing a review of the certification guidance material with the FAA and TC.

The review of the certification guidance material with the FAA and TC may result in changes in the application of the rules related to the "extremely remote" provision and the 30 minute requirement.

Board assessment of the responses from the Federal Aviation Administration, Transport Canada, and the European Aviation Safety Agency to Recommendation A11-01 (June 2011)

Therefore, the responses in aggregate are assessed as **Satisfactory Intent**.

Response of the Federal Aviation Administration to Recommendation A11-01 (September 2011)

> This is our response to your letter dated July 25, 2011, requesting the FAA to clarify its response of April 28, 2011, on three specific matters relating to SR 11.035.
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> You requested a timeline for completing the regulatory review and proposal to change the loss of lubrication rule to either clarify or eliminate the "extremely remote" provision in this rule. The timeline to examine the adequacy of the "extremely remote" provision in Title 14 Code of Federal Regulations (CFR) 29.927(c) at Amendment 29-26 is as follows: The first meeting of the FAA, European Aviation Safety Agency (EASA), and Transport Canada Civil Aviation (TCCA) Joint Cooperation Team (JCT) is scheduled for October 4th and 5th , 2011. The JCT will report its final recommendations to the FAA/EASA/TCCA Certification Management Team during the summer of 2012. If a decision is made to change the rule and develop corresponding guidance material, many variables will influence the date for these activities to occur making it impractical to establish a completion date at this time.
>
> You also requested a timeline for completing the revised guidance material associated with the loss of lubrication rule. We plan to complete the revised guidance material and publish it by March 2012. We have provided a draft copy of the proposed guidance material to our technical counterparts in TCCA and EASA for review and comment. We will provide TSB a copy of the final guidance material when it is completed.
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> In response to your statement that "the only Transport Category A helicopter that cannot operate safely for 30 minutes is the S-92A, which is the only Category A helicopter certified so far under the extremely remote provision," we offer the following information. Specifically, the requirement for Category A helicopters to operate safely for 30 minutes following a loss of lubrication became effective on October 3, 1988, with the adoption of Amendment 29-26 to 14 CFR 29.927(c). In essence, any Transport Category A helicopter certified before that date was not required to comply with this amendment to the regulation. The Bell Model 222 and 412, Sikorsky Model S-76B, and Eurocopter Model BK 117B-l and AS 332L are examples of Transport Category A helicopters that were certified prior

to this amendment and were not certified to operate safely for 30 minutes following a loss of lubrication.

We also would like to clarify that the certification approach used by Sikorsky for the S-92A did not invoke the provision of "extremely remote." Sikorsky's use of a solenoid-activated bypass valve was considered a new method of maintaining an oil reserve to meet the 14 CFR 29.927(c)(1) loss of lubrication test requirement. The bypass valve, which is incorporated into production Model S-92A helicopters, is intended to shut off an oil leak in the oil cooler or hose system and to prevent further loss of oil from the Main Gearbox (MGB). With this configuration, Sikorsky was able to run the loss of lubrication test on the MGB for about 3 hours in "bypass mode."

In response to your request for the FAA to be clear and to provide its official position, details on actions to be taken, and a corresponding timeline for implementing any actions about requiring Sikorsky to redesign or refit its S-92A MGB with a supplementary lubrication system so it will be capable of operating for at least 30 minutes following a massive loss of MGB oil, we provide the following information. We have issued two airworthiness directives (ADs) that we believe have significantly improved the level of safety of the Model S-92A helicopters. One of the ADs requires replacing the MGB oil filter bowl with a more "robust" two-piece filter bowl design. The other AD requires changing the S-92A flight manual emergency procedures to enable the crew to more easily identify a sudden "loss of lubrication" event and to complete the required flight crew actions without confusion or delay.

We are continuing discussions with Sikorsky regarding the potential for any additional Model S-92A MGB failure modes that could result in a loss of MGB oil. To support our evaluation, Sikorsky has provided us with an S-92A MGB hazard analysis that identifies MGB failures that could result in a loss of MGB oil condition. As a result of our review of the hazard analysis, we have requested that Sikorsky perform certain testing and further analysis to validate some of the assumptions made in the hazard analysis. Any decision on whether we will require future AD actions and any future MGB redesigns, such as a redesign of the MGB so that it will be capable of operating for at least 30 minutes following a massive loss of MGB oil, will not be made until we have completed our evaluation of the S-92 MGB hazard analysis and the requested information.

We would like to emphasize to the TSB that the AD requirements, along with the MGB design improvements made by Sikorsky in recent years, have resulted in a more reliable and robust MGB. We believe the responses we have provided in this letter are sufficient to address TSB recommendation A11-01. The FAA will continue to investigate this matter and will take appropriate action to address any unsafe condition.

Transport Canada's response to Recommendation A11-01 (September 2011)

Transport Canada (TC) has initiated, through a meeting in June, a coordinated formal review with the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) of the rules related to the extremely remote provision and the 30 minute requirements. The objective of the review is to reach an international agreement on what changes may be required to the rules.

