aibn Accident Investigation Board Norway

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# REPORT SL 2016/01

# REPORT ON THE SERIOUS AIRCRAFT INCIDENT 12 AUGUST 2014 AT RØRVIK AIRPORT, NORWAY, WITH AIRBUS HELICOPTERS EC 130 B4, LN-ORR, OPERATED BY HELICOPTER UTLEIE AS



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*This report has been translated into English and published by the AIBN to facilitate access by international readers.*
*As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.*

**Photos: AIBN and Trond Isaksen/OSL**

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## REPORT REGARDING SERIOUS AIRCRAFT INCIDENT

| | |
|---|---|
| Aircraft: | Airbus Helicopters EC 130 B4 |
| Nationality and registration: | Norwegian, LN-ORR |
| Owner: | ANS Munkedammen, Norway |
| User: | Helikopter Utleie AS, Norway |
| Crew/commander: | 2, commander and loadmaster, no injuries |
| Passengers: | None |
| Accident site: | Runway 22 Rørvik Airport, Ryum ENRM (64.50.20N 11.08.50E) |
| Accident time: | Tuesday, 12 August 2014 at 1800 hours |

All hours stated in this report are local time (UTC + 2 hours) unless otherwise indicated.

## NOTIFICATION

On Tuesday 12 August at 1827 hours, the Accident Investigation Board's officer (AIBN) on duty received notification from the Flight Operations Manager in Helikopter Utleie AS that LN-ORR, one of the company's EC 130 B4, had lost tail rotor control during approach to Rørvik Airport, Ryum. The pilot managed to land the helicopter on the runway without damage.

An inspector of accidents from the Accident Investigation Board was dispatched the next day to start the investigation. In accordance with ICAO Annex 13, "Aircraft Accident and Incident Investigation", the Accident Investigation Board notified the investigation authority of the manufacturing country France (Bureau d'Enquêtes et d'Analyses pour la securité de l'aviation civile - BEA). BEA appointed an accredited representative who, together with consultants from Airbus Helicopters, assisted in the investigation. The EASA (European Aviation Safety Agency) was also notified.

## SUMMARY

The helicopter was about to land at Rørvik Airport for refuelling. There were two people on board, the commander and loadmaster. Uncontrolled rotation to the left started as the helicopter passed runway treshold at an altitude of 5-10 metres. The commander quickly understood that he had no directional control, and chose to land the helicopter without engine power. The helicopter rotated twice around its own axis before it was landed on the runway. No injuries or damage occurred. After landing, it was quickly discovered that there was no mechanical connection between the fenestron (tail rotor) and the engine's reduction gearbox.

A technical investigation revealed that the tail rotor shaft had fractured due to incorrect installation of the tail rotor shaft bearing no. 1. The incorrect installation led to cyclic loads in the tail rotor

shaft, which eventually caused a fracture. The bearings on the tail rotor shaft were replaced in connection with scheduled maintenance 98 flying hours prior to the incident.

Since an incorrect installation of bearing no. 1 caused the fracture, further investigations were conducted both in the helicopter company's Part M organisation and in the maintenance organisation that delivers maintenance services to the helicopter company. The investigations identified a number of deficiencies in connection with planning of maintenance, routines for systematic control of critical maintenance activities, as well as routines for maintaining technical personnel's competence.

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

1.1.1 The helicopter was on a ferry flight from Bardufoss to the company's base in Stryn. It took off at 1515 hours with the commander and a loadmaster on board. The original plan was to land in Brønnøysund for refuelling, but they had enough fuel to continue to Rørvik Airport.

1.1.2 Passing treshold of runway 22 at Rørvik at an altitude of 5-10 metres and with a speed of approximately 30 kt, the helicopter started rotating to the left. There were no noises or other indications of technical failure, and the commander initially believed there was a wind gust from behind. The pedals had no effect, and the rotation towards left increased rapidly.

1.1.3 When the helicopter had rotated approximately 180 degrees, the commander understood that the tail rotor control had failed. He rolled off the "twist-grip" (engine control) on the collective lever and the rotation slowed down somewhat. During this phase, the commander focused on keeping the helicopter's attitude correct in order to land the helicopter on the runway. When the helicopter was close to the ground, the commander pulled the collective lever to reduce the sinkrate. The helicopter hit the ground somewhat hard, and made a few jumps before it settled in a position that deviated 45-90 degrees from the first contact with the ground. According to the commander, the helicopter rotated 720 degrees before landing.

1.1.4 No noises or vibrations were observed after the helicopter had landed and the engine still was running. The loadmaster exited the helicopter to check for any abnormalities. He observed that the tail rotor had stopped. The commander shut off the engine and stopped the main rotor using the rotor brake.

1.1.5 The commander inspected the helicopter after the rotor had stopped. No visible damage was observed. The company's Flight Operations Manager was notified, and the commander received a message to not move the helicopter until Accident Investigation Board Norway (AIBN) had granted permission.

## 1.2 Injuries to persons

*Table 1: Injuries to persons*

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatalities | | | |
| Serious | | | |
| Light/none | 2 | | |

## 1.3 Damage to aircraft

There was no damage to the helicopter apart from the fractured tail rotor shaft, see also Chapter. 1.12 for further details.

## 1.4 Other damage

None.

## 1.5 Personnel information

### 1.5.1 Commander

The commander, aged 41, had civil helicopter education from 1999. He received his training in USA and operated there until 2003, when he converted to European/Norwegian CPL(H). He started working as a pilot in Helikopter Utleie AS in 2008.

*Table 2: Flying hours commander*

| Flying hours | All types | Relevant type |
|---|---|---|
| Last 24 hours | 6.5 | 6.5 |
| Last 3 days | 9.5 | 9.5 |
| Last 30 days | 59 | 59 |
| Last 90 days | 109 | 100 |
| Total | 2,753 | 284 |

### 1.5.2 Licensed aircraft technician

1.5.2.1 The licensed aircraft technician, aged 62, had a Part 66 certificate valid until 2 August 2016. The certificate documented B1/B2/C privileges on single-engine turbine-powered helicopters (Group rating HSTE – Helicopters Single Turbine Engine). The employer SAM Aero (maintenance organisation/EASA Part 145) renewed his privileges to perform maintenance on this group of helicopters 16 July 2014 through an internal authorisation certificate. The basis for renewal of the internal certificate was training and individual assessment carried out in accordance with routines described in the company's Maintenance Organisation Exposistion (MOE). He also held the role as "Maintenance Senior Engineer" in SAM Aero.

1.5.2.2 SAM Aero's helicopter maintenance services were only performed by the mentioned technician. He worked alone at Helicopter Utleie's base in Stryn and performed the work according to work orders issued by Helikopter Utleie's Continuing Airworthiness (Part M) function.

1.5.2.3 The technician was one of the founding members of the company Scandinavian Aircraft Maintenance in 2004. This company declared bankruptcy in 2010, and SAM Aero was founded the same year, with the technician as the principal shareholder (see also Item 1.17.2). He was contracted from Scandinavian Aircraft Maintenance as the technical manager in Helikopter Utleie AS from 2004 to 2008. He has recently worked as a licensed aircraft technician employed by SAM Aero and contracted to Helikopter Utleie AS.

1.5.2.4 After the incident, Helikopter Utleie AS did a review of performed maintenance work on all their helicopters. Shortly thereafter, the Norwegian Civil Aviation Authority also conducted a technical inspection of the helicopters. These inspections revealed several irregularities, and the technician's privileges were suspended.

## 1.6 Aircraft information

### 1.6.1 Introduction

The EC 130 B4 is a light single engined helicopter with three main rotor blades and a fenestron tail rotor.[1] The helicopter is a successor to helicopter type AS 350, and has the same engine and main rotor system. Significant parts of the helicopter are made of composite materials. The cabin has two doors on each side. LN-ORR is equipped with three seats in the front and four seats in the back. The helicopter can be flown from the left and middle front seats. The flight controls are operated by two independent hydraulic systems. The helicopter was new in 2009, and had flown 432 hours at the time of the incident. Helikopter Utleie AS acquired the helicopter in 2010, with a total time of 27.3 hours.

*Figure 1: EC 130 B4. Photo: Helikopter Utleie AS*

[1] Fenestron is a built-in tail rotor that is constructed to reduce noise and increase the safety for personnel moving around the aircraft on the ground. The "fan housing" also protects the rotor against foreign objects upon landing and take-off from narrow sites.

### 1.6.2 Helicopter data

| | |
|---|---|
| Manufacturer: | Airbus Helicopters |
| Type designation: | EC 130 B4 |
| Serial number: | 2427 |
| Construction year: | 2009 |
| Airworthiness certificate: | Issued 23 April 2010 |
| Airworthiness Review Certificate: | Valid until 22 April 2015 |
| Accumulated flying hours: | 432 hours |
| Engine: | 1 Turbomeca Arriel 2B1 |
| Engine rating max take-off power: | 543 kw/728 shp |
| Diameter main rotor: | 10.69 m |
| Maximum mass: | 2,427 kg |
| Mass empty (company configuration): | 1,557.73 kg |
| Fuel: | Jet A1 |

### 1.6.3 Relevant weight and location of the centre of gravity

| | Arm | Weight (kg) | Moment |
|---|---|---|---|
| The helicopter's empty mass | 3.552 | 1,557.73 | 5,533.45 |
| Crew | 1.55 | 173.00 | 268.15 |
| Compartment right side | 3.20 | 20.00 | 64.00 |
| Compartment left side | 3.20 | 20.00 | 64.00 |
| Aft compartment | 4.60 | 10.00 | 46.00 |
| Fuel | 3.475 | 426.00 | 1,480.35 |
| CG and total mass at the time of the accident | **3.38** | **2,206.73** | **7,455.95** |

Operation of the helicopter was within limitations as regards both weight and the location of the centre of gravity.

