Norwegian Safety Investigation Authority

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REPORT AVIATION 2022/10

Serious aviation incident in Kongsvikdalen, Tjeldsund municipality in Troms og Finnmark county 20 November 2021 involving Airbus Helicopters MBB-BK117 D-2, LN-OOS, operated by Norsk Luftambulanse AS

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The Norwegian Safety Investigation Authority (NSIA) has compiled this report for the sole purpose of improving flight safety.

The purpose of the NSIA's investigations is to clarify the sequence of events and causal factors, elucidate matters deemed to be important to the prevention of accidents and serious incidents, and to make possible safety recommendations. It is not the NSIA's task to apportion blame or liability.

Use of this report for any other purpose than for flight safety should be avoided.

Photo: Norsk Luftambulanse AS

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

Table of contents

Serious aviation incident report

Table 1: Data

Type of aircraft:	Airbus Helicopters Deutschland GmbH, MBB-BK117 D-2[1]
Nationality and registration:	Norwegian, LN-OOS
Owner:	Skandinaviska Enskilda Banken AB (publ), Swedish
Operator:	Norsk Luftambulanse AS
Crew:	3
Passengers:	3 persons and 1 dog
Accident site:	Kongsvikdalen, Tjeldsund municipality, Troms og Finnmark county, Norway, 68.5842539N 16.2003917E
Accident time:	1806 hrs on Saturday 20 November 2021

All times given in this report are local time (UTC + 1), if not otherwise stated.

Notification

At 1920 hrs on 20 November, Norsk Luftambulanse AS notified the Norwegian Safety Investigation Authority that one of its helicopters had experienced a shutdown of both engines. One of the engines had an in-flight shutdown. The commander landed the helicopter immediately. Right after landing, when engine number 2 was set to idle, it also shut down.

After a brief preliminary investigation, the Norwegian Safety Investigation Authority concluded that this was a serious aviation incident and started an investigation. The following organisations were notified:

- The International Civil Aviation Organisation, ICAO
- The European Union Aviation Safety Agency, EASA
- The accident investigation agency in the state of manufacture Germany, Bundesstelle für Flugunfalluntersuchung – BFU
- The accident investigation agency in the engine state of manufacture France, Bureau d'enquêtes et d'analyses pour la sécurité de l'aviation civile – BEA
- The helicopter manufacturer, Airbus Helicopters Deutschland
- The engine manufacturer, Safran Helicopter Engines
- The Norwegian Civil Aviation Authority

Both the French and German accident investigation agencies appointed accredited representatives, and Safran Helicopter Engines and Airbus Helicopters Deutschland provided technical advisors.

[1] *Airbus Helicopters market the helicopter as H145.*

Summary

On Saturday afternoon 20 November 2021 LN-OOS, operated by Norsk Luftambulanse AS, was on a search and rescue mission in the Kongsvikdalen valley in Lofoten. It was dark and there were snow showers in the area. The helicopter operated in snow of varying intensity while the crew waited for the party in distress to arrive at the landing site. Icing conditions were not forecast, and snow is not automatically defined as icing conditions. An assessment of the weather conditions must be made to determine if icing is suspected or not. It took longer than the crew anticipated for the party in distress to reach the helicopter. During this period the helicopter operated in hover and on the ground with the engines running. After the party in distress boarded, the helicopter flew east and south-east towards Kongsvika.

The crew were aware of a power line that crosses Kongsvikdalen valley, but they had not located it visually. Therefore, they flew slowly down the valley while they searched. Suddenly, and without warning, the left engine shut down. The crew made an emergency landing without issue and without anyone being injured. While the helicopter was on the ground, the right engine also suddenly shut down.

The Norwegian Safety Investigation Authority believes that both engines on LN-OOS shut down due to flameout caused by the ingestion of ice. The investigation and tests after the incident have not found any technical fault with the engines that could have caused the shutdowns. The ice probably built up in the Inlet Barrier Filter (IBF) system while the helicopter was waiting for the party in distress. The IBF system is a dust and particle filter that replaces the standard air inlet.

Flight tests by Airbus Helicopters Deutschland after the incident have shown that, under certain weather conditions, significant amounts of ice can build up in the IBF system and this ice can enter the engine unhindered. The weather conditions that can cause ice build-up are typical Norwegian winter conditions along the coast with temperatures of around zero degrees centigrade and high humidity.

The helicopter type, MBB-BK117 D-2, has two configurations for the air intake and the safety issue is only for helicopters with IBF installed. Airbus Helicopters Deutschland have started the process of correcting this safety issue.

About the investigation

Purpose and method

The NSIA has classified this occurrence as a serious aviation incident. The purpose of this investigation has been to clarify what caused the sudden shutdown of both engines on LN-OOS. The NSIA has also considered what can be done to improve safety and prevent the recurrence of similar accidents and consequences in future.

The investigation was conducted in line with the NSIA's framework and analysis process for systematic safety investigations (the NSIA method[2]).

Sources of information

The NSIA has used, among others, the following sources of information:

- Interviews with the crew
- Information provided by the helicopter manufacturer
- The Rotorcraft Flight Manual
- Information provided by the engine manufacturer
- Inspection, and testing of the engines and inspection of the helicopter
- Cockpit voice / Flight Data Recorder
- The operator's operational manuals

The investigation report

The first section of the report, Factual information, describes the sequence of events, associated data and information gathered in connection with the accident, and the NSIA's examinations and related findings.

The second section, Analysis, describes the NSIA's assessments and analyses of the sequence of events and contributing factors, on the basis of factual information and examinations carried out. Details and factors that are found to be less relevant in order to explain and understand the serious incident is not discussed in depth.

The report ends with the NSIA's conclusions.