Any agreement by the three authorities on a response to the recommendation would be followed by changes to the airworthiness requirements in each jurisdiction.

Update request to European Aviation Safety Agency (October 2011)

On 21 October 2011 the TSB requested that EASA provide an update of its activities taken to mitigate the residual risks associated with Recommendation A11-01. No response was received.

Board reassessment of the Federal Aviation Administration's response to Recommendation A11-01 (March 2012)

In its first response the FAA indicated that it would propose a rule change to either clarify or eliminate the "extremely remote" provision in this regulation. This statement acknowledged the deficiency and one proposed course of action, eliminating the "extremely remote" provision, followed A11-01's recommended course of action. However, no timeframe to complete this process was specified. At the time it was assessed that the proposed action, if fully implemented, would substantially reduce or eliminate the deficiency for newly certified Category A helicopters.

In response to a TSB request to provide a timeline for completing these actions the FAA has indicated the initial meetings are scheduled for October 2011 and the Joint Cooperation Team will provide its recommendations to the Certification Management Team during the summer of 2012. Its latest response indicates the decision to change the rule and develop corresponding guidance material will rest with the Certification Management Team and it would be impractical to establish a completion date at this time.

The FAA has indicated that the certification guidance material has been revised and is currently under review by TC and EASA with the intention of publishing it in March 2012. The new guidance material may result in a better application of the current rules related to the "extremely remote" provision and the 30 minute requirement for newly certified Category A helicopters.

In its first response the FAA stated that it "does not believe it is practical or necessary to require that all existing and newly- manufactured transport Category A helicopters be equipped with MGBs that meet the 30-minute "loss of lubrication" requirement under 14 CFR 29.927(c), (Amendment 29-26)". This suggested that the FAA, having already certified the S-92A under the existing "extremely remote" criteria, may not require the redesign and refit of the S-92A MGB, which would not be in keeping with the intent of the Board's recommendation.

The Board asked for clarification from the FAA on this point making it clear that the recommendation was only directed at the S-92A, the only Category A helicopter certified

without a 30-minute continued flight capability since the "loss of lubricant" requirement was introduced. Although the FAA has introduced two new ADs which have improved the level of safety of S-92A helicopters these aircraft are still not capable of 30-minute continued flight capability if there is a total loss of lubricant in the MGB. The FAA has indicated that it is now waiting for the completion of a failure analysis and testing being conducted by Sikorsky before it makes any decisions on whether it will require a redesign of the MGB so that it will be capable of operating for at least 30 minutes following a massive loss of MGB oil.

Additional requests were made by the TSB between 02 November 2011 and 17 January 2012 to obtain further clarification from the FAA regarding its responses to A11-01 but no additional information was provided.

On 12 January 2012, the FAA issued a draft Advisory Circular (AC) with proposed changes to AC 29-2C, Section 29.927/927A, titled Additional Tests (Powerplant - Rotor Drive System). Comments from the public about the draft AC could be submitted to the FAA until 13 March 2012. This guidance is intended to change the advisory material in AC 29-2C, sections 29.927 and 29.927A by providing an explanation of the term "extremely remote" as used in the context of 14 CFR 29.927(C)(1) at Amendment 29-26. It also clarifies the explanation of the term "lubrication failure" as used in these AC sections for the 29.927(c) paragraphs.

Board reassessment of Transport Canada's response to Recommendation A11-01 (March 2012)

TC has not yet indicated if it is in agreement with the recommendation. In addition, it has not indicated what TC's position is on the future certification of Category A helicopters or with respect to the S-92A helicopters that fly today or those that will be manufactured in the future. Specifically, TC has not indicated whether it will eliminate the "extremely remote" provision nor has it indicated whether it will require all Category A helicopters to meet a 30 minute run dry requirement. However, TC is participating in the review of the certification requirements with the FAA and EASA which may result in changes to the rules related to the "extremely remote" provision and the 30 minute requirement for helicopters certified in the future.

Board reassessment of the European Aviation Safety Agency's response to Recommendation A11-01 (March 2012)

The TSB had requested that EASA provide an update as to the progress of its activities taken to mitigate the residual risks associated with Recommendation A11-01. No response was received.

However both the FAA and TC have indicated in their latest responses that EASA is working with them to review the rules related to the "extremely remote" provision and the 30 minute requirements. The review of these certification rules with the FAA and TC may result in changes in the application of the rules related to the "extremely remote" provision and the 30 minute requirement.

Board reassessment of the responses from the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency to Recommendation A11-01 (March 2012)

The three separate regulatory bodies (FAA, TC, EASA) must work together to achieve certification harmonization. If the planned actions result in Category A helicopters being capable of 30 minutes of safe operation following a massive loss of main gearbox lubricant, then this will eliminate or substantially reduce the safety deficiency. However, the action has not been sufficiently advanced to reduce the risks to transportation safety.

Therefore, the responses in aggregate are assessed as **Satisfactory Intent**.