### 1.6.4 Tail rotor shaft

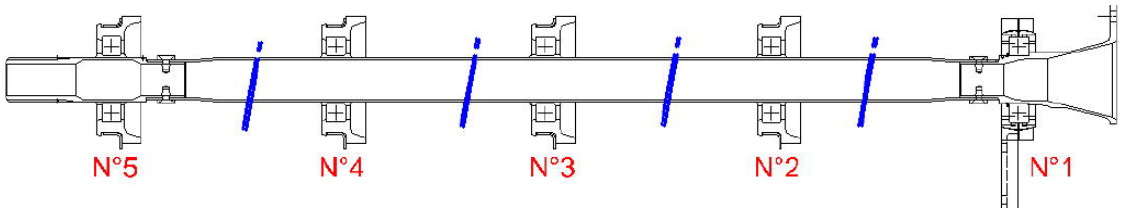


*Figure 2: Illustration of the intermediate section of the tail rotor shaft. Source: Airbus Helicopters*

A shaft consisting of three sections drives the fenestron (tail rotor). The shaft fracture occurred in the intermediate section. This section is supported by five bearings (see Figure 2). The aft part of the intermediate shaft section consists of a steel adapter attached with six rivets. This adapter is the part of the shaft on which bearing no. 1 is installed. From bearing no. 1, a short shaft (not illustrated) runs back to the tail rotor's gearbox. This short shaft is connected to the intermediate shaft section's adapter with a flexible coupling that absorbs movements between the tail boom and tail structure with the tail rotor. The tail boom is made of aluminium, whereas the tail structure is made of composite material.

### 1.6.5 Description of bearing no. 1

Bearing no. 1 is the aft bearing on the tail rotor shaft. The bearing is held in place by clamping the outer bearing race, which consists of two "Half Spherical Bearings", between "Bearing drive" and "Bearing flange" (see Figure 3). The purpose of this installation is to allow for adjustments of the bearing's position to prevent bending of the tail rotor shaft.

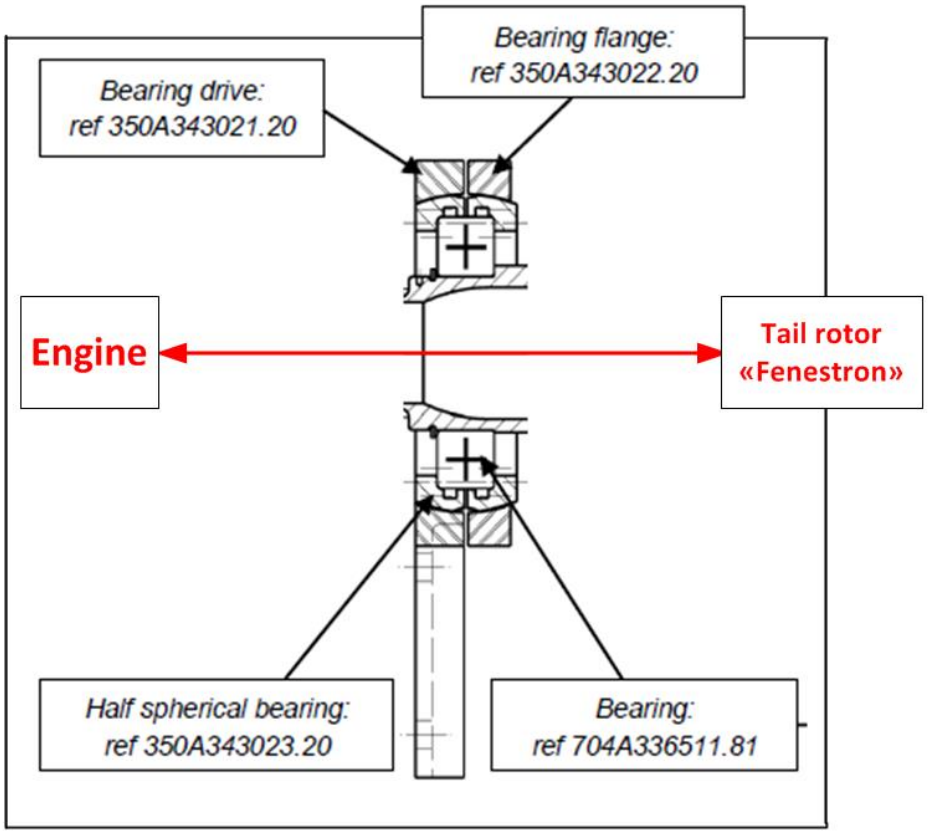


*Figure 3: Bearing no. 1 layout. Source: Airbus Helicopters/processed by AIBN*

## 1.7 Meteorological information

METAR for Rørvik at 1620 hours on 12 August shows that there were visual meteorological conditions (VMC), light clouds at 4,500 feet with visibility over 10 km, the wind was variable 2 knots. The temperature was 21 °C and dew point was 8 °C.

Actual wind as given by AFIS (Aerodrome Flight Information Service) was approximately 3-5 kts from south westerly direction.

## 1.8 Aids to navigation

Not applicable

## 1.9 Communications

Not applicable

## 1.10 Aerodrome information

Rørvik Airport Ryum (ENRM) has a runway length of 890 metres. The airport has Aerodrome Flight Information Services (AFIS), and an AFIS representative witnessed the incident.

## 1.11 Flight recorders

The helicopter is equipped with Vehicle and Engine Multifunction Display (VEMD) which registers exceedances and system faults for the last 31 registered flights. There were no registered limit value exceedances as regards torque or rotor rpm on these flights.

## 1.12 Wreckage and impact information

The helicopter landed approximately 100 metres past the threshold on runway 22, and was moved from the runway to an apron for closer investigation after the landing. It was quickly concluded that the tail rotor (fenestron) no longer was mechanically connected to the engine's reduction gearbox. When the Accident Investigation Board arrived the following day, the covers over the tail rotor shaft were opened, and a fracture was found in front of bearing no. 1 on the tail rotor shaft (see Figure 4).

*Figure 4: Fracture in the rivet joint on the intermediate tail rotor shaft section installed in LN-ORR. Photo: AIBN*

The fracture occurred in the rivet joint between the shaft and the adapter for aft flexible coupling (see Figure 5).

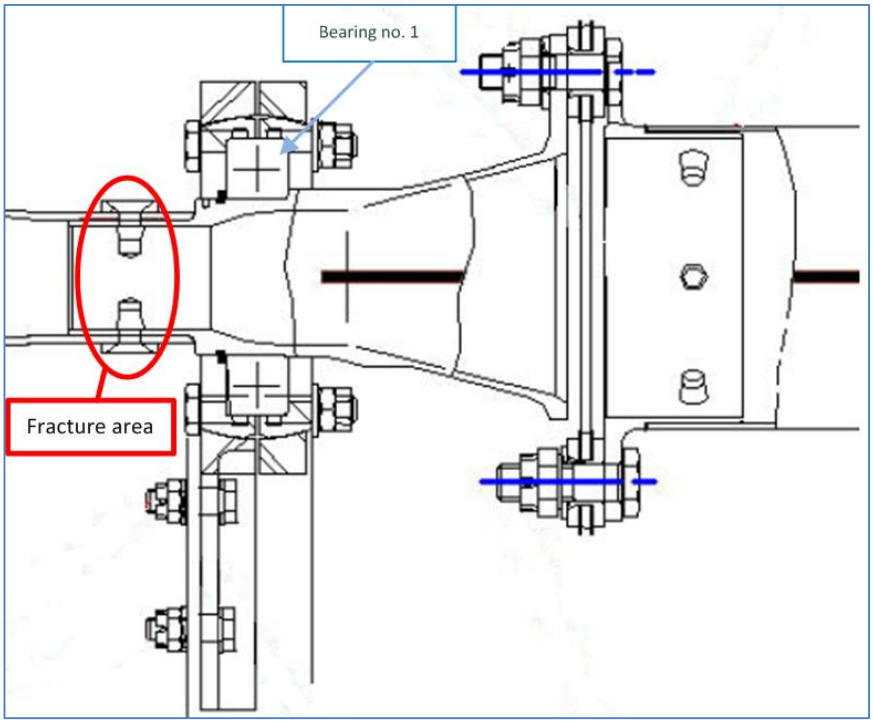


*Figure 5: Details bearing no. 1. The flexible coupling on the right. Damage area marked in red. Source: Airbus Helicopters*

## 1.13 Medical and pathological information

Not applicable

## 1.14 Fire

Not applicable

## 1.15 Survival aspects

Not applicable

## 1.16 Tests and research

1.16.1 Preliminary technical investigation

1.16.1.1 Following the initial investigations at Rørvik Airport, the helicopter was transported by lorry to the company's base in Stryn. Representatives from BEA and Airbus Helicopters conducted a preliminary technical investigation under the leadership of AIBN. Due to the shaft fracture and readout from the VEMD, the investigation focused on the tail rotor shaft and the shaft installation. The condition of the shaft, bearings and their attachments were inspected, as well as the geometry of the tail boom

1.16.1.2 The position[2] of bearing nos. 2, 3, 4 and 5 was measured in relation to the shaft, and they complied with acceptable criteria. There were no abnormalities in the actual bearings.