[2] *See https://www.nsia.no/About-us/Methodology*

1. Factual information

1. Factual information

1.1 History of the flight

On 20 November 2021, LN-OOS, an air ambulance operated by Norsk Luftambulanse AS (NOLAS) stationed in Harstad, was on a search and rescue mission. Three persons and a dog had lost their way on a hike to Haakonsbu in the Botnfjellet mountains in Troms og Finnmark county (see Figure 1). It was dark and snow showers were forecast. The crew had just returned from another mission in the same area where they had experienced good weather with scattered showers. The weather in the Harstad area was clear with good visibility.

The helicopter lifted off from Harstad at 1634 hrs and set course for Botnfjellet and the Kongsvikdalen valley. The mission was carried out using Night Vision Goggles (NVG). As they approached Kongsvikdalen, they encountered snow showers. The crew have told the Norwegian Safety Investigation Authority (NSIA) that they had a possible GPS position of the party in distress and therefore flew towards the northern side of Botnfjellet. Due to the reduced visibility, low cloud ceiling and lack of contours in the terrain, it was not possible to fly all the way up to the GPS position.

The helicopter therefore flew towards the southern side of Botnfjellet and entered a hover over the easternmost of Vesterforsvatnan lake. The crew saw the headlights of the party in distress further up the mountain. They contacted them by mobile phone and explained that it was not possible to fly up to them due to the weather conditions. They agreed that the party in distress should try and make their way down the mountain towards the helicopter. The party in distress used the lights and noise of the helicopter to navigate down the mountain.

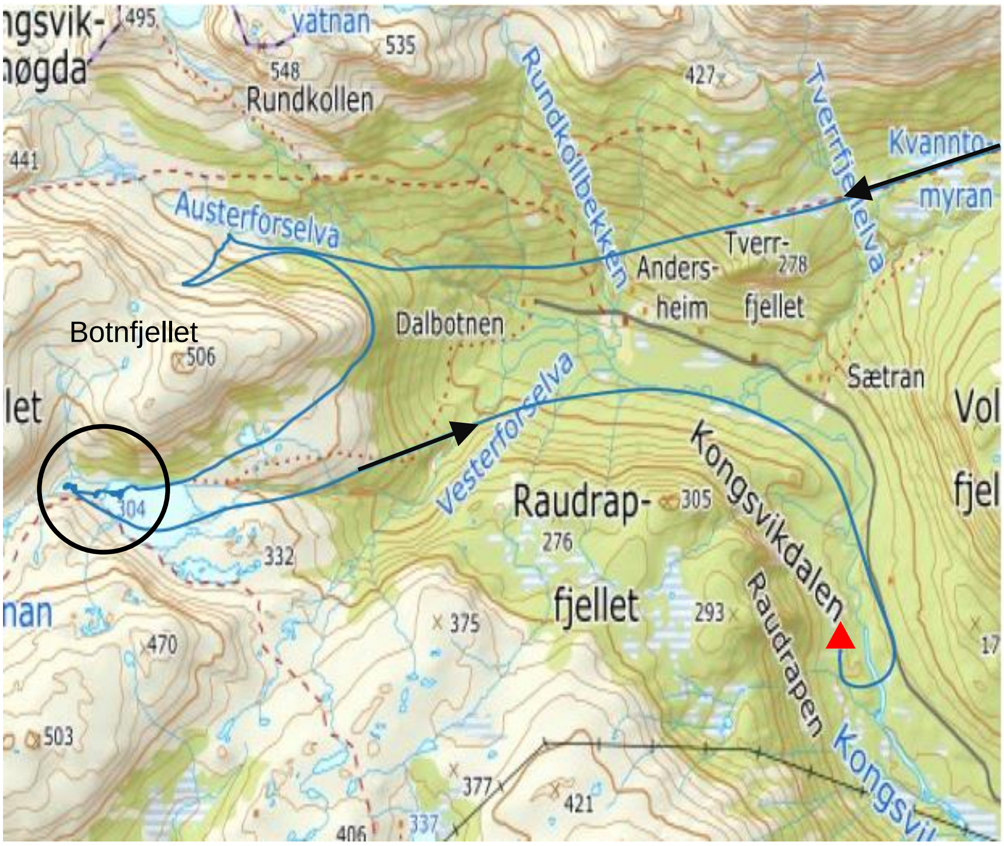

Figure 1: Map of the Kongsvikdalen valley. The blue line is the route LN-OOS flew; red arrows indicate direction of flight. The black circle marks Vesterforsvatnan where the helicopter waited for the party in distress and the red triangle is the landing site. The power line is in the bottom right corner.
Map: © The Norwegian Mapping Authority / SHK

The crew initially thought it would take a relatively short period of time for the party in distress to reach the helicopter. While LN-OOS operated in hover and waited, the snowfall varied in intensity. The crew saw the terrain around them and the party in distress on their way towards the helicopter the entire time.

The crew have explained that while they waited, they assessed several times whether they should leave the area. The varying intensity of the snowfall, however, meant they did not find an opening in the weather suitable to leave the area. In addition, the party in distress used the lights and noise of the helicopter as a means of navigation. Replaying the cockpit voice recorder shows that the crew were aware of the weather situation and that they had decided to leave the area if the opportunity arose.

While the helicopter operated in hover, the commander got an IBF CLOG TREND alert. This is an alert that indicates that the engine air inlet filter is starting to clog. The alert is triggered when the clogging level is 40%. The commander followed the normal procedure, which is to open a bypass door to ensure that the engine receives enough air. This air is supplied from the main gearbox compartment. Due to an issue with the actuator the left engine had the bypass door permanently open during the entire flight. Therefore, it was the right IBF bypass door that was opened.