Response of the Federal Aviation Administration to Recommendation A11-01 (November 2012)

> A group of technical specialists from the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency formed a Joint Cooperation Team (JCT). The JCT was chartered by a Certification Management Team (CMT) to review the current design standards and accompanying guidance material relating to the certification of helicopter gear boxes. As a part of this review, the JCT was tasked to address TSBC Recommendations A11-01 and A11-02 and their underlying safety issue, specifically with respect to loss of lubrication. The JCT has completed their task and will be presenting a report to the CMT. We have no further updates on these safety recommendations until the CMT reviews and either accepts, rejects, or modifies the JCT' s report.
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> We will continue to provide periodic updates to TSBC safety recommendations A11-01 and A11-02 until final resolution.

Transport Canada's response to Recommendation A11-01 (December 2012)

> In June 2011, Transport Canada (TCCA) initiated a coordinated Joint Cooperation Team (JCT) with the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) to formally review the rules related to the "extremely remote" provision and the 30 minute requirements. The objective of the review was to reach agreement on what changes may be required to the rules. The JCT met twice (October 2011 and February 2012) and has drafted a set of recommendations that are being currently circulated within the respective authorities for final review and approval.
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> This TSB recommendation asserts that the design standard may be deficient. However, subsequent investigation has revealed that it was not a deficiency of the standard that led to the accident, but rather that the accidented (sic) rotorcraft possessed a design defect that invalidated one of the design assumptions for the main gearbox lubrication system. An airworthiness directive was issued to address the unsafe condition and restore the rotorcraft design to the level of safety implicit in its certification basis.

> In parallel and in advance of approval of the JCT report, changes have been made to the related advisory circular (AC) 29-2C, specifically to clarify the application of "extremely remote" and the failure conditions that must be considered when performing loss-of-lubrication tests (e.g. oil lines, fittings, seal plugs, sealing gaskets, valves, pumps, oil filters, oil coolers, accessory pads, etc.). Revision pages to AC 29-2C, dated 07/06/2012, have been posted on the FAA's Regulatory Guidance Library (RGL) internet website. These changes to the AC are believed to substantially address the immediate concern raised by the TSB recommendation.
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> Finally, as part of an anticipated future FAA Part 27/29 ARC, a second phase of review on the design standards of 14 CFR 29.927(c) may be expected. Areas of review may include the drafting of a more prescriptive test requirement, the consideration of operating environment (e.g. availability of landing opportunities) and/or other factors in determining the appropriate information to furnish in the rotorcraft flight manual.

Response of the European Aviation Safety Agency to Recommendation A11-01 (March 2013)

> EASA accepts that the interpretation of "extremely remote" in paragraph 29.927 of the rotorcraft certification specifications is ambiguous and has caused confusion in demonstrating compliance. EASA together with the Federal Aviation Administration (FAA) and Transport Canada (TCCA), are considering methods to clarify the intent.
>
> In addition, a Joint Cooperation Team (JCT) between EASA, FAA and TCCA is being initiated under the leadership of TCCA, to undertake a detailed review of current certification standards and guidance material (Advisory Circular) relating to the certification of helicopter main gear box lubrication systems. This will include issues such as loss of lubrication, the reliability of lubrication systems, and the adequacy of the 30 minute Cat A capability. The JCT aims to be completed within 1 year and any recommendations will be considered for future rulemaking. Open.

Board reassessment of the responses from the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency to Recommendation A11–01 (March 2013)

The Joint Cooperation Team (JCT) has completed its task of reviewing the current design standards and accompanying guidance material relating to the certification of helicopter gear boxes and its report is awaiting review and approval. It is unknown whether this review will result in the elimination of the "extremely remote" concept from the certification standard. At this time, the actions taken to date have not been sufficiently advanced to reduce the risks to transportation safety.

Therefore, the responses in aggregate are assessed as **Unable to Assess.**

Response of the Federal Aviation Administration to Recommendation A11-01 (November 2013)

In response to Safety Recommendations A11-01 and A11-02, the FAA is able to provide an update on the activities of the Joint Cooperation Team (JCT) which consisted of technical specialists from the FAA, Transport Canada, and the European Aviation Safety Agency. The JCT was chartered by a Certification Management Team (CMT) to review the current design standards and accompanying guidance material relating to the certification of helicopter gear boxes and the underlying safety concerns, specifically with respect to loss of lubrication. The JCT has completed its task, and we have enclosed the final report that was accepted and signed by the CMT team.

The final report provided by the JCT has effectively addressed the intent of Safety Recommendations All-01 and All-02. The FAA considers these recommendations closed, and no further action is planned.

Enclosure:

September 28, 2012

Report of the Joint Cooperation Team (JCT) on the Review of Helicopter Main Gearbox Certification Requirements for TCCA/FAA/EASA

Joint Cooperation Team:

Transport Canada (TCCA), the FAA and the European Aviation Safety Agency (EASA) agreed to create a Joint Cooperation Team (JCT) to conduct a review of the current design standard and guidance material relating to the certification of helicopter MGBs, specifically with respect to loss of lubrication including AWM 529.927(c), 14 CFR § 2.9.927(c), and CS 29.927(c). In light of the above safety recommendations and in accordance with terms of reference document, this joint review was intended to review the adequacy of transport category rotorcraft standards with respect to gearbox loss of oil and consider potential areas for improvement with the intention that the certification requirements remain harmonized among TCCA, FAA, and EASA.