1.16.1.3 The brackets attaching bearings nos. 2, 3, 4 and 5 to the tail boom were intact and correctly installed.

1.16.1.4 The tail boom and bearing support brackets were inspected with optical measuring equipment and were found to be within acceptable criteria as regards geometry.

1.16.1.5 The condition of the flexible connections behind bearing no. 1 and in front of bearing no. 5 was normal, apart from an indication of separation between the flexible plates in the coupling behind bearing no. 1 (see Figure 6).

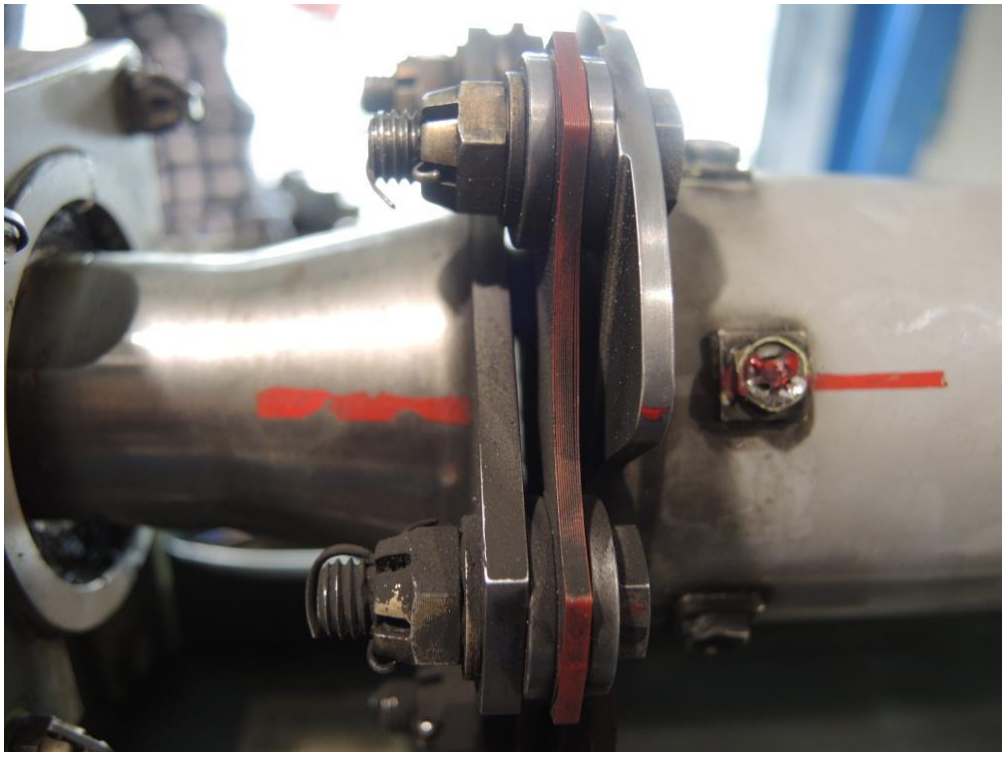

*Figure 6: Sign of separation in the flexible coupling behind bearing no. 1. Photo: BEA*

[2] The bearings shall be installed in a perpendicular position in relation to the tail rotor shaft.

1.16.1.6 Bearing no. 1 was subject to special attention as the shaft fracture occurred in its vicinity. It became evident that the position of the bearing in relation to the shaft did not comply with the Aircraft Maintenance Manual (AMM) requirements. The measured discrepancy was approximately 1 millimetre, whereas the maximum permitted value in the AMM is 0.1 millimetre (see Figure 7).

*Figure 7: Bearing no. 1, clamped between Bearing Drive and Bearing Flange. Angular discrepancy marked with red lines. Photo: AIBN*

1.16.2 Investigation of the tail rotor shaft

1.16.2.1 The tail rotor shaft and all bearings were sent to Airbus for further investigations in accordance with AIBN guidelines. The results of these investigations showed that the shaft fracture occurred in the shaft/adapter joint due to cyclical loads.

1.16.2.2 The connection has six rivets (see Figure 5). The adapter and shaft were removed, and the rivet holes in the adapter showed signs of the rivets moving (see Figure 8).


*Figure 8: Rivets and rivet holes in adapter. Photos: Airbus Helicopters*

1.16.2.3 The deformation in the holes and the wear on the rivets appears to have occurred over time. The wear pattern indicates that the rivets lost their grip after installation. This caused movement, and the holes in the adapter were deformed and rivet material became worn.

1.16.2.4 When the rivets came loose gradually, the load increased to such a point that fatigue fractures occurred in some of the rivet holes on the shaft. There were also signs of a ductile fracture in one of the rivet holes (see Figure 9).

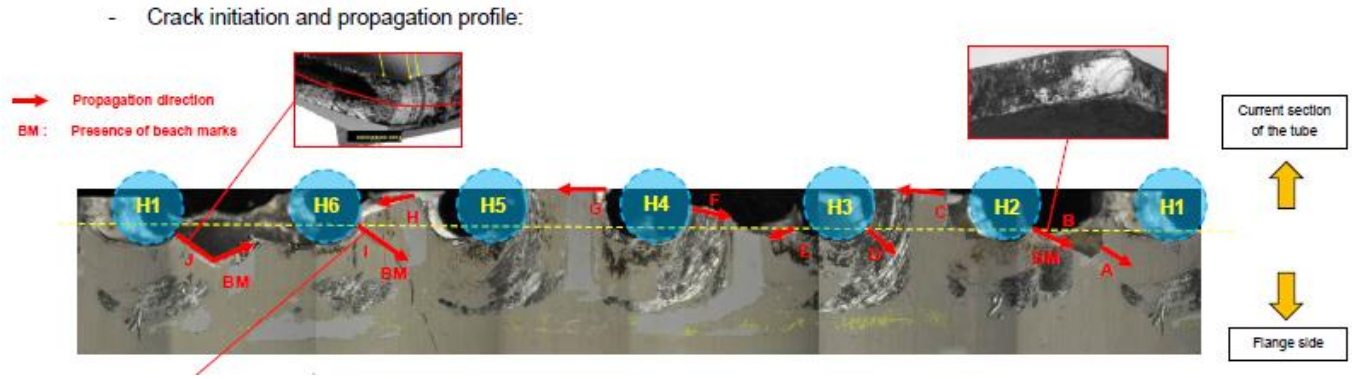


*Figure 9: Fractures and surface of fractures in the shaft. Source: Airbus Helicopters*

### 1.16.3 Investigation of bearing no. 1

#### 1.16.3.1 *Condition of the bearing*

In consultation with AIBN, Airbus sent bearing no. 1 to the manufacturer, FAG, for analysis. The analysis showed that the bearings balls had made an abnormal track in the outer race (OR "Outer Race" on Figure 10).

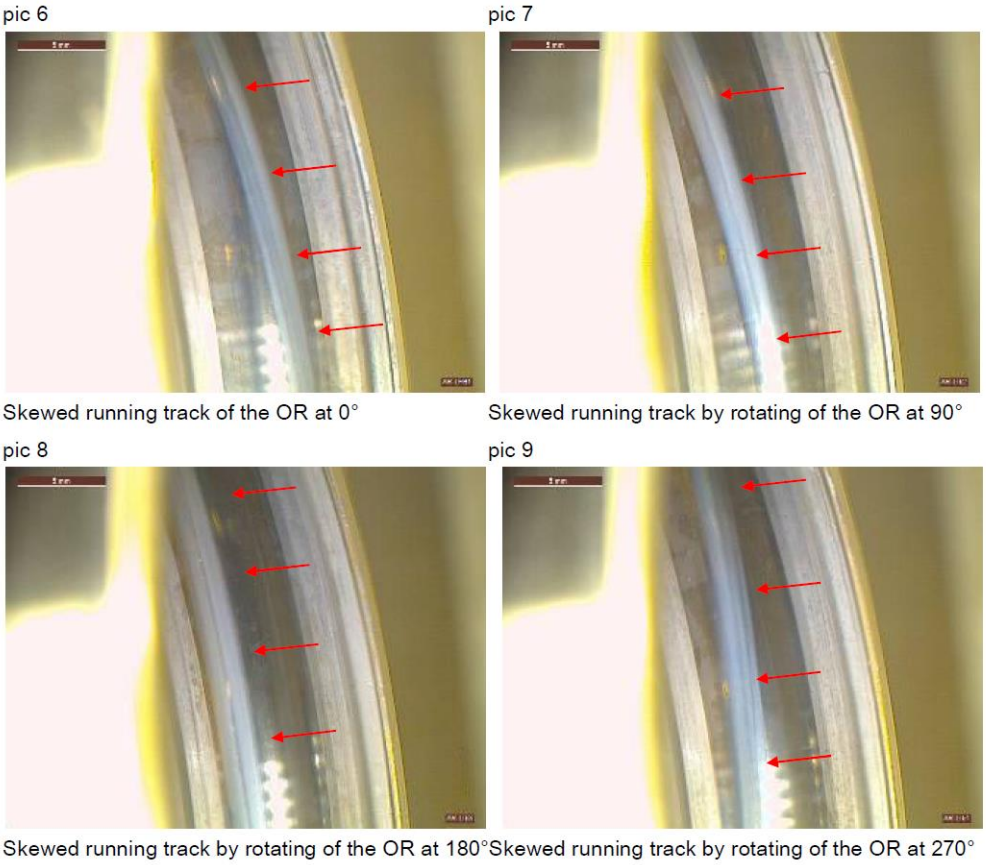


*Figure 10: Abnormal tracks in the outer race. Source: FAG*

FAG's conclusion:

> *This detrimental operation must have occurred for a number of hours before the fracture of the drive shaft in order to cause the distinctively degenerated running tracks. The misalignment of the bearing requires a bending moment induced from / to the shaft and this is the reason for the fretting of the inner ring bore essentially on one side only. Accordingly, the reason for the fracture of the drive shaft could be the incorrect misaligned assembly of the bearing. However, the reason for the misaligned assembly in the spherical bearing housing is not understood.*

### 1.16.3.2 *The bearing's position in "Bearing drive/Bearing flange"*

Bearing no. 1 was installed 98 flying hours before the fracture in the tail rotor shaft. The investigation showed that the position of the bearing was askew in relation to "Bearing drive/Bearing flange" (Figure 7). There were no signs of movement between the bearing and "Bearing drive/Bearing flange" after installation. Three out of the four fastening bolts had somewhat low torque values. The AMM requires a value of 7.5-9 Nm, whereas these had values between 5.5 and 6 Nm.