After about 45 minutes in hover, the crew landed. By this time, the party in distress was so close to the helicopter that the crew wanted to land before they reached the helicopter. They maintained some power to ensure that they did not sink down into the snow. It took another 20 minutes for the party in distress to reach the helicopter.

While waiting the last few minutes, the crew planned how they should fly out from the area. They considered climbing into the clouds above and flying a short distance in Instrument Meteorological Conditions before descending to Vågsfjorden using radar. This was something they did not want to do as it would expose the helicopter to a significant risk of icing.

After the crew had boarded the party in distress, they had to wait a few minutes for the weather to be clear enough so they could take off. After a normal takeoff, it became evident that there was better visibility down Kongsvikdalen, and the crew chose that route down from the mountains.

When they reached Kongsvikdalen, they saw the lights from Kongsvika and had visibility of about 4 km, although it was still snowing. The crew were aware of a power line that crosses Kongsvikdalen in a north-westerly / south-easterly direction but had not located it. The commander has explained that they therefore flew slowly and carefully down the valley while they searched for the power line.

During in the search, the left engine suddenly shut down without warning. Since the commander had not located the power line and there was rising terrain on both sides of the helicopter, he made the decision that it was not justifiable to climb out. He has explained that he did not think that they would locate the power line during a second attempt due to the darkness and weather. The commander performed a 180° turn and the crew saw a landing site straight ahead. The helicopter made an emergency landing without issue and without anyone sustaining any injury.

After the helicopter had landed, the right engine was set to idle. While the commander was in the process of shutting down the helicopter, the right engine suddenly shut down without warning. The commander has explained that he first thought he had done some of the shutdown checklist points in the wrong order. After double checking, he confirmed that the right engine had suffered an unintentional shutdown.

While the commander contacted operations and technical duty officers in NOLAS, the other members of the crew and the Red Cross helped the party in distress down to Kongsvika. The technical duty officer wished to know if it was still possible to rotate the engines, which the commander was able to confirm after a short test.

The helicopter was wrapped as best as possible by the crew before they left the landing site. A few days later, it was lifted out by another helicopter. It was then moved to NOLAS' main technical base at Oslo Airport Gardermoen for further examination.

The helicopter did not sustain any other damage than that to the engines, and no persons were injured in the incident.

1.2 Injuries

Table 2: Injuries

Injuries	Crew	Passengers	Other
Fatal			
Serious			
Minor/none	3	3	

1.3 Damage to aircraft

Damage to compressor blades in both engines' axial compressor, see also Section 1.12.2.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 THE COMMANDER

The commander started his flying career in the Royal Norwegian Airforce. He gained his pilot's licence there and flew the Westland Lynx for 12 years. Since 2013, he has flown for Norsk Luftambulanse AS, evenly distributed between Airbus Helicopters H135 and Airbus Helicopters H145[3].

The commander had valid rights and licences for H145 and a valid medical licence without restrictions.

[3] *Airbus Helicopters market the MBB-BK117 D-2 as H145.*

Table 3: Flying experience commander

Flight time	All types	On type
Last 24 hours	4	4
Last 3 days	8	8
Last 30 days	24	12
Last 90 days	75	43
Total	4,199	871

1.5.2 THE HEMS[4] CREW MEMBER

After finishing education and certification the HEMS crew member started his career as a HEMS crew member in the armed forces in 2016 working on the Coast Guard's NH90. He worked as a HEMS crew member there until 2020 when he started in Norsk Luftambulanse AS. At NOLAS he has worked as a HEMS crew member on the H145.

The HEMS crew member had valid HEMS rights for H145 and valid medical licence without restrictions.

Table 4: Flying experience HEMS crew member

Flight time	All types	On type
Last 24 hours	4	4
Last 3 days	8	8
Last 30 days	19	19
Last 90 days	74	74
Total	671	356

1.6 Aircraft information

1.6.1 GENERAL INFORMATION

Airbus Helicopters MBB-BK117 D-2 is a "CS-29 large rotorcraft" certified helicopter that was developed in collaboration between Airbus Helicopters Deutschland (previously Messerschmitt-Bölkow-Blohm) and Kawasaki. The helicopter type is used for freight, personnel transport, air ambulance services and as a police helicopter. The helicopter is powered by two turboshaft engines, has one main rotor with four blades and a Fenestron[5] tail rotor. The prototype had its first flight in 1979 while the model MBB-BK117 D-2 was type certified in 2014.

The fuselage is made from aluminium and composite materials. The rigid main rotor consists of a titanium rotor head where the four rotor blades are attached hingeless with bolts. The main rotor blades and the ten Fenestron-blades are made from composite materials.

The helicopter can be operated by one pilot and it is certified for nine passengers. Configured as an air ambulance, the helicopter can be equipped with one or two stretchers, seats for medical

[4] Helicopter Emergency Medical Services.
[5] Fenestron is a trademark of Airbus Helicopters and is an encapsulated tail rotor fan that counteracts the torque from the main rotor.

personnel and two passengers. During the incident LN-OOS was fitted out with one stretcher and two seats in addition to the seats in the cockpit.

1.6.2 DATA FOR LN-OOS

Manufacturer and model:	Airbus Helicopters Deutschland GmbH, MBB-BK117 D-2
Serial no.:	20039
Year of fabrication:	2015
Type certificate number:	EASA.R.010
Airworthiness Review Certificate (ARC) valid until:	24 October 2022
Total number of flight hours:	3,451:55
Total number of landings:	9,252
Engines:	Safran Helicopter Engines, Arriel 2E
Left serial no.:	60417
Right serial no.:	60048
Fuel:	Jet A-1
Empty mass:	2,397 kg
Maximum take-off weight:	3,700 kg
Never exceed speed:	150 kt

1.6.3 SAFRAN HELICOPTER ENGINES ARRIEL 2E

Safran Helicopter Engines Arriel 2E is a turboshaft engine which consist of five modules:

1. Driveshaft and accessory gearbox.
2. Low-pressure axial compressor.
3. High-pressure gas generator with compressor, combustion chamber and turbine.
4. Power turbine.
5. Reduction gearbox.