The terms of reference did not address any other TSB (operational) recommendations.

Approach and Scope of the JCT:

Technical specialists from TCCA, FAA and EASA formed a JCT to review the current design standards and accompanying guidance material that address loss of lubrication from pressure lubricated gearboxes and are the subject of TSB recommendations A11-01 and A11-02.

Specialists from all three national civil airworthiness authorities (CAAs) have arrived at a common recommendation maintaining a harmonized airworthiness framework. This report states the findings of the JCT which are to be provided to the FAA, EASA and TCCA management for their consideration.

Regarding loss of oil endurance capability, the current loss-of-lubrication test requirement for MGB of a transport category rotorcraft sets a minimum objective for the applicant to demonstrate a minimum of 30 minutes of safe operation for Category A rotorcraft. FAA Advisory Circular (AC) AC29-2C provides guidance on failures of interest in the oil system sub-components (see section AC29.927A). This AC is referenced by all three CAAs as acceptable guidance; however, it does not provide guidance on application of the "extremely remote" failure criteria.

The JCT have examined the adequacy of these regulations, including the provision of the "extremely remote" criteria in the standard, and provided recommendations for revising 14 CFR § 29.927(c) and the related AC material. These recommendations identify the need to clarify the application of "extremely remote" and the failure conditions that must be considered when performing loss-of-lubrication tests.

JCT Recommendations:

This report to the FAA, EASA and TCCA management presents recommendations for harmonized action to improve the design standards and guidance material, or elsewhere, which address the safety risk associated with loss of oil from pressure lubricated gearboxes. These recommendations address gaps identified between the existing requirements, clarification of the intent of the rule and redefinition of test requirements to meet the safety standard. This final report also provides technical justification to support those recommendations.

General Recommendation:

An FAA Advisory Rulemaking Committee {ARC), or European equivalent should be formed with multi-lateral CAA participation and/or a multi-lateral CAA working group (WG) which will consider the subject of loss of oil as follows:

a. Consider further technical detail in requirements

b. Include helicopter design and manufacturing industry representation

c. Consider rule changes at the 14 CFR part 29/CS-29/ AWM 529 level

d. Consider impact on other categories

e. Consider impact on operating rules and emergency procedures

The JCT is of the opinion that the scope of this rulemaking activity should only be applicable to new Part 29 Cat A helicopter Types (i.e. not applicable to variants unless considered to be a "significant change"). Though TSB recommendation A11-01 applies to "all newly constructed Category A transport helicopters and, after a phase-in period for all existing ones'', the JCT believe that once the certification basis for an aircraft type is set, and the type approval has been granted the certification basis should remain fixed. If subsequently an unsafe condition is found to exist this should be addressed using the continued operational safety or continued airworthiness procedures of the NAA of the state of design. These procedures usually require any unsafe condition to be managed using one or more Airworthiness Directives (ADs). Accordingly an AD will not change the design standards applied to the aircraft, but can mandate a design change to restore the level of safety to that envisioned by the requirements defined in the certification basis.

The specific recommendations made below are the current opinion of the JCT but may be subject to change after review by an ARC.

Note 1 : Near-term action (pre-ARC review) - AC stand-alone changes have already been pursued, independent of 14 CFR part. (FAA AC was published and posted in the FAA Regulatory Guidance Library (RGL) internet website in July2012.)

Note 2: ARC review will include an initial feasibility study.

Recommendations Relating to 14 CFR part 29.927(c) and AC

Recommendation 1: All part 29 Cat A new Types (i.e. not applicable to variants unless 21.101 significant change) should comply with a loss of oil test and "extremely remote" should be removed from the requirement.

Recommendation 1.1: Interim position to issue revised AC to clarify intent of 29.927(c) Amdt 26. Accordingly, FAA, TC and EASA should continue to progress the draft revision of the loss of lubrication guidance material that is currently in work for AC 29.927 and publication of the material prior to the end of calendar year 2012.

Note: Since drafting this recommendation FAA AC has been published and posted in the FAA RGL internet website in July 2012.

Supporting Rationale: The AC revision provides an explanation of the phrase "unless such failures are extremely remote" as used in the context of 14 CFA § 29.927(c)(1). The explanation brings to attention that unforeseen variables and complexity associated with predicting potential failure modes and their associated criticality and frequency of occurrence make it challenging to employ the "extremely remote" concept.