AIBN asked the technician who installed the bearing to demonstrate the measurement method for verifying the bearing's position in "Bearing drive/Bearing flange". The measurement demonstrated to AIBN did not comply with the method described in the helicopter's AMM. The tail boom was used as a reference for the measurement in the demonstration (see Figure 11).

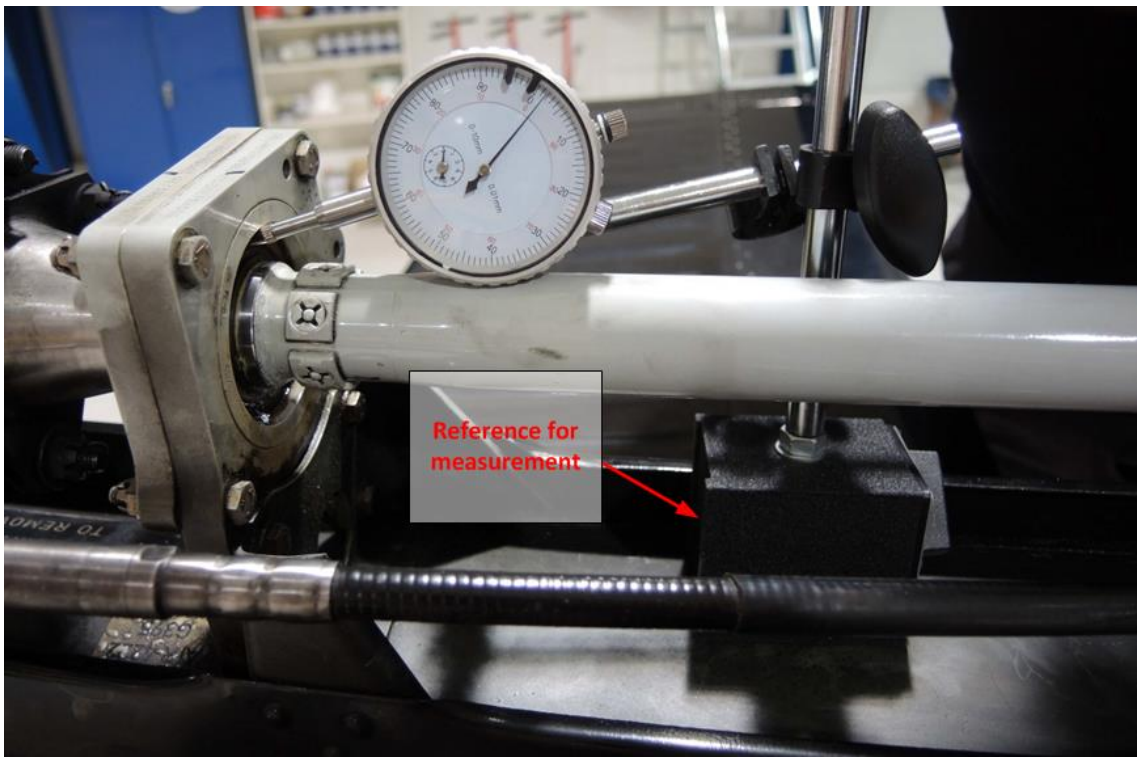


*Figure 11: Technician's measurement demonstration. The tail boom structure is the refence for the measurement. Photo: AIBN*

In order to achieve a result that expresses the bearing's position in relation to the tail rotor shaft, the tail rotor shaft must form the basis for the measurement, as shown in Figure 12. This is also illustrated in the AMM (see Figure 13).

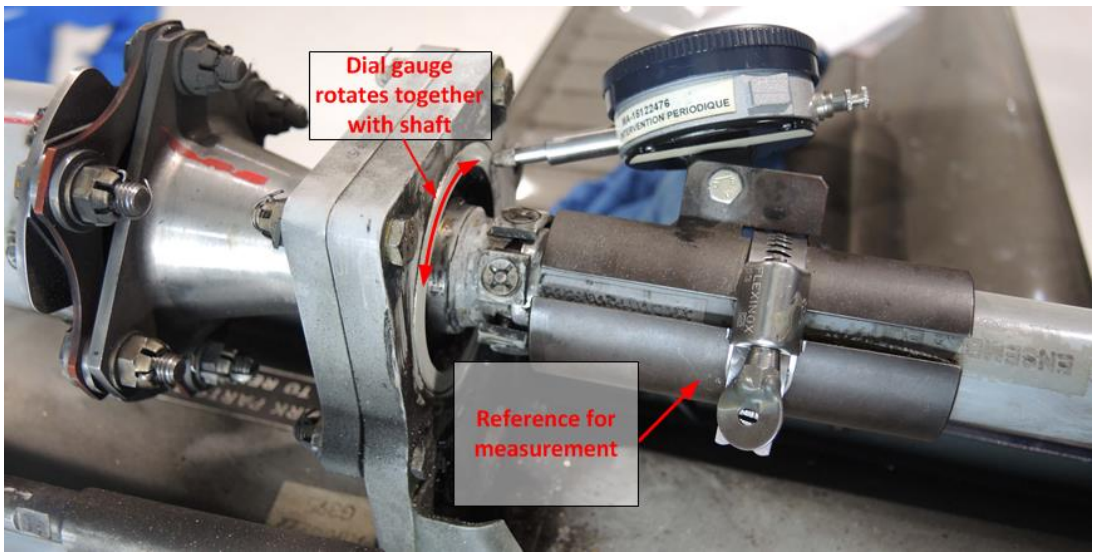


*Figure 12: Correct use of measuring equipment. The tail rotor shaft is the reference for the measurement. Photo: AIBN*

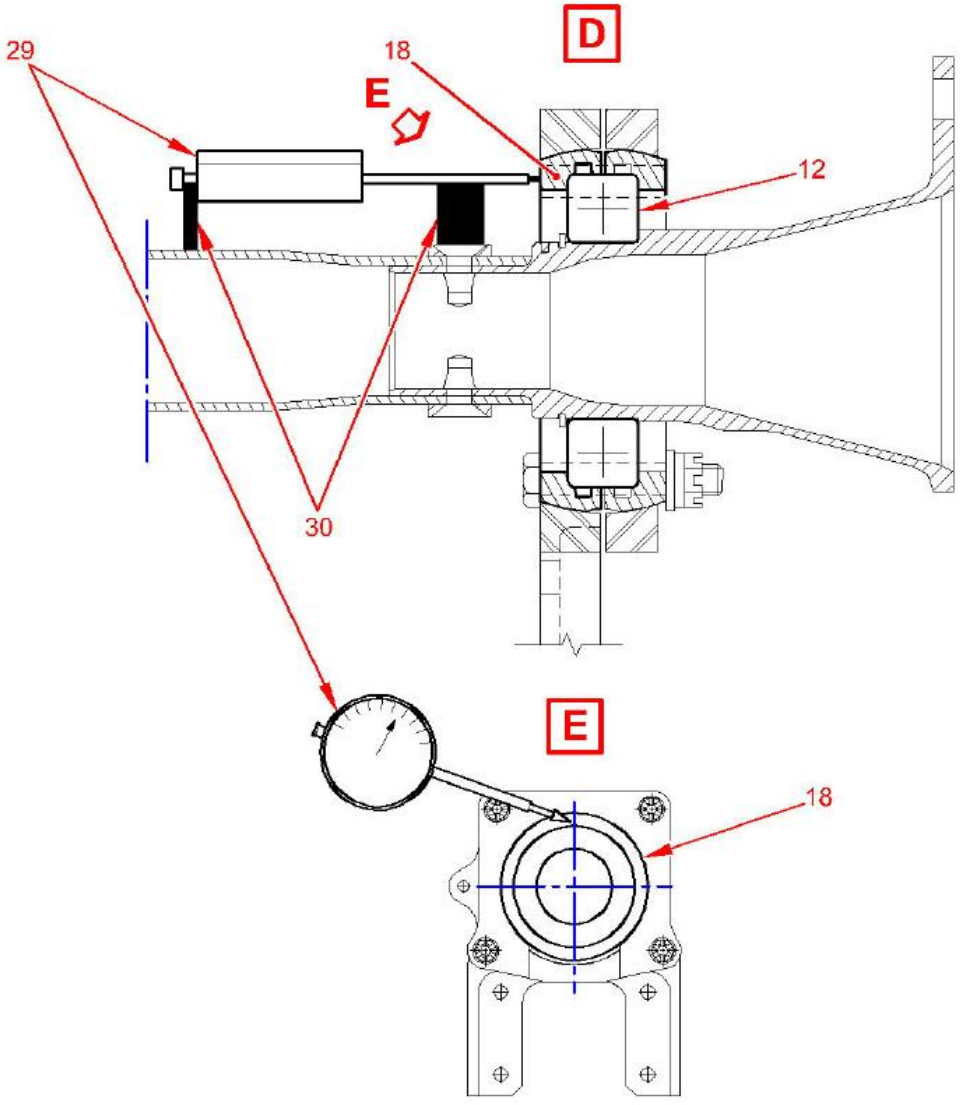


*Figure 13: Measurement method i.a.w. AMM. Source: Airbus Helicopters*

An adapter is attached to the tail rotor shaft, and the dial gauge is installed on this adapter. This causes the dial gauge to rotate together with the shaft, and a potentially skewed installation of the bearing can be measured.

