APPENDIX F: SAFETY ACTIONS FOLLOWING THE LN-OJF ACCIDENT

The following table describes the many safety actions and precautionary measures that were taken during the period following the LN-OJF accident and until the Accident Investigation Board Norway (AIBN) published the official accident report.

Date	Title	Description
29 April 2016	LN-OJF crashed into the sea at Turøy outside Berge, Norway.	The Accident Investigation Board Norway (AIBN) was notified by the Joint Rescue Coordination Center for Southern Norway at 1200 hrs. The first team of investigators from the AIBN was at the scene at 1850 hrs. The AIBN notified the involved organisations and authorities in accordance with the regulations.
29 April 2016	Grounding of EC 225 LP in Norway and UK	Shortly following the accident, CAA Norway (Safety Directive 16/05616-1) and CAA-UK (Safety Directive SD-2016/001) grounded Airbus Helicopters EC 225 LP helicopters. Search and Rescue (SAR) flights for the purpose of saving lives were exempted from this ban.
3 May 2016	EASA AD 2016-0089-E	EASA issued Emergency Airworthiness Directive AD 2016-0089-E (1) to require, as a precautionary measure, the accomplishment of one-time inspections on EC 225 LP helicopters: *Check the correct installation of the Front and Right Hand and Left Hand Rear MGB suspension bars in accordance with the instructions of Airbus Helicopters (AH) EC225 Alert Service Bulletin No. 53A058.* AD 2016-0089-E also called for precautionary examination of the MGB magnetic chip detectors and the MGB oil filter to check for absence of metallic particles, as well as to download data and check for any threshold exceedance for helicopters equipped with M'ARMS Vibration Health Monitoring system. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
11 May 2016	Grounding of AS 332 L2 in Norway and UK	CAA Norway (Safety Directive 16/05616-5) and CAA-UK (Safety Directive SD-2016/002) extended the scope of the Safety Directives by also grounding Airbus Helicopters type AS 332 L2 helicopters, except SAR.
13 May 2016	AIBN first preliminary report	The AIBN published the first preliminary report 13 May 2016, which gave a brief update on the progress and findings two weeks into the investigation, including a statement based on the CVFDR. Photos of some of the retrieved components were shown, including parts from the second stage planet gear and the fractured gear.

Date	Title	Description
27 May 2016	AIBN second preliminary report	The AIBN published a second preliminary report 27 May 2016, which stated that scenarios under consideration included failure of the epicyclic module, suspension bars (lift strut) and the MGB conical housing. This was in contrary a fault tree analysis presented by Airbus Helicopters to the AIBN, which did not include an internal epicyclic gear seizure. In addition, the report noted that the BEA had succeeded in downloading FDM data that extended approximately 13 seconds beyond the CVFDR data presented in the 13 May report.
1 June 2016	AIBN third preliminary report with safety recommendation	The AIBN published a third preliminary report 1 June 2016 with the following safety recommendation: *Recent metallurgical findings have revealed features strongly consistent with fatigue in the outer race of a second stage planet gear in the epicyclic module of the MGB. It cannot be ruled out that this signifies a possible safety issue that can affect other MGBs of the same type. The nature of the catastrophic failure of the LN-OJF main rotor system indicates that the current means to detect a failure in advance are not effective.* *The AIBN therefore recommends that EASA take immediate action to ensure the safety of the Airbus Helicopters H225 Main Gear Box.*
1 June 2016	EASA AD 2016-0103-E	Also on 1 June 2016, EASA issued superseding AD 2016-0103-E for further inspection and replacement instructions for correct installation of the MGB suspension bars and attachment fittings on EC 225 LP helicopters. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
1-2 June 2016	N-CAA and CAA-UK grounded all operations	Based on the third preliminary report with safety recommendation, the CAA Norway (Safety Directive 16/05616-9) grounded all operations with EC 225 LP and AS 332 L2 helicopters. The CAA-UK (Safety Directive SD-2016/003) also grounded all operations on 2 June 2016.
2 June 2016	EASA AD 2016-0104-E	EASA issued AD 2016-0104-E on 2 June 2016 and temporarily grounded all civilian[1] EC 225 LP and AS 332 L2 helicopters. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
28 June 2016	AIBN forth preliminary report	The AIBN published a forth preliminary report 28 June 2016. The report stated that: *At this stage of the investigation, the AIBN finds that the accident most likely was the result of a fatigue fracture in one of the second*

[1] The AD does not apply to EC 225 LP and AS 332 L2 helicopters while carrying out military, customs, police, search and rescue, firefighting, coastguard or similar activities or services, which remain under national legislation in the EASA Member States.