Recommendation 1.2: Propose a new amendment to AWM 29.927(c), 14 CFR § 29.927(c), and CS 29.927(c) as a test requirement, similar in format to that of

29.923 and 29.927(b). This will require the creation of an aviation authorities and industry working group (ARC). This group should consider removal of the term “extremely remote” and rewriting the requirement to become a prescriptive "oil out" durability test of the rotor drive system gearboxes used on Category A rotorcraft. The JCT recommends that this test be of a duration to be agreed by the ARC group but in any case not less than 30 minutes. The test should prescribe the torque(s) and rotational speed(s) that must be applied to the rotor drive system. The type of operation, such as search and rescue, human external cargo, emergency medical systems, and the operating environment, i.e., hostile terrain, over water, etc., should also be considered when determining the appropriate test duration, torque(s), and rotational speed(s). At a minimum, the torque and rotational speed-should not be less than that required to maintain continued level flight at maximum takeoff gross weight (applicant may elect to consider some adjustment to gross weight as a result of fuel burn). On completion of the test, the test results and the duration of the test should be taken into consideration when developing the appropriate emergency procedures in the rotorcraft flight manual for loss of lubrication.

Supporting Rationale: The 29.927(c) 30 minute loss of lubrication regulatory requirement was always intended as a test requirement to ensure that the rotor drive gearbox designs used on Category A rotorcraft are capable of operating safely for an extended period of time under various operating conditions following a loss of lubrication to the rotor drive gearboxes. The opportunity to extend the period of operation following a loss of lubrication was deemed essential in order to increase the eventual landing opportunities that are available to the flight crew.

Recommendation 2: Ideally a new 29.927(c) requirement should define a test which can justify confidence that 30 minutes of continued flight would be probable. This test data could be used to allow emergency operation up to 30 minutes in flight manual emergency procedures. This will be a subject for review by the ARC group and any determination on this subject should be made in association with each Authority’s flight test department. The JCT believe that this would be consistent with the intention of 29.927(c) amendment 26 text which requires 30 minutes of continued safe operation in service to be shown by test.

Note: The JCT consider that operation of an independent auxiliary lubrication system to achieve this duration would be acceptable.

Recommendation 3: Propose a change to AC 29.927(c) to state the method for draining oil from the gearbox.

Note: Since drafting this recommendation FAA AC has been published and posted in the FAA RGL internet website in July 2012. This describes that the method for draining oil should be determined by identifying and simulating the worst-case oil leak.

Recommendations Relating to AC Sections 29.917

Recommendation 4: In conjunction with the JCT's review of the current 29;927(c} regulatory requirements and associated guidance material, the team found it necessary to review the rotor drive system related guidance material in AC 29 . 917 and, as a result, makes the following additional recommendation to the CMT:

Lubrication system design should be subject to a drive system design assessment to assess failures in the lubrication system. Accordingly, JCT recommends revising the guidance material in AC 29.917 to include the rotor drive lubrication system as part of the rotor drive system and therefore include lubrication system failures in the rotor drive system design assessment. Under the 29.917(b) rotor drive system design assessment requirement, a failure analysis would be required to identify all lubrication failures that will prevent continued safe flight or safe landing. Consideration should be given to extending the AC to provide specific advice for the assessment of lubrication system reliability in addition to minimizing the likelihood of individual lubrication system failure modes;

Supporting Rationale: The lubrication system is an integral part of the rotor drive system and is necessary to achieve continued safe operation of the rotor drive system.

Current Status:

The JCT recommendations fit into near and far term strategies. Some of the near-term strategies, such as revising AC 29.927 have already been accomplished. Further revisions will be required as other changes are implemented; however, these initial steps begin to address some of the weaknesses identified by the JCT.

Next Steps:

The JCT members recommend to the FAA, EASA and TCCA management that these recommendations be endorsed and initiated in a timely fashion.

Respectfully,

Joint Cooperation Team

Response of the European Aviation Safety Agency to Recommendation A11-01 (September 2013)

Changes to FAA Advisory Circular AC 29.927 have been published and the Joint cooperation Team (JCT) completed its tasking with the publication of a final report in December 2012. The report recommends establishing a rulemaking group to further consider the technical details and the need for rule changes in the fields of design requirements, operating rules and emergency procedures. This should include removing "extremely remote" from FAR/CS 29.927.

The Agency has accepted the JCT report and has taken the lead in initiating rulemaking task RMT.0608 which will establish an international group of experts, including FAA and TCCA specialists. This task is scheduled to start in early 2014. As part of the rulemaking group's tasking, a regulatory impact assessment will be undertaken which will establish the case for action to the existing fleet.

Transport Canada's response to Recommendation A11-01 (November 2013 and April 2014)

November 2013

The Joint Cooperation Team (JCT) final report has been accepted by the 3 authorities. Both Transport Canada and EASA have the JCT final report on their respective 4-year work plans.

The next steps include:

- Canada suggest that the JCT final report be placed on the agenda for the next Certification Management Team Trilateral meeting in 2014.
- Form a Working Group made up of the 3 authorities to review and make decisions on the recommendations made by the JCT.