According to the AMM, the adapter to attach the dial gauge to the tail rotor shaft shall be produced locally. This adapter was not used by the technician during the measurement.

Airbus Helicopters' internal report following the incident concluded that the measuring method and adapter to attach the dial gauge to the tail rotor shaft should be emphasised more clearly in AMM, so there is a greater degree of reproducibility of the measurement results when replacing bearing no. 1.

### 1.16.4 Tail structure

1.16.4.1 Scratches were detected on the underside of the skid underneath the tail (see Figure 14). The purpose of this tail skid is to protect the tail structure from hitting the ground. These scratches indicated contact with the ground, and the tail boom was therefore subject to closer investigation.

*Figure 14: Skid underneath tail structure. Photo: BEA*

1.16.4.2 Cyclic bending of the tail rotor shaft could have been caused by deformations in the tail boom. Such deformations might be the result of unintended contact with ground or obstacles. To check for this possibility, a measurement was conducted using optical equipment as shown in Figure 15. An optical pointfinder and optical target plates were installed on the tail rotor bearing attachment brackets. The check showed that the tail boom geometry was within acceptable criteria.

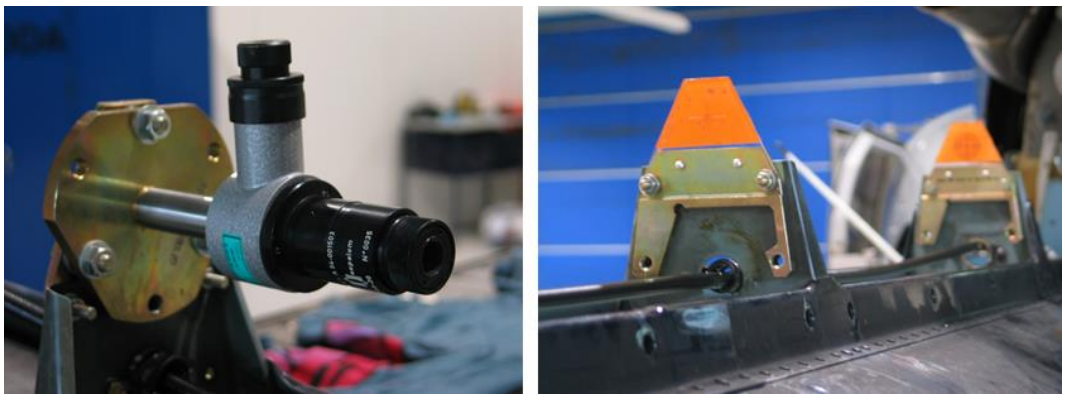

*Figure 15: Equipment for measuring the tail structure's geometry. Photo: BEA*

## 1.17 Organisational and management information

### 1.17.1 Helikopter Utleie AS

#### 1.17.1.1 *Introduction*

Helikopter Utleie AS was founded in 2001. The company received an Air Operator Certificate (AOC) in 2003. The company built up its business with sight-seeing flights for tourists, air taxi flights and cargo flights. In 2007, the company gathered its operations in a new facility at Stryn (hangar, operative base and landing site). At the time of the incident, the company operated two EC 130 B4s and one EC 120, all produced by Airbus Helicopters.

On 25 March 2011, Helikopter Utleie's "Continuous Airworthiness" department entered into a maintenance contract with the Part 145 organisation SAM Aero.

Helikopter Utleie AS later changed its name to Fjord Helikopter AS. The name Fjord Helikopter AS has been used in a commercial context for a long time.

#### 1.17.1.2 *Organisation Helikopter Utleie AS*

Helikopter Utleie AS' organisation according to the company's "Quality and Internal Control Handbook" (QAI):

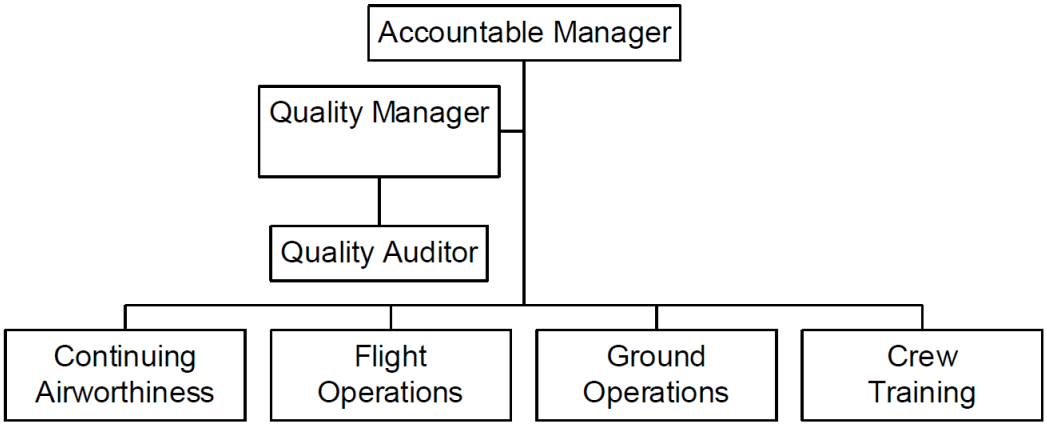


*Figure 16: Organisation chart Helikopter Utleie AS. Source: Helikopter Utleie AS*

The Accountable Manager was also the Quality Manager in the company. An external quality auditor was contracted to cooperate with the company's Quality Manager on a permanent basis.

The person responsible for the company's "Continuing Airworthiness" (Nominated Postholder Part M) was a contractor. He had the same role in another helicopter company, while also working as a licensed aircraft technician in a third company. This job involved preparing maintenance programmes based on the manufacturer’s recommendations and aviation authority requirements, and to order maintenance so that maintenance and component replacements were done within given intervals. This was done in the form of "Maintenance Orders" to the maintenance organisation with which the company currently had a maintenance contract.

1.17.1.3 *Excerpts from the company's QAI, safety policy*

> *Owners and management must assure that quality, internal control, flight operations, maintenance and air safety programs are followed. All directives from the government shall be complied with within the given time limits.*
>
> *Nowhere in the organization shall the safety be compromised. This includes internal control, flight operations, maintenance, inspections, modifications or other operative dispositions.*

1.17.1.4 *The company's "Continuing Airworthiness Management Exposition" (CAME)*

The company's CAME is the governing document for maintaining the airworthiness of the company's aircraft fleet and is based on the regulations in EASA part M, "Continuous Airworthiness Requirements

Chapter 1.2.0.4 of the company's CAME states the following:

> ***Inspection Standards***
>
> *The Inspection Standards applicable are those given by the type certificate holders of the airframe, engine, propellers and rotors and equipment and detailed in Part M. Other Inspection Standards will be adopted if and when these are promulgated by EASA.*

1.17.2 SAM Aero (SAM)

1.17.2.1 *Introduction*

SAM Aero was established in 2010, and has its main base at Oslo Airport. SAM Aero is a maintenance service provider of Part 145 services to helicopter companies and airlines. At the time of the serious incident involving LN-ORR, the company had privileges to perform maintenance on AS 350 series, EC 130 B4 and EC 120 B helicopters. This service was only performed for Helikopter Utleie AS.

Following the incident with LN-ORR, the Norwegian Civil Aviation Authority conducted an extraordinary audit of the company. The company's A3 (Helicopter) privileges were withdrawn based on findings during the audit.

1.17.2.2 *Organisation SAM Aero*

SAM Aero's organisation according to the company's "Maintenance Organisation Exposition":

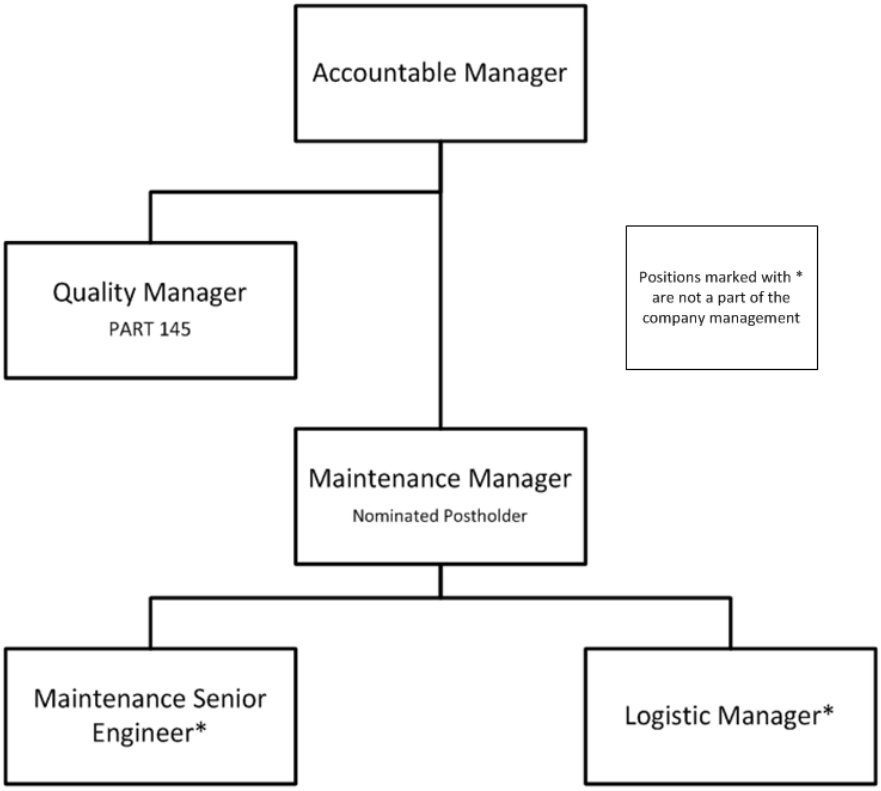


*Figure 17: Organisation chart SAM Aero. Source: SAM Aero*

The "Maintenance Senior Engineer" was the principal shareholder in the company through a personal shareholding of 20.45 % and through a Norwegian registered foreign enterprise (NUF) with an additional shareholding of 40.62 %.