Date	Title	Description
		stage planet gears. What initiated the fatigue fracture has not yet been determined.
June 2016	Airbus Helicopters military EASB	On 15 June Airbus Helicopters published Emergency Alert Service Bulletins (EASB[2]) addressing Time Limits and Maintenance Checks – Main Rotor Drive, applicable only to helicopters which are not subject to EASA Flight Prohibition in AD 2016-0104-E. These require, as precautionary measures, repetitive inspection of the MGB oil filter and chip detectors and removal of all MGB repaired following unusual events. On 29 June Airbus Helicopters issued EASB[3] addressing Main Rotor Drive – Epicyclic Module – Replacement of the epicyclic module second stage planet gears, applicable to helicopters which are not subject to EASA AD 2016-0104-E. In effect, this meant replacement of FAG with NTN-SNR gears on all helicopters not subject to EASA AD 2016-0104-E.
June-October 2016	Plan for Return to Service (RTS)	Following EASA grounding of the civilian EC 225 LP and AS 332 L2 helicopters on 2 June 2016, Airbus Helicopters started working towards a plan for Return to Service (RTS). As per their DOA obligations, Airbus Helicopters reported to EASA the status of their investigation and analysis at the time, and presented a proposal for RTS with two axis of action based on the two published military EASBs: 1. *To prevent planet gear fatigue failure initiation.* *2. To enhance the planet gear spalling detection means.* After technical discussions, Airbus Helicopters substantiated a corrective actions package for RTS that EASA assessed to restore acceptable level of safety in accordance with Part-21 and later on mandated it by EASA AD 2016-0199 lifting the EASA grounding of the fleet. EASA paired it with a post-RTS action plan for Airbus Helicopters (see CARI below). Before the EASA RTS on 13 October 2016 (the effective date of AD 2016-0199), EASA briefed the AIBN on the proposed RTS actions.
6 October 2016	Post-return to service Continuing Airworthiness Review Item (RTS CARI)	The post RTS CARI was an essential element of the EASA strategy for return to service. The CARI is an EASA tool that the Agency used to keep control of the RTS safety, to steer the type certificate holder investigation works and to instigate new actions towards further safety progress in an agreed timeframe. The CARI was raised on 6 October 2016 in conjunction with issuance of EASA AD 2016-0199.

[2] Alert Service Bulletin Nos. ASB 05.01.07 (AS 332 L2), ASB 05.00.82 (AS 532). ASB 05A049 (EC 225 LP) and ASB 05A045 (EC 725).
[3] Alert Service Bulletin Nos. ASB 63.00.83 (AS 332 L2), ASB 63.00.38 (AS 532), ASB 63A030 (EC 225 LP) and ASB 63A029 (EC 725).

Date	Title	Description
		The RTS CARI consisted of a batch of 17 post-RTS actions/items (Note: this initial CARI was amended by EASA in 2017 to require additional post-RTS actions/items): 1. Outer race (OR) spalling cases expertise. 2. Lift bearing and mast splines reliability. 3. "G-REDL test" additional analysis. 4. Decision on ISIR SP1502 (M1018) planet gear (NTN-SNR planet gear with spalling on outer race). 5. Particles speed detection. 6. "Aggressive" spalling (related to NTN-SNR planet gears). 7. Fatigue characteristics of shocked gears. 8. New oil debris monitoring means. 9. Design criteria. 10. Service experience: feedback on post-RTS spalling instances. 11. a) Further FAG gear test after impact damage. b) Further test of current oil debris monitoring. 12. MGB lubrication. 13. Application of EASA CM-S-007 Issue 01. 14. DOA procedures for reliability analysis of critical parts. 15. ICA and maintenance related actions. 16. Post-RTS feedback on MGB in-service issues. 17. Sub-surface cracking from spalling.
7 October 2016	EASA AD 2016-0199	On 7 October 2016, EASA lifted AD 2016-0104-E and issued AD 2016-0199 which allowed AS 332 L2 and EC 225 LP helicopters to fly, based on the accomplishment of the corrective actions package for RTS (see above) as specified in relevant Airbus Helicopters service publications[4]. In particular, this mandated prohibition of MGB second stage epicyclic planet gears (FAG gears) that failed and a strict inspection regime of MGB chip detectors and oil filter with more severe maintenance criteria (also associated with service life reduction of serviceable gears, flight manual amendment and the ban of all MGBs having been subject to unusual events). *Note: This AD is considered to be an interim action and further mandatory action may follow.*
25 February 2017	EASA AD 2017-0042	On 25 February 2017 EASA issued AD 2017-0042 requiring a one-time inspection of the oil cooler to acquire additional information on the condition of the MGB oil system[5]. The basis of this AD

[4] Alert Service Bulletin Nos. ASB 63.00.83 (AS 332 L2), ASB 63A030 (EC 225), ASB 05.01.07 (AS 332 L2) and ASB 05A049 (EC 225 LP).
[5] Airbus Helicopters has issued EASB 05A049 Rev 3 (EC 225 LP) and 05.01.07 Rev 3 (AS 332 L2) in line with the AD 2017-0042.