The FAA issued revised Advisory Circular (AC) 29-2C in July of 2012, containing updated guidance for FAR 29.927(c). (Transport Canada Civil Aviation accepts most FAA guidance, including this AC, for showing compliance with standards of the Airworthiness Manual.) This AC contains clarification to address possible misinterpretation of the term "extremely remote".

April 2014 update

Transport Canada Civil Aviation (TCCA), the Federal Aviation Administration (FAA), and the European Aviation Safety Agency (EASA) have together taken steps since the Cougar Sikorsky S-92 accident to both restore this aircraft type design to its expected level of safety and to address the certification test standards for helicopter gearboxes and how they are applied. Through the actions and plans described below, TCCA believes that it has fully implemented TSBC Recommendation A11-01.

During certification testing, in demonstrating compliance with the loss-of-lubrication test requirement of FAR 29.927(c) (harmonized among TCCA, FAA and EASA), Sikorsky assumed that the oil filter housing and studs were structural in nature and showed analytically that their failure was "extremely remote"; thus this failure mode was not tested. An oil cooler leak was determined to be most likely cause of a main gearbox loss of lubrication, and testing (and subsequent abnormal procedures) catered to mitigating that failure mode. Repeated failure of the studs proved otherwise, placing the helicopter outside the assumptions of its certification basis.

Following the accident, the FAA issued an Airworthiness Directive (AD) which TCCA immediately adopted to replace the titanium studs with heavier but more durable steel studs. This action restored the level of safety of the S-92 helicopter to that envisioned by the

requirements defined in its certification basis, and TCCA joined an FAA and EASA initiative to review and revise the related certification guidance and test standards.

TCCA, FAA and EASA formed a Joint Cooperation Team (JCT) to review the TSB Report and the accident in relation to the current design standards and guidance material relating to the certification of helicopter MGBs, specifically with respect to loss of lubrication, including AWM 529.927(c), FAR 29.927(c), and CS 29.927(c). The JCT met in late 2011 and early 2012 and developed a two-prong approach for both the medium and longer terms (the AD addressed the safety deficiency in the short term). In the medium term, to address the misapplication of the "extremely remote" provision, a revision to the guidance material relating to the loss-of-lubrication certification test requirement was developed.

Test guidance in FAA Advisory Circular AC 29.729A was revised and expanded in 2012. The revised AC provides a full explanation of the context and objective of the test; an explanation of what the term "extremely remote" means; clarification that the expected compliance approach is to assume a failure in the normal lubrication system leading to rapid loss of lubrication; complete test procedures, including test entry conditions; and, examples of failure modes that are expected to be evaluated. This revision satisfied the medium term strategy of clarifying the certification requirement and mitigating the risk of repeated misapplication of the test parameters.

This combination of short and medium term actions is considered by TCCA to fully address the safety concern raised by the TSB.

For the longer term, the JCT took the opportunity of the final report, submitted to TCCA, FAA and EASA management in September of 2012, to recommend a broader review of helicopter main gearbox design and test requirements, as part of the ongoing development of design standards for rotorcraft. The JCT recommended reviewing the relationship between the specified test duration and target continued flight time, associated emergency procedures, extension of test requirements to other parts of the drive system, and tailoring the test to suit different operational requirements. These recommendations, while not considered by TCCA as necessary to address the specific safety concern raised by the TSBC, will nonetheless be accepted.

The follow-on work has already been initiated. In March 2013, TCCA, FAA and EASA agreed to a multi-year review of helicopter main gearbox design and test requirements, including the adequacy of the 30 minute loss-of-lubrication endurance test and appropriateness of the term "extremely remote". This review, lead by EASA, is scheduled to begin in 2014. While the JCT recommended that the term "extremely remote" be considered for removal from the certification test requirement, it was coupled with a recommendation to more closely define the test parameters for a loss of lubrication test, thus effectively performing the same function: making sure that the appropriate failure mode(s) are tested and mitigated. The aim of the certification test standards is not to drive aircraft designers to a specific solution, it is to provide flexibility in developing designs that maximize opportunities for robustness and safety. Realistic and probable failures must be investigated, however innovative design safety features (such as post-failure oil retention capability) should not be discouraged by overly prescriptive test standards.

The outcome of that follow-on work will be taken together with other design standards development work in a plan to revise the rotorcraft design standards generally, such as under the anticipated FAA Aviation Rulemaking Committee (ARC) on 14 CFR parts 27 and 29.

Board reassessment of the Federal Aviation Administration's response to Recommendation A11-01 (May 2014)

In the case of A11-01 the TSB asked that: The Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency remove the "extremely remote" provision from the rule requiring 30 minutes of safe operation following the loss of main gearbox lubricant for all newly constructed Category A transport helicopters and, after a phase-in period, for all existing ones.

Regarding the first part of the recommendation "remove the "extremely remote" provision from the rule requiring 30 minutes of safe operation following the loss of main gearbox lubricant for all newly constructed Category A transport helicopters": In the FAA's cover letter it states that the JCT report (dated 28 September 2012) has effectively addressed the intent of A11-01 and A11-02 and that no further action is planned by the FAA. This would imply that the FAA considered JCT Recommendation 1.2, removal of the term "extremely remote", and did not accept the suggestion, since the term is still in the certification requirements. In January 2014 a request was sent to the FAA asking for confirmation that the FAA does not intend to remove the term "extremely remote" from the certification requirements.