1.17.2.3 *The company's safety and quality policy*

The company's safety and quality policy is expressed in Chapter 1.2 of the company's Maintenance Organisation Exposition (MOE) :

> *The Safety and Quality Policy of the company is during all aircraft maintenance actions and processes to focus on the highest possible level of flight safety. All maintenance shall be in compliance with Type Certificate holder requirements, National and EASA requirements,* ***as well as the contracted CAMO Operator's additional requirements*** (emphasis added by AIBN*) and Part 145 own Maintenance Management Requirements.*
>
> ***It is the company policy to put a special focus on procedures reflected to detect and rectify maintenance errors (MOE 2-25) and to the limitations of human performance (MOE 2-28), to improve the maintenance reliability and minimise errors based upon human factors*** (emphasis added by AIBN).

*It is the company policy to encourage all personnel to report maintenance related errors and incidents according to procedures in MOE 2-18. It is the company policy to recognise that compliance with procedures, quality standards, safety standards and regulations is the duty of all personnel. (MOE) It is the company policy to recognise the need for all personnel to cooperate with the quality manager and auditors. (MOE 3-1)*

1.17.2.4 *The company's Maintenance Organisation Exposition (MOE)*

The company's MOE is the governing document for performing aircraft maintenance in accordance with EASA part 145, "Maintenance Organisation Approvals". Chapter 2.16.8 of the MOE describes the procedure for control of maintenance work in the following manner:

*Dual signature requirements*

*Normally the CRS requires only a single signature by certifying staff.* ***However, in some cases, the CAMO Operator requires dual signatures in the Maintenance Programs*** (emphasis added by AIBN). *The purpose of dual signatures is that two qualified certifying staff members shall monitor and participate in the work process to ensure the tasks are completed according to the work instructions. In cases where only one certifying staff is available, the same person can perform the second inspection. The specific inspection shall be separated from the maintenance work. In this case the certifying staff is required to complete all other tasks first before carrying out the second inspection. When sufficient certifying staff is available then the dual inspection must be carried out by different persons.*

EASA Part 145.A.65 require the following of a Part 145 organisation with regard to work on critical systems:

*With regard to aircraft line and base maintenance, the organisation shall establish procedures to minimise the risk of multiple errors and capture errors on* ***critical systems*** (emphasis added by AIBN), *and to ensure that no person is required to carry out and inspect in relation to a maintenance task involving some element of disassembly/reassembly of several components of the same type fitted to more than one system on the same aircraft during a particular maintenance check.* ***However, when only one person is available to carry out these tasks, then the organisation's work card or worksheet shall include an additional stage for re-inspection of the work by this person after completion of all the same tasks*** (emphasis added by AIBN).

1.17.2.5 Chapter 2.25.3 of the company's MOE describes how to inspect work on "critical systems":

*After re-assemble or installation of components in categories above, all tasks shall be rechecked and signed out by another qualified certifying staff. In some cases when this person is not available, the same person might perform the second inspection only if the inspection is separated from the maintenance work.*

1.17.2.6 EASA Part 145.A.45(e) describes how the work specification for "Complex Maintenance Tasks" should be detailed:

> *Complex maintenance tasks shall be transcribed onto the work cards or worksheets and subdivided into clear stages to ensure a record of the accomplishment of the complete maintenance task.*

1.17.2.7 EASA Part 145.A.30(e) define competence requirements for maintenance planners. AMC to 145.A.30(e) describes this in the following manner:

> *To assist in the assessment of competence and to establish the training needs analysis, job descriptions are recommended for each job function in the organisation. Job descriptions should contain sufficient criteria to enable the required competence assessment.*
>
> *Criteria should allow the assessment to establish that, among others (titles might be different in each organisation):*
>
> ***Planners are able to interpret maintenance requirements into maintenance tasks*** (emphasis added by AIBN)*, and have an understanding that they have no authority to deviate from the maintenance data.*

1.17.3 Helicopter Utleie AS "Maintenance Order 2014-04"

"Maintenance Order 2014-04" issued by Helikopter Utleie AS refers to AMM procedure 65-11-00. 4-8B for replacement of the tail rotor shaft bearings. This procedure refers to AMM 60-00-00, 3-1 with regards to preparation for performing the work. This AMM chapter refers further to AMM 01-10-00, 2-1, which defines critical parts on the EC 130 B4.

**MAINTENANCE ORDER: 2014-04**

**MAINTENANCE REQUISITION FORM**

| Expected maintenance date: 21.mar.2014 | Requested by: | A/C Reg.: LN-ORR | Place: Stryn | Requsition date: 21.mar.2014 |
|---|---|---|---|---|

**Maintenance Reason:**

1. 600 FH / 24 M AF insp, iaw MP EC130 5.3.
2. 1200 FH / 48 M AF insp, iaw MP EC130 5.4.
3. FDC engine inlet filter, 100/300H / 12M insp, iaw 1130-SERIES-ICA-1 §3.2 c-i rev A.
4. Remove main battery for Check, s/n T05919, iaw AMM 24-33-00, 4-1.
5. After Check, install main battery, s/n T05919, iaw AMM 24-33-00, 4-1.
6. ASB 80A005 r1, Twist grip mod, §3.A and 3.B.
7. Cabin fire extinguisher, weight check, iaw AMM 26-21-00, 6-2.
8. Check first aid kit for content, iaw JAR OPS 3.745.
9. MGB oil, change, Nyco 3525, iaw AMM 12-10-00, 3-1.
10. TGB oil, change, Nyco 3525, iaw AMM 12-10-00, 3-1.
11. Replace 5ea tail rotor drive bearings, p/n 593404, iaw AMM 65-11-00, 4-8B.
12. Hydraulic pump splines, visual check and greasing, GVI, LUB, iaw AMM 63-11-00, 6-3.
13. Float assy, Check, iaw CMM 25.69.20 Insp/check §4 rev 20.
14. Cylinder assy, Weight or pressure check, iaw CMM 25.69.11 Insp/check §2A/B/C rev 15.
15. Emergency float gear, check and functional test, DI, FT, iaw AMM 25-67-00, 5-1 & 6-1.
16. Emergency float gear, Functional check frangible disc, FT, iaw AMM 25-67-00, 5-2.
17. ASB EC130-52A016 Crew door actuators, §3.B. Rev 0 25/3
18. EASB EC130-53A019 Tail boom, §3.B.4. Rev 0
19. ASB EC130-05A009 Twist grip, §3. Rev 1
20. Compass swing, iaw MP 6.4.3.
21. After Last Flight inspection, iaw Flight Manual.

**Related documentation:**
**All inspections are to be carried out i.a.w. the appropriate Aircraft Maintenance Program with revision Date / Nr.: 01.05.2013 /rev 04**

**All ordered work has been performed and CRS is signed on HUT's ATL no:** 1363

**Part-145 MO, name and number:** SAM AERO NO.145.0137

*Figure 18: Helikopter Utleie's "Maintenance Order". Item 11 relates to replacing bearings on the tail rotor shaft. Source: Helikopter Utleie AS*

1.17.4 SAM Aero "Work Sheet no. 77"

1.17.4.1 The work ordered by Helikopter Utleie AS through the "Maintenance Order" was converted to work descriptions in SAM Aero's "Work Sheets", where performed work was signed off in the form of "Certified Release to Service" (CRS) by technician.

1.17.4.2 There was no documented "Independent Inspection" or "Second Inspection" for any of the performed work in "Work Sheet no. 77", as indicated by Chapter 2.16 of the company's MOE.

1.17.4.3 The work on replacing all bearings on the tail rotor shaft is a process involving several sub-tasks, including measurements of bearing no. 1's position in relation to the tail rotor shaft upon installation and vibration measurement of the shaft after the work is completed. This work is considered a "Complex Maintenance Task" by the Norwegian

Civil Aviation Authority. "Work Sheet 77" describes the work on replacing all bearings on the tail rotor shaft in one item as follows (see Figure 19):

| SAM Aero AS<br>**WORK SHEET** | A/C REG<br>LN-ORR | A/C TYP<br>EC130B4 | A/C SERIAL N°<br>4684 | *NEXT DUE MAINTENANCE*<br>*DUE -/+* |
|---|---|---|---|---|

*WORK SHEET no.: 77* *Aircraft Operator: HELIKOPTER UTLEIE AS*

| Item | Remarks | Date | Sign | Corrective Action | Date | Sign Mech | CRS |
|---|---|---|---|---|---|---|---|
| Item 10 Of 23 | REPLACE 5 EA TAIL ROTOR DRIVE BEARINGS, P/N 593404, IAW AMM 65-11-00,4-8B<br>Rem. P/N: S/N: | 20.03.2014<br>MEL Rel | MEL Sign | P/N: 593404, PartName: BRG - T/R DRIVE SHAFT, Batch No: 1263-2-0, Qty: 5 Installed<br>Maintenance Ref: AMM65-11-00,4-8B<br>Inst. P/N: S/N: | 07.04.2014<br>ACTT 334.30<br>LND 1071 | | |

*Figure 19: Work Sheet no. 77 – work specification for replacing bearings on the tail rotor shaft. Source: Helikopter Utleie AS*

## 1.18 Additional information

1.18.1 Findings in EASA "Standardisation Inspection" by the Civil Aviation Authority

EASA completed "Standardisation Inspection AIR.NO.06.2014" of the Norwegian Civil Aviation Authority in June 2014. "Finding" 18305 states the following:

> *The CAA-NO does not ensure that the requirement for independent inspections as specified in M.A.402(a) is applied in maintenance organisations.*
>
> *Substantiation:*
>
> *Both Part-145.A.65(b)(3) 'capture errors on critical systems' and M.A.402(a) 'flight safety sensitive maintenance tasks', require methods to control maintenance errors that could endanger the safe operation of an aircraft if not performed properly. Independent inspections are required to capture these 'safety related' errors according to M.A.402(a) and these should be carried out by at least two persons (the second person not necessarily CS, but at least appropriately qualified to perform the task), UNLESS otherwise specified by Part 145 or agreed by the competent authority.*

1.18.2 Use of terms in EASA Part M and Part 145

1.18.2.1 EASA Part M subpart D, M.A 402(a) requires "Independent Inspection" following "Flight Safety Sensitive Maintenance Tasks" unless other requirements are listed in EASA Part 145.

1.18.2.2 EASA Part 145.A.65(b)3 allows for the possibility of a technician to inspect his/her own work on "Critical Systems", assuming that "an additional stage for re-inspection" is added in the worksheet that is used.

1.18.2.3 The terms "Flight Safety Sensitive Maintenance Task" and "Critical Systems" are used in EASA Part M and EASA Part 145, respectively. The terms "Independent Inspection" and "Re-inspection" are also used. "Re-inspection" can be done by the same person that carried out the work.

1.18.2.4 The use of these terms indicates a need to harmonise both regulations. EASA has realised this, and the "Notice of Proposed Amendment (NPA) No. 2012-04" clarifies and

harmonises the use of terms. It also includes a clarification regarding when "Re-Inspection" can be used. NPA No. 2012-04 states the following:

> ***A re-inspection as an error capturing method should only be used in unforeseen circumstances when only one person is available to carry out the task and perform the independent inspection*** (emphasis added by AIBN). *The circumstances cannot be considered unforeseen if the organisation has not programmed a suitable "independent qualified person" onto that particular line station or shift.*

1.18.2.5 The consequence of this, is that scheduled maintenance involving critical maintenance activities cannot be completed by one single person if NPA No. 2012-04 is implemented through EU Commission Regulation 2015/1536 with implementation date 25 August 2016.

## 1.19 Useful or effective investigation techniques

No methods qualifying for special mention have been used in this investigation.

# 2. ANALYSIS

## 2.1 Introduction

2.1.1 This incident was caused by a fracture in the tail rotor shaft. Malfunctions in flight control systems are critical, and will immediately have a dramatic effect on the ability to control the helicopter. The reason it did not have more serious consequences was because the commander quickly figured out that the tail rotor was not functioning, and he made the right decisions. Furthermore, it was decisive for the outcome that the incident occurred over a flat surface where it was possible to execute emergency landing relatively safely (the runway at Rørvik Airport). Had the tail rotor shaft fracture occurred at a less favourable moment, and over rugged terrain, the outcome of the incident could have been fatal.

2.1.2 The analysis focuses on what caused the fracture in the shaft, and the underlying causes allowing this to take place. AIBN believes that incorrect installation of bearing no. 1 caused the shaft fracture. Insufficient safety barriers in the form of maintenance planning routines and inspection of completed work were identified in both the operating company and maintenance organisation. In addition, the existing routines were not fully followed.

## 2.2 Technical aspects

The first part of the investigation focused on the possibility of deformation of the tail structure, which could have introduced abnormal loads in the tail rotor shaft. Scratches on the underside of the tail skid indicated that it had been in contact with the ground. However, there were no signs of deformation of the skid or its attachment in the tail structure. This indicates that neither the skid nor its attachment structure have been exposed to excessive forces. It was not found that the tail structure was exposed to deformation that could have caused displacement of bearing no. 1. AIBN knows that scratch marks such as the tail skid of LN-ORR are not uncommon to this helicopter type.

Movements of short duration caused by structural elasticity would be absorbed by the flexible connection behind bearing no. 1 and cannot have contributed to the cyclic loads that finally caused the fracture in the shaft.

Bearing no. 1 did not have the correct position in relation to the shaft. The bearing outer race was clamped in the "Bearing drive/Bearing flange" assembly and there were no signs of the bearing moving after installation. This observation led to further examinations of bearing no. 1 performed by the manufacturer of the bearing (FAG). The bearing races showed abnormal wear caused by assymetric bearing ball track. FAG could not explain the reason for the assymetric wear in the bearing races. The reason for this was that FAG was not informed about the skewed installation of the bearing. FAG’s findings were consistent with faulty alignment when installing the bearing causing the tail rotor shaft to be exposed to repeated cyclical forces, and that these forces were introduced due to incorrect installation of bearing no. 1 during replacement.

## 2.3 Organisational aspects

AIBN decided to investigate matters that could explain the faulty installation. It was natural to take a closer look at how the operating company and maintenance organisation

had described how inspection of completed work was done and the working condition for the licensed aircraft technician.

2.3.1 The technician's role

2.3.1.1 The aircraft technician had worked alone on Helikopter Utleie's helicopters for many years. Without having a community of colleagues for support, there may be a risk of developing sub-standard working methods.

2.3.1.2 The procedures described in the manufacturer's AMM are to be followed. This investigation revealed that the work was performed without the correct measuring tools, and the described procedure in AMM was not followed. This led to the incorrect installation of bearing no. 1 on the tail rotor shaft.

2.3.1.3 The work on LN-ORR was carried out at the helicopter company base in Stryn. The technician carried out this work alone. In a best case scenario, he would have inspected his own work. This would have been an inspection based on his personal understanding of the procedure in AMM, which was incorrect as regards installation of bearing no. 1. An independent inspection performed by another competent person could have identified the error.

2.3.2 Company procedures

2.3.2.1 AIBN is of the opinion that replacement of bearings on the tail rotor shaft can be considered as a complex maintenance task on a critical system. The bearing no. 1 replacement also included check of the bearing’s position relative to the shaft. The shaft should also be checked for vibration before the helicopter could be released for service. Maintenance errors can, as in this case, result in loss of control of the helicopter. As such, the bearing replacement can be considered both as a "Flight Safety Sensitive Maintenance Task" as mentioned in EASA Part M, and as a "Complex Maintenance Task" as mentioned in EASA Part 145.

2.3.2.2 The LN-ORR incident has uncovered differences in the interpretation of how EASA Part M M.A 402(a) shall be complied with in the helicopter company and in the maintenance organisation. Helikopter Utleie AS refers in their work order to the Airbus Helicopter AMM, which is in line with what is written in its CAME chapter 1.2.0.4 "Inspection Standards". SAM Aero states in their MOE chapter 2.16.8 that it is the operators Part M organisation that has to require independent control on certain maintenance tasks.

2.3.2.3 There is always a risk that individuals make errors. Organisations involved in planning and execution of maintenance must have well established procedures to reduce the risk of maintenance errors. The purpose of such procedures are to reduce the risk for maintenance errors, and to ensure that errors made are discovered before the aircraft is released to service. AIBN is of the opinion that both the operator, in this case Helikopter Utleie, and the maintenance organisation, in this case SAM Aero, should have great concern for the risk of maintenance errors, and it should be reflected clearly in their procedures.

2.3.2.4 In addition, SAM Aero did not split up and specify the work in their worksheets for "Complex maintenance tasks" as described in EASA Part 145. The Accident Investigation Board is of the opinion that specifying complex work is essential for keeping an overview of the various steps in complex maintenance tasks, as well as to

have the possibility of recording the measurement values that may be relevant as barriers against maintenance errors.

2.3.2.5 SAM Aero did not ensure that the technician had the correct tools available to perform the work as described in AMM with regard to measurement of the position of bearing no. 1 in relation to the tail rotor shaft.

2.3.2.6 SAM Aero's MOE did not contain competence requirements for personnel that prepare work specifications for complex maintenance tasks. A work specification must be detailed so that required inspection of performed work are separate steps. The technician made the work specification himself for the maintenance tasks.

2.3.2.7 In this case one person had the sole responsibility for preparing the worksheet, understand the maintenance tasks, ensure that correct tooling was available, perform the work and perform inspection of completed maintenance tasks. This had been the situation for a long period of time (several years) without any effective actions from the companies to verify if the technician performed the maintenance tasks according to standard.

## 2.4 Airbus Helicopters

2.4.1 The AMM procedures for replacement of bearing no. 1 on the tail rotor shaft described how to measure the bearing's position in relation to the tail rotor shaft. The procedure did not describe what type of dial gauge to use, how to fasten the dial gauge on the shaft and in what position the dial gauge plunger should be in contact with "Half Spherical Bearing" (see sect. 1.16.3.2).