Date	Title	Description
		related to additional results delivered from further investigation performed by Airbus Helicopters, as required by the EASA's CARI (action item #11b), which showed that particles can be kept trapped in the oil cooler in case of MGB gears spalling degradation. Almost concurrently, Airbus Helicopter discovered a particle recovered from the oil cooler of LN-OJF and identified it as 16NCD13 spalling, thus possibly stemming from the fractured second stage planet gear. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
17 March 2017	EASA AD 2017-0050-E	On 17 March 2017 EASA issued AD 2017-0050-E following additional analysis and flight testing performed by Airbus Helicopters. It introduced additional repetitive inspections of the oil cooler, with relevant revision of the inspection intervals of the previous mandatory periodical check of the MGB oil filter[6]. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
29 April 2017	AIBN fifth preliminary report	One year following the accident, the AIBN published its fifth preliminary report. The report was about 100 pages with mainly factual information. The AIBN issued no safety recommendations in connection with the report.
13 June 2017	EASA AD 2017-0104	With regard to the two types of planet gears used on AS 332 L2 and EC 225 LP, Airbus Helicopters reviewed its entire range of helicopters. As a result, it was decided to implement precautionary measures on the SA365 / AS365 / EC155 helicopters (i.e. the Dauphin helicopters) to improve the reliability of the installed MGB. On 13 June 2017 EASA issued AD 2017-0104 requiring repetitive inspections of the MGB magnetic plugs, the identification of the planet gear assemblies installed in the MGB and, depending on finding, the replacement of the planet gear assemblies (replacement of FAG and SFK gears with NTN-SNR gears).
23 June 2017	EASA AD 2017-0111	Following EASA AD 2017-0050-E mandating repetitive inspection of the MGB oil cooler, the potential increased risk associated to this heavy maintenance had led to accelerate Airbus Helicopters' work for the development of new oil debris monitoring means as required by the EASA CARI (action item #8). On 23 June 2017 EASA approved the major MOD 07 53047 on EC 225 LP helicopters for installation of a Full Flow Magnetic Plug (FFMP) device enabling collection of MGB particles upstream of

[6] Airbus Helicopters has issued EASB 05A049 Rev 4 (EC 225 LP) and 05.01.07 Rev 4 (AS 332 L2) in line with the AD 2017-0050-E.

Date	Title	Description
		the oil cooler. The same day, EASA issued AD 2017-0111 to mandate this FFMP modification for the EC 225 LP helicopters with post-MOD 07 53047 cancellation of the oil filter and oil cooler inspections[7]. In addition for both AS 332 L2 and EC 225 LP this AD required further reduction of MGB serviceable gears service life to align with the decision to streamline MGB maintenance practices by suppressing of the MGB modularity concept prevailing so far. For the EC 225 LP, a new service life limit (SLL) for the second stage planet gear was set to 1,100 hours (1,000 + 10 %). For AS 332 L2, new SLL was set to 1,650 (1,500 + 10 %). *Note: This AD is considered to be an interim action and further mandatory action may follow.*
20 July 2017	N-CAA and CAA-UK lifted the flight prohibition	On 20 June 2017 N-CAA and CAA-UK lifted the flight prohibition on AS 332 L2 and EC 225 LP helicopters. This was based on the safety measures introduced by EASA as listed above.
25 July 2017	Airbus Helicopters Information Notice No. 3140-I-00	Airbus Helicopters introduced an improved container with spring dampening for transporting MGB components. The container is equipped with g-recorder. If any exceedances are registered, Airbus Helicopters must be contacted.
27 July 2017	EASA AD 2017-0134	On 27 July 2017 EASA issued AD 2017-0134. This AD retains the requirements of EASA AD 2017-0111, which is superseded and requires an improvement for the FFMP of the EC 225 LP helicopters (MOD 07 53052) and installation of an FFMP device for AS 332 L2 helicopters (MOD 07 53049) with adaptation of the MGB oil filter and oil cooler inspections. *Note: This AD is considered to be an interim action and further mandatory action may follow.*
22 September 2017	EASA AD 2017-0133 and EASA AD 2017-0189	Following the review of data, reported after accomplishing actions as required by EASA AD 2016-0089-E, applicable to EC 225 LP helicopters, it was determined that the installation of MGB upper deck fittings of the three MGB suspension bars, could lead to tightening torque loss on the attachment pins of the fittings. Due to design similarity, AS 332 L2 helicopters could also be affected by the same installation condition. EASA issued first AD 2017-0133 to require implementation of an add-on penalty factor to the FH accumulated by the affected parts and, before exceeding the applicable SLL, replacement. However, the referenced ASB contained an error. On 22 September 2017 EASA issued

[7] Airbus Helicopters has issued EASB 05A049 Rev 5 (EC 225 LP) and 05.01.07 Rev 5 (AS 332 L2) in line with the AD 2017-0111.

Date	Title	Description
		AD 2017-0189 which retains the requirements of EASA AD 2017-0133, which is superseded, but requires use of the revised ASB for AS 332 L2 helicopters. *Note: This AD is considered to be an interim action and further mandatory action may follow.*