Regarding the second part of the rec "after a phase in period for all existing ones": The intent of this part of the recommendation was for the FAA to address the fact that the S92 main gearbox does not meet the 30 minute safe operation capability requirement, not to change the original certification basis. To date, the FAA has not addressed this specific issue. It is not clear if the FAA will take definitive action to restore the level of safety to that envisioned by the requirements defined in the original certification basis before the "extremely remote" provision was introduced.

Board reassessment of Transport Canada's response to Recommendation A11-01 (May 2014)

In the TC response, it has indicated that the JCT report has been accepted by TC/FAA and EASA. It indicates the report will be put on the agenda for the next Certification Management Team Trilateral meeting in 2014 and a Working Group made up of the 3 authorities to review and make decisions on the recommendations made by the JCT. TC and EASA have put the JCT report on their four year work plans. TC states that the outcome of follow-on work based on the JCT recommendations will be taken together with other design standards development work in a plan to revise the rotorcraft design standards generally. From the information received it is not clear when and how the deficiencies identified in A11-01 will be addressed.

Board reassessment of the European Aviation Safety Agency's response to Recommendation A11-01 (May 2014)

In the EASA response dated 27 September 2013 it has also indicated that the JCT report has been accepted by TC/FAA and EASA and a Working Group made up of the 3 authorities to review and make decisions on the recommendations made by the JCT. This task is scheduled to start in early 2014. TC and EASA have put the JCT report on their four year work plans.

EASA has indicated as part of the rulemaking group's tasking, a regulatory impact assessment will be undertaken which will establish the case for action to the existing fleet. This suggests that the S-92 MGB inability to run safely for 30 min following a total loss of lubricant may be addressed. It also suggests this should include removing "extremely remote" from FAR/CS 29.927. However from the information received it is not clear when and how the deficiencies identified in A11-01 will be addressed.

Board reassessment of the responses from the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency to Recommendation A11–01 (May 2014)

JCT has completed its task and its report has been reviewed and accepted by the FAA/TC and EASA. It has been indicated to the TSB that now a working group will be formed to decide if action needs to be taken to address the recommendations made by the JCT. It is unknown whether this working group will eliminate the "extremely remote" concept from the certification standard or address the deficiency with the S-92 MGB oil loss capability. At this time, the actions taken to date have not been sufficiently advanced to reduce the risks to transportation safety.

Therefore, the responses in aggregate are assessed as **Satisfactory Intent.**

Response of the Federal Aviation Administration to Recommendation A11-01 (November 2014)

Your recommendations in question A11-02, A11-01, A06-10 and A06-09 have been addressed in last year's FAA response to your annual reassessment and were considered closed, with no further action planned by the FAA.

Response of the European Aviation Safety Agency to Recommendation A11-01 (December 2014)

The Terms of Reference (ToR) for rulemaking task RMT.0608 were published on 22 May 2014 on the EASA Website, together with its Group Composition which includes Transport Canada (TCCA) and the Federal Aviation Administration (FAA). A reference to this accident and safety recommendation is included in the ToR. The specific objective of this task is to implement the recommendations of the Joint Cooperation Team (JCT) and to strengthen the existing Certification Specifications for Large Rotorcraft (CS-29) requirements pertaining to rotor drive system lubrication.

Following initial discussions within RMT.0608, it is the group's view that the "extremely remote" provision remains justified for designs which provide an independent means of continued lubrication in the event of loss of oil or failure of the main lubrication system. It is

accepted that further clarification would be beneficial and some additional guidance to the Advisory Circular (AC) 29.927 has already been jointly developed by FAA/EASA/TCCA and published. In addition, RMT.0608 will explore the possibilities of bringing the main gearbox lubrication system within the design assessment of CS 29.917, thereby strengthening the approach to design and certification. Regarding existing Category A transport helicopters, the Agency will continue to address any identified type specific unsafe condition within the scope of Part-21.

Transport Canada's response to Recommendation A11-01 (January 2015)

Transport Canada, the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) formed a Joint Cooperation Team (JCT) and met in late 2011 and early 2012 to review the TSB accident investigation report and the accident in relation to the current design standards and guidance material relating to the certification of the helicopter's main gearbox, specifically with respect to loss of lubrication.

The JCT review resulted in the revision and expansion of the test guidance for the certification of the helicopter's main gearbox, FAA Advisory Circular AC 29-2C. The revisions provided further clarification in testing and certification procedure, including explanation of the term "extremely remote".

Through the actions taken, as described above and further to the briefing that Transport Canada provided to the board in April of 2014, Transport Canada believes that it has fully addressed the intent of recommendation A11-01 and has addressed the underlying safety issue**.**

No further updates will be provided, and Transport Canada considers this Recommendation closed.