Following this incident, Airbus Helicopters' internal investigation report concluded that the measuring method and adapter to attach the dial gauge to the tail rotor shaft must be detailed more clearly in AMM, so that there is a greater degree of reproducibility of the measurement values when replacing bearing no. 1.

## 2.5 Civil Aviation Authority's role

2.5.1 The Norwegian Civil Aviation Authority performs technical audits of operators and maintenance organisations.

2.5.2 In this investigation, AIBN identified a number of unfortunate circumstances in both organisations that collectively led to this incident. This includes:

- Difference in definition of requirements for inspection of maintenance work in both the operating company and maintenance organisation.
- Inadequate planning of maintenance tasks, both as regards specifying the work, and facilitation with regard to tools.
- Both Helikopter Utleie AS and SAM Aero accepted that one person was conducting all maintenance alone on the helicopters.
- The use of the combination of contracted maintenance organisations performing maintenance and contracted responsible personnel can be challenging for the operating company regarding supervision of the maintenance processes.

2.5.3 The conditions mentioned above represent weaknesses and minimum solutions that were unable to prevent maintenance errors. The AIBN is of the opinion that such risks should be a topic covered by the Civil Aviation Authority's audits, and that the Civil Aviation Authority should review the entire maintenance process and include the different players under one, from planning to execution of the work.

2.5.4 A "Standard Inspection" performed by an EASA team on 27 June 2014 identified that the Norwegian Civil Aviation Authority had not sufficiently prioritised following up requirements concerning routines for inspection of maintenance work. The AIBN believes that this serious aircraft incident confirms that the mentioned finding is relevant.

2.5.5 Based on the EASA inspection, the Norwegian Civil Aviation Authority has dedicated more focus on what the organisations do to prevent maintenance errors when performing audits. The AIBN considers this change a good contribution to flight safety.

## 2.6 EASA regulations

2.6.1 In this investigation, AIBN reviewed the EASA Part M and EASA Part 145 regulations regarding requirement for procedures intended to reduce the possibility of maintenance errors. These two regulations use different terms and definitions for what constitutes critical systems where additional inspection of performed maintenance work is required. Furthermore, there is an allowance for technicians to inspect their own work under certain conditions, but these conditions are not clearly defined.

2.6.2 EASA has realised this, and issued NPA No. 2012-04, which proposes harmonisation of terms, and clearer guidelines for what preconditions apply for allowing technicians to inspect their own maintenance work. According to AIBN's interpretation of the proposed amendment, it will not be permitted to perform inspection of their own work during planned maintenance when NPA 2012-04 is implemented through EU Commission Regulation 2015/1536 with implementation date 25 August 2016.

2.6.3 AIBN believes implementation of NPA No. 2012-04 will help to reduce the maintenance error risk, particularly in small organisations with marginal resources and staffing. Re-inspection of own work has traditionally been a common practice in this part of Norwegian aviation.

## 2.7 Safety responsibility

2.7.1 The investigation has illustrated that the responsibility for safe execution of maintenance rests on several links in a chain.

- The technician is responsible for executing maintenance in accordance with the manufacturer’s maintenance instructions, described maintenance programme from the operator (Part M), competence and sound technical judgement.
- Both the operating company and maintenance organisation are responsible for describing the planned maintenance tasks precisely and clearly.
- The helicopter manufacturer is responsible for describing the individual helicopter maintenance tasks in an understandable and precise manner.

- Through audits, the Norwegian Civil Aviation Authority shall ensure that the involved parties perform maintenance in accordance with regulations.

- EASA must ensure that their regulations are clear and comprehensive.

2.7.2 The aircraft technician is at "the sharp end", where errors can have direct consequences for flight safety. The AIBN is therefore of the opinion that having just one person carry out maintenance tasks that qualify as "Flight Safety Sensitive Maintenance Tasks" or "Complex Maintenance Tasks" alone should be avoided. In the case in question, one person had conducted the maintenance alone on the helicopters in the company over an extended period of time. In reality, the aircraft technician could have developed unfortunate ways of working, without good routines in place to detect this.

2.7.3 SAM Aero was responsible for renewing the aircraft technician's privileges, but had in reality little opportunity to inspect the work the aircraft technician performed alone. In addition, the aircraft technician did not have a collegial professional environment where he could discuss questions and issues at the location where the maintenance work was performed.

2.7.4 SAM Aero did not specify inspection of "Flight Safety Sensitive Maintenance Tasks" or "Complex Maintenance Tasks". This was a contributing factor in allowing a major maintenance error to occur.

2.7.5 As the operating company, Helikopter Utleie AS has a responsibility to design the maintenance programme, and SAM Aero as the maintenance organisation is responsible for describing how this work should be executed and documented in practice (Work Specification). In this case, it appears as if Helikopter Utleie AS expected SAM Aero to use AMM 01-10-00, 2-1 "List of Critical Parts" as reference for executing independent inspections, while SAM Aero’s MOE chapter 2.16.8 states that requirements of such shall be raised by the operators Part M organisation.

2.7.6 The AIBN is of the opinion that the helicopter manufacturer's description of the measuring method for bearing no. 1 on the tail rotor shaft was fully understandable. In retrospect, however, Airbus Helicopters recommended in an internal report further improvement of the description.

2.7.7 Following the investigation, the AIBN is left with the impression that certificates and governing documents from both the helicopter company and the maintenance organisation were adequate. The fact that good intentions and formulations were not always followed, first emerged in connection with investigation surrounding the actual incident. Following the LN-ORR incident, the Norwegian Civil Aviation Authority inspected performed maintenance activities on the fleet of helicopters belonging to Helikopter Utleie AS. Anomalies found during the extraordinary inspection led to revocation of privileges for the maintenance organisation. This is an illustrative example that system audits alone are not sufficient.

# 3. CONCLUSIONS

## 3.1 General

a) The aircraft was registered in accordance with the regulations and had valid airworthiness documents.

b) The aircraft's mass and balance were within the limitations at the time of the incident.

c) The commander had valid license and rating for the helicopter type.

d) The licensed aircraft technician had a valid licende and rating for the helicopter type.

e) The commander quickly understood what was happening, and his way of handling the situation prevented injuries and damage of the helicopter.

f) In this investigation, AIBN found that a tail rotor fracture caused loss of directional control of the helicopter.

## 3.2 Technical aspects

a) The tail rotor shaft fractured completely 98 hours after replacement of all bearings on the tail rotor shaft.

b) The technician did not follow the procedure in AMM that explains how to inspect the installation of bearing no. 1 for correct position in relation to the shaft. This caused a skewed installation of the bearing.

c) The consequence of the incorrect installation was cyclical overloads in the shaft that resulted in a fracture.

## 3.3 Organisational aspects

a) Helikopter Utleie’s "Maintenance Order" which described the work to be performed contained no requirement for control of the performed work.

b) The maintenance organisation's "Work Sheet" for the maintenance describing tail rotor shaft bearing replacement contained no requirements for control of "Complex Maintenance Tasks", and did not have a sufficient level of detail in relation to the complexity of the work.

c) The technician replaced bearing no. 1 without using the correct tools to verify the bearing's position, and executed the measuring procedure incorrectly.

d) Supervision of and opportunities for "independent inspection" were not present as the technician worked alone at the operating company's base in Stryn.

e) Following an inspection of the Norwegian Civil Aviation Authority, EASA noted that NCAA audits must dedicate more focus to the regulatory requirements related to control of complex maintenance tasks.

f) EASA regulations Part M and Part 145 use different terms for inspection of performed work, complex maintenance tasks and critical systems, and do not have sufficiently clear guidelines for when inspection of such work can be completed by the person who carried out the work.

# 4. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway makes no recommendations in connection with this investigation.

The Accident Investigation Board Norway

Lillestrøm, 21 January 2016

# APPEDICES

Appendix A: Abbreviations

# APPENDIX A: ABBREVIATIONS

| | |
|---|---|
| ACTT | Aircraft Total Time |
| AF insp | Airframe Inspection |
| AFIS | Aerodrome Flight Information Service |
| AMC | Acceptable Means of Compliance |
| AMM | Aircraft Maintenance Manual |
| ANS | Company with liability |
| ASB | Alert Service Bulletin |
| BEA | Bureau d'Enquetes et d'Analyses pour la securitè de'aviation civile |
| BRG | Bearing |
| CAME | Continuing Airworthiness Management Exposition |
| CG | Centre of Gravity |
| CMM | Component Maintenance Manual |
| CPL(H) | Commercial Pilots Licence Helicopter |
| CS | Certifying Staff |
| ea | each |
| EASA | European Aviation Safety Agency |
| EASB | Emergency Alert Service Bulletin |
| FH | Flight Hours |
| HSTE | Helicopter Single Turbine Engine |
| IAW | In Accordance With |
| MEL | Minimum Equipment List |
| METAR | Meteorological Aerodrome Report |
| MOE | Maintenance Organisation Exposistion |
| MP | Maintenance Programme |
| NCAA | Norwegian Civil Aviation Authority |
| Nm | Newton metre |
| NPA | Notice to Proposed Amendment |
| P/N | Part Number |
| QAI | Quality and Internal Control Handbook |
| Qty | Quantity |
| S/N | Serial Number |
| AIBN | Accident Investigation Board Norway |
| T/R | Tail Rotor |
| UTC | Universal Time Coordinated |
| VEMD | Vehicle and Engine Multifunction Display |
| VMC | Visual Meteorological Conditions |
| W.O | Work Order |