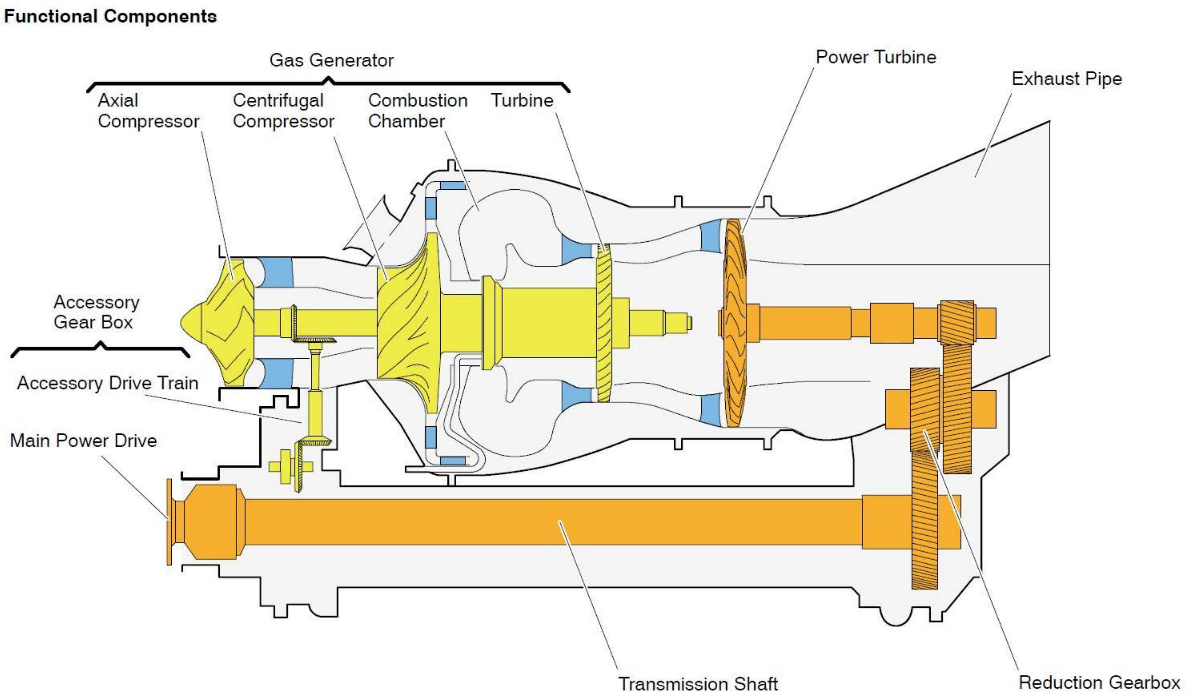

Figure 2: Schematic of the Arriel 2E. Illustration: Safran Helicopter Engines / NSIA

Air enters the axial compressor where it is compressed and streamlined before it reaches the centrifugal compressor and is further compressed. After the centrifugal compressor, the air enters the diffuser, which reduces the airspeed and additionally compresses the air before it reaches the combustion chamber. In the combustion chamber, fuel is added by an injection wheel before the mixture is ignited.

The reaction products after combustion are first accelerated through the gas generator turbine. Power to run the compressor is extracted. The reaction products then pass the power turbine, which extracts power to run the main and tail rotor. The gas generator and power turbine are decoupled so they can rotate at different speeds.

At 100% power, the gas generator rotates at 52,110 rpm and the power turbine at 39,158 rpm. The engine's reduction gear box reduces this to 6,000 rpm. The main rotor rotates at 383 rpm after being geared down by the main gearbox.

1.6.3.1 Digital Engine Control Unit

Each engine is controlled by a dual channel Digital Engine Control Unit (DECU). The DECU controls and monitors several parameters in the engine. The DECU ensure, among other things, that the power turbine rotates at an approximately constant speed and activates the Stop Electro Valve (SEV) if the rpm reaches a predefined high rpm (overspeed) to prevent damage to the engine and the helicopter. The system has an built-in safety mechanism to prevent both SEVs from being activated at the same time.

After the incident involving LN-OOS, Safran investigated whether one of the DECUs had activated its SEV by mistake, but found that both DECUs performed as expected.

The DECU also stores some data, this is discussed in Section 1.11.2.

1.6.3.2 Fuel and ignition system

Arriel 2E has two separate ways of delivering fuel to the combustion chamber. One is only used on start-up and consists of fuel injectors in the top of the combustion chamber. The fuel injectors and electric igniters are co-located, and when the speed of gas generator is self-sustaining at 61%[6] the fuel injectors are shut off and the power to the igniters is disconnected.

When the fuel injectors are shut off an injection wheel connected to the gas generator shaft supplies the engine with fuel. Fuel is pumped into the fuel wheel which delivers it to the combustion chamber using the centrifugal force. The combustion is self-sustaining and there is no form of auto ignition[7] in case of uncommanded flame-out.

The igniters are located at the periphery of the combustion chamber so as not to sustain damage from the heat. This means that the fuel from the injection wheel will not reach the ignitors if the flame should go out during operation beyond the starting phase, due to the design and aerodynamics of the combustion chamber. Safran has told the NSIA that the rotational speed of the engine must be around 20% before the start injectors and igniters can be used in such a situation.

It is possible to start the engine in flight using the procedure presented below.

3.8.4.4 Inflight restart

NOTE An inflight restart may be attempted after a flameout or shutdown subject to the pilot's evaluation of the cause of flameout.

CAUTION DO NOT ATTEMPT INFLIGHT RESTART IF CAUSE OF ENGINE FAILURE IS OBVIOUSLY MECHANICAL.

Procedure

1. Collective lever	– Adjust to OEI MCP or below
2. Electrical consumption	– Reduce
3. ENG MAIN sw (affected engine)	– OFF
4. Caution indication	– Check no FADEC FAIL or FADEC DEGRADED
5. FUEL PRIME PUMP sw (affected engine)	– ON, FUELi PRIME PUMP indicated
6. ENG MAIN sw (affected engine)	– FLIGHT
7. Electrical consumers	– As required
8. FUEL PRIME PUMP sw (affected engine)	– OFF

If restart is not successful:

9. LAND AS SOON AS PRACTICABLE

Figure 3: Excerpt from the rotorcraft manual. The procedure to perform an inflight restart. Source: Airbus Helicopters / NSIA

After the pilot selects the FLIGHT position on the main switch, the engine control system will automatically re-initiate the start sequence as soon as the gas generator speed has dropped to 17%.

The engine control system is not capable of autonomously determine if it is acceptable to restart the engines. It can declare a flame-out if the monitored engine parameters indicate that the flame has gone out, but it cannot determine the reason why. This means that an autonomous restart of the engine can lead to more damage. Safran has previously investigated the possibility of auto ignition but has not found a satisfactory solution.

[6] The rotational speed of the components in a gas turbine is often presented as a percentage of a nominal value.
[7] System that automatically tries to re-ignite the flame in the combustion chamber if this should go out.

1.6.4 OPERATIONS IN ICING CONDITIONS

MBB-BK117 D-2 is not certified for operations in icing conditions per CS 29.1419[8], and it therefore cannot be planned for such operations. Even when meteorologists do not forecast icing conditions, the helicopter can still inadvertently enter situations with a risk of icing. The helicopter manufacturer states in the rotorcraft flight manual that icing conditions should be exited immediately. After the event the helicopter manufacturer have clarified what they define as icing conditions when IBF is installed, see 1.18.2.

In its operations manual OM-A, NOLAS has procedures and information about how to detect icing and handle the situation. Below is an excerpt from OM-A 8.3.8 (b).

Avoidance of icing conditions

When planning to avoid areas with possible icing conditions, the following should kept in mind:

- the regions of most severe icing are associated with frontal surfaces;
- vertical convection sustains large water droplets and thereby induces severe icing, providing temperatures are below freezing and clouds associated with strong convection should therefore be avoided;
- temperature inversions do not always exist above freezing temperatures at higher levels.
- When uncertain of ice distribution in clouds, flight in clear air above the clouds is the safest flight path. If possible the flight path on climb and descent should be through broken or thin clouds remote from the frontal surface;
- a thorough study of the latest synoptic weather aid to determine the slope and tendency of fronts before flight is attempted, is the only means by which ice forming regions may be located and the probably intensity of icing determined;
- the falling of precipitation (mist, snow, sleet etc.) from a cloud is indicative of ice formation therein if the cloud is presumably or known to be at or below 0°C;
- take into account the freezing level on all segments of an instrument flight and select altitudes/flight levels in such a way that the flight will be accomplished below the freezing level at all times; and
- mountain ranges cause upward motions (forced lift) of the air that is moving across them;
    - These vertical currents over the ridges will support large droplets of water while adiabatic cooling of the air will drop the temperature to the freezing point or below;
    - The most severe icing will take place above the crests and to the windward side of the ridges.

Figure 4: Excerpt from NOLAS OM-A 8.3.8 (b) on how to avoid icing conditions. Source: NOLAS / NSIA

1.6.5 AIR INLET – INLET BARRIER FILTER

MBB-BK117 D-2 has two possible configurations for the air inlet. The standard air inlet is called “mushroom grid” and does not have a filter. The other configuration is the IBF which does have a filter (see Figure 5). The IBF is installed to remove foreign objects such as sand, dust, and other particles. The IBF system consists of two parts (see Figure 6), the filter and the filter tray on which the filter is mounted. Operation and monitoring systems are also in place. In the bottom of the filter tray, there is a bypass door that opens to ensure that the engine gets enough air if the filter starts to clog. Under the bypass door, there is a grid to prevent foreign objects from entering the engine when the door is open.

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[8] *In the certification documentation icing conditions are defined as flight into clouds where ice may build up on the airframe due to the atmospheric conditions.*

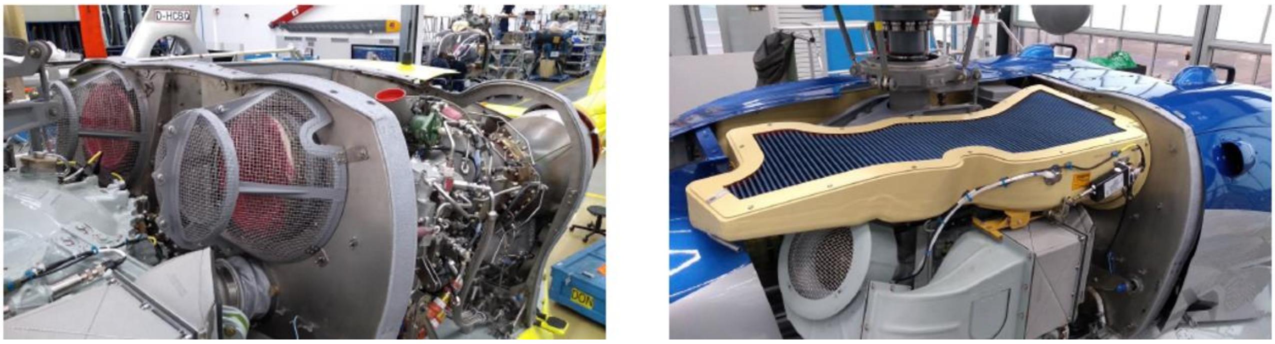

Figure 5: The difference between mushroom to the left and IBF to the right. Both air inlets are attached to the firewall. Photo: Airbus Helicopters / NSIA

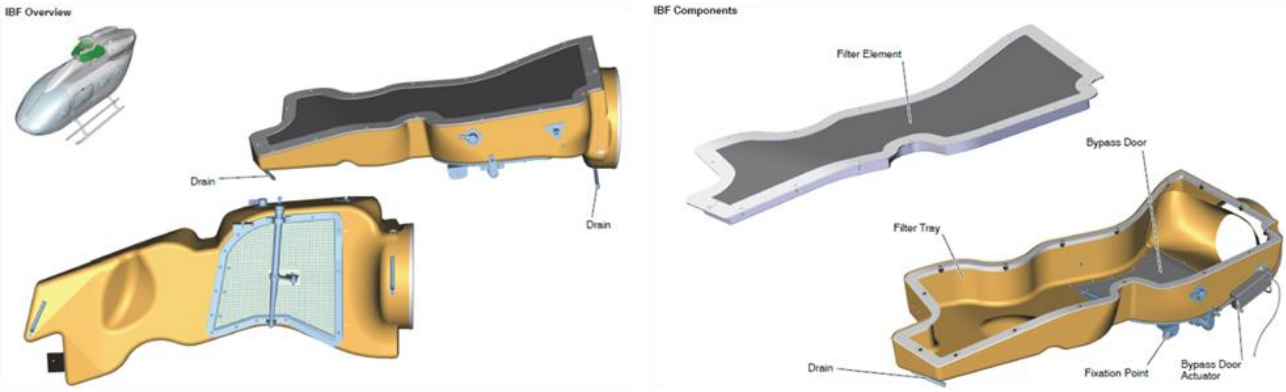

Figure 6: Parts of the IBF system. Source: Airbus Helicopters / NSIA

Each engine has a separate IBF system that can be operated independently. The two filter systems are monitored for clogging. Indicated clogging of 100% does not mean that the filter is completely clogged, but that the system no longer has any margin if the engine requires more air. This means that the filter can limit the performance of the engine and, if more clogging occurs, the bypass door will open automatically. It will also open automatically if the engine shuts down. The bypass door can also be opened by the pilot using a switch in the cockpit.

1.6.5.1 Icing of IBF

Figure 7 below shows an excerpt from the rotorcraft flight manual procedure if icing of the IBF is suspected such that the engine is not supplied with enough air. The procedure is to leave immediately if icing conditions are encountered or open the bypass door to ensure that the engine gets enough air and continue flight if the flight is outside icing conditions.

3.3 **INADVERTENT ICING OF IBF**

Conditions/Indications

- Icing conditions are entered inadvertently
- Icing shall be suspected when the IBF CLOG TREND alert appears during flight when OAT < 3° C in visible moisture.

NOTE Icing of the IBF may occur before other signs of icing are visible on the aircraft.

Procedure

1. Icing conditions	– Leave immediately
2. IBF1 sw	– OPEN – Check IBF1 BYPASS OPEN – Wait 60 sec
3. IBF2 sw	– OPEN – Check IBF1 BYPASS OPEN IBF2
4. Continue flight	

Figure 7: Excerpt from the rotorcraft flight manual showing the procedure if the IBF starts to ice. Source: Airbus Helicopters / NSIA

1.6.5.2 Certification of IBF

Identical requirements for air induction systems are provided in CS 29.1093[9], and FAR 29.1093 are quoted below:

> *§ 29.1093 Induction system icing protection.*
> *(b) Turbine engines. (1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)—*
> *(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in appendix C of this Part; and*
> *(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.*
> *(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30 °F (between −9° and −1 °C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.*

The certification of MBB-BK117 D-2 was mainly based on the tests from the certification of MBB-BK117 C-2. This was accepted by the type certification authorities. The air induction design for C-2 and D-2 are identical, but D-2 is upgraded with a new engine with better performance[10].

As part of the certification of both air induction configurations, Airbus Helicopters transformed the results from the C-2 testing such that they were valid for the D-2. Some dedicated tests were also

[9] CS – Certification Specification, European regulations | FAR – Federal Aviation Requirements, United States Regulations
[10] The air flow through the engine is increased and as the area remains the same, it is the air flow speed that increases.

done during the D-2 certification, but these did not apply to the IBF system. During the transformation of the test results, the effect of the increased engine performance, and increased air flow speed, on the air temperature in the air intake[11] were not investigated.

For the standard air intake, the testing showed that the areas of the mushroom grid that the air had the most direct path to iced first and to a greater extent. One explanation for this is that when the air has to change direction, some of the water droplets in the air are deposited, since their momentum is too high to change direction. The results concluded that ice build-up in the air intake or on the mushroom grid would never affect engine performance.

When it came to the IBF system, the assessment was that ice would not build up on the grid of the bypass door and this was not investigated further. The reasoning for this was that when the bypass door is open the air has a more tortuous path into the engine, which leads to even more water droplets being removed and drying out the air. In addition, the bypass screen is located close to the warm oil cooler which radiates heat. Both factors were seen as making a positive contribution with respect to icing.

Flight tests performed by Airbus Helicopters, see Section 1.16.2, have shown that this is incorrect and that in certain situations significant amounts of ice can build up in the air intake.

1.7 Meteorological information[12]

1.7.1 THE NORWEGIAN METEOROLOGICAL INSTITUTE

At NSIA's request the Norwegian Meteorological Institute prepared a report on the weather conditions. Quoted from the report:

> *On Saturday 20 November, there was a low-pressure system over Kvitsjøen, which created northerly winds over all of Northern-Norway. There were snow showers in Troms og Finnmark, and after a while in Nordland as well. The temperature on the ground was about 0 °C and fell by roughly 1 °C per 100 m of elevation. There were relatively calm winds on the ground, 8 – 18 kt.*

No icing was forecast, and the prognosis of the Meteorological Institute does not indicate icing conditions. The exception was that icing could be associated with CB[13] activity within the snow shower clouds. The difference between air temperature and the dew point was only 3–4 °C, which together with an air temperature of around 0 °C means relatively high humidity.

1.7.2 METAR – WEATHER OBSERVATIONS

Times in UTC.

ENEV 201520Z 33017G30KT 9999 -SHSN BKN036 01/M01 Q0996 RMK WIND 1400FT 36018KT=

ENEV 201550Z 34011KT 300V010 9999 FEW026 BKN043 01/M03 Q0997 RMK WIND 1400FT 35018KT=

[11] The total energy of the flow is constant. This means that the stagnation temperature, which is the temperature the air would have if it were brought to rest, is the same everywhere in the flow. When the air speed increases, the static temperature will drop.
[12] See www.ippc.no for standard weather abbreviations.
[13] CB = Cumulonimbus clouds

ENEV 201620Z 33010KT 290V010 9999 -RA FEW016 BKN032 01/M02 Q0997 RMK WIND 1400FT 35018KT=

ENEV 201650Z 33008KT 9999 FEW028 BKN042 01/M03 Q0998 RMK WIND 1400FT 36020KT=

ENEV 201720Z 33012KT 280V360 9999 SCT015 BKN053 01/M02 Q0998 RMK WIND 1400FT 34020KT=

1.7.3 IGA – WEATHER PROGNOSIS

WIND SFC............: N-NE/05-25KT, STRONGEST COT, OCNL 30KT COT
WIND 2000FT.........: N-NE/10-30, OCNL 40KT COT, STRONGEST COT
WIND/TEMP FL 050....: S OF ENBO: 290-350/15-30KT, N OF ENBO: 350-050/15-30KT /MS11-MS04, LOWEST N PART
WIND/TEMP FL 100....: 300-360/20-35KT / MS22-MS15, LOWEST N PART
WX..................: SHRA/SHRAGS/SHRASN
VIS.................: LCA 4-8KM ASSW WX, ELSE +10KM
CLD.................: SCT/BKN 1500-4000FT, LCA ISOL/OCNL TCU/CB 1200FT
0-ISOTHERM..........: SFC-2000FT, HIGHEST COT S PART
ICE.................: LCA MOD ASSW CB, ELSE NIL
TURB................: LCA MOD ASSW CB, ELSE FBL
OUTLOOK FOR TOMORROW: NW-NE/05-20KT, OCNL 30KT, SHSN/SHSNRA

1.8 Aids to navigation

The flight was conducted under visual flight rules. GPS and Moving Map were used as the primary sources of information, in addition to HTAWS[14].

1.9 Communication

After departure from Harstad, LN-OOS contacted the air traffic services, both Polaris Control and Evenes. The crew provided information about where they were headed and what their mission entailed, but had no further contact. They had routine communication with the AMK[15] centre in Tromsø during the flight. This was to ensure flight following and to get weather updates, since the EFB[16] was outside coverage in Kongsvikdalen.

1.10 Aerodrome information

Not relevant.

[14] *Helicopter Terrain and Warning System – system that helps the pilot to be aware of terrain and obstacles.*
[15] *Emergency medical communications centre.*
[16] *Electronic Flight Bag – Tablet with several applications for planning and navigation.*

1.11 Flight recorders

1.11.1 COCKPIT VOICE AND FLIGHT DATA RECORDER

LN-OOS was fitted out with a FA 5001 combined cockpit voice and flight data recorder (CVFDR) from L3 Technologies. The unit can store two hours of voice recordings and 25 hours of data. The data were downloaded and analysed.

On behalf of the NSIA, the BEA conducted a spectral analysis of the noise in the cockpit. This found that 2 min and 57 seconds before the left engine shut down, several unusual harmonics emerged from the engine's gas generator. This type of acoustical irregularity is typical of foreign object damage to an engine.

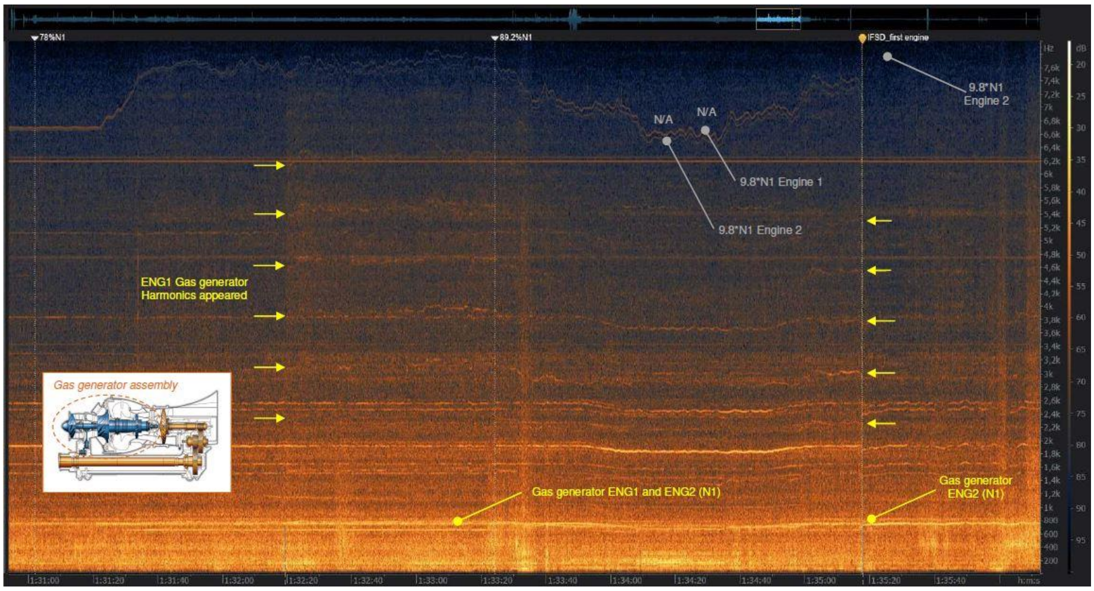

Figure 8: The spectral analysis conducted by the BEA. Source: BEA / NSIA

1.11.2 ENGINE DATA RECORDER

Each Arriel 2E engine is equipped with an Engine Data Recorder (EDR). Data from both EDRs were downloaded and analysed after the incident. The EDR can register data at two sampling rates. Continuous Recordings have a sampling rate of 1 Hz while Context Recordings have a sampling rate of 50 Hz. Context recording is activated if the engine registers any abnormalities.

Safran analysed the data from the EDR, and the results are presented below. Both engines' EDR had Continuous Recordings, but only the left engine had Context Recordings. The data sets were downloaded by NOLAS, and due to equipment limitations, they had to prioritise which data sets were downloaded. BEA and Safran were able to obtain Context Recordings for the right engine from the DECU.

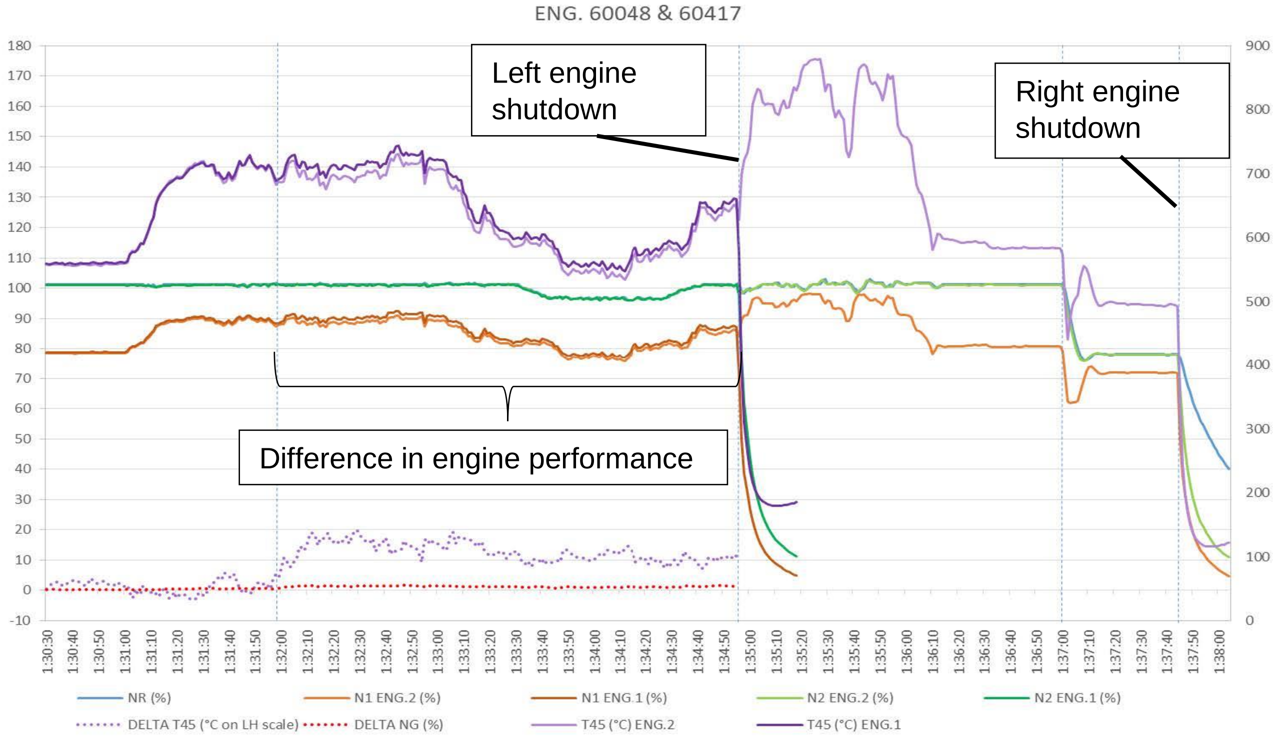

Figure 9: Graph of some of the engine parameters during the last eight minutes of the flight. Source: Safran / NSIA

Figure 9 shows the engine parameters for the 8 last minutes of the flight. It can be observed that a difference in gas generator rpm and turbine temperature about 3 minutes before the left engine shut down. The difference correlates in time with when the acoustical anomaly appeared.

Safran have also looked at other parameters such as fuel flow, fuel pressure, temperatures etc. and everything is nominal until the engine suddenly shuts down. There are no indications that there were any technical faults before the engines shut down, and this was verified during engine testing, see 1.16.3.

Figure 10 shows the context recording from the left engine when it shuts down. Both the gas generator rpm and the turbine temperature dropped suddenly. The DECU tried to compensate by providing more fuel. This was attempted twice before the DECU declares quick flame-out. 1.6 seconds later it declared flame-out and shuts down the fuel flow.