Board reassessment of the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency's responses to Recommendation A11–01 (March 2015)

In the FAA's response, 14 November 2013, it advised the JCT had completed its task, and the JCT final report was accepted and signed by the CMT team. Despite repeated attempts by the TSB, the FAA has provided no additional information as to whether the CMT had modified the JCT's report. Also no update was provided regarding the formation of an ARC group or any work that group may have completed. The more recent FAA response 19 November 2014 reaffirmed the FAA considers TSB recommendation A11-01 to be closed and no further action is planned.

In the EASA response, it advised the "extremely remote" provision remains justified for designs which provide an independent means of continued lubrication in the event of loss of oil or failure of the main lubrication system. It is accepted that further clarification would be beneficial and some additional guidance to the Advisory Circular (AC) 29.927 has already been jointly developed by FAA/EASA/TCCA and published. Regarding existing Category A transport helicopters, like the S-92, they will continue to address any identified type specific unsafe condition within the scope of Part-21.

In the TC response, it indicated that together with the FAA and EASA they have together taken steps since the Cougar Sikorsky S-92 accident to both restore this aircraft type design to its expected level of safety and to address the certification test standards for helicopter gearboxes and how they are applied. TC believes these actions taken to date have fully implemented TSB Recommendation A11-01.

Since recommendation A11-01 was issued, together FAA, EASA and TC have carefully considered the deficiency identified by the TSB. Their collective answer to date is that they believe the use of the "extremely remote" provision used in the MGB 30 minute run dry certification criteria for Category A transport helicopters should stay in place. This implies that new Category A transport helicopter designs can continue to be certified without having to prove they are capable of 30 minutes of safe operation following a total loss of MGB.

They have also indicated that the actions taken to date following the Cougar Sikorsky S-92 accident have restored this aircraft type design to its expected level of safety. However the safety deficiency identified by the TSB remains in that if any S-92 helicopter currently in operation was to lose all the oil from its MGB, it would not be able to continue to operate safety for 30 minutes.

No further action is planned by the regulatory bodies to address the deficiencies identified in A11-01. The action taken to date has significantly eliminated a potential loss of oil from the filter bowl assembly on the S-92 MGB, but the action does not reduce or eliminate the deficiency that Category A transport helicopter designs with a MGB certified under the "extremely remote" provision like the S-92 cannot sustain safe operation following a total loss of MGB oil.

Therefore, the responses in aggregate are assessed as **Unsatisfactory.**

Transport Canada's response to Recommendation A11-01 (November 2015)

As per the 2014 update, Transport Canada believes that the issue has been addressed. TC has no further activities planned on this recommendation.

2014 update:

Transport Canada, the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) formed a Joint Cooperation Team (JCT) and met in late 2011 and early 2012 to review the TSB accident investigation report and the accident in relation to the current design standards and guidance material relating to the certification of helicopter's main gearbox, specifically with respect to loss of lubrication.

The JCT review resulted in the revision and expansion of the test guidance for the certification of helicopter's main gearbox, FAA Advisory Circular AC 29-2C. The revisions provided further clarification in testing and certification procedure, including explanation of the term "extremely remote".

Through the actions taken, as described above and further to the briefing that Transport Canada provided to the Board in April of 2014, Transport Canada believes that it has fully addressed the intent of recommendation A11-01 and has addressed the underlying safety issue.

Board reassessment of the Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency's responses to Recommendation A11–01 (March 2016)

Since recommendation A11-01 was issued, together FAA, TC and EASA have carefully considered the deficiency identified by the TSB. Their collective answer to date is that they believe the use of the "extremely remote" provision used in the MGB 30 minute run dry certification criteria for Category A transport helicopters should stay in place. This implies that new Category A transport helicopter designs can continue to be certified without having to prove they are capable of 30 minutes of safe operation following a total loss of MGB oil.

They have also indicated that the actions taken to date following the Cougar Sikorsky S-92 accident have restored this aircraft type design to its expected level of safety. However, the safety deficiency identified by the TSB remains. If any S-92 helicopter currently in operation was to lose all the oil from its MGB, it would not be able to continue to operate safely for 30 minutes.

No further action is planned by the regulatory bodies to address the safety deficiencies identified in A11-01. The action taken to date has significantly eliminated one potential loss of oil from the filter bowl assembly on the S-92 MGB. However, the action does not reduce or eliminate the underlying safety deficiency. Category A transport helicopter designs with an MGB certified under the "extremely remote" provision like the S-92 cannot sustain safe operation following a total loss of MGB oil.

Therefore, the responses in aggregate are assessed as **Unsatisfactory**.

Next TSB action

The Board concludes that, as no further action is planned by the FAA, Transport Canada and EASA to address the risks identified in Recommendation A11-01, continued assessments will not likely yield further results.

The TSB will continue to monitor and investigate loss of main gearbox lubricant occurrences and communicate its findings to the FAA, Transport Canada and EASA.

This recommendation will not be reassessed on a regular basis.

This deficiency file is **Dormant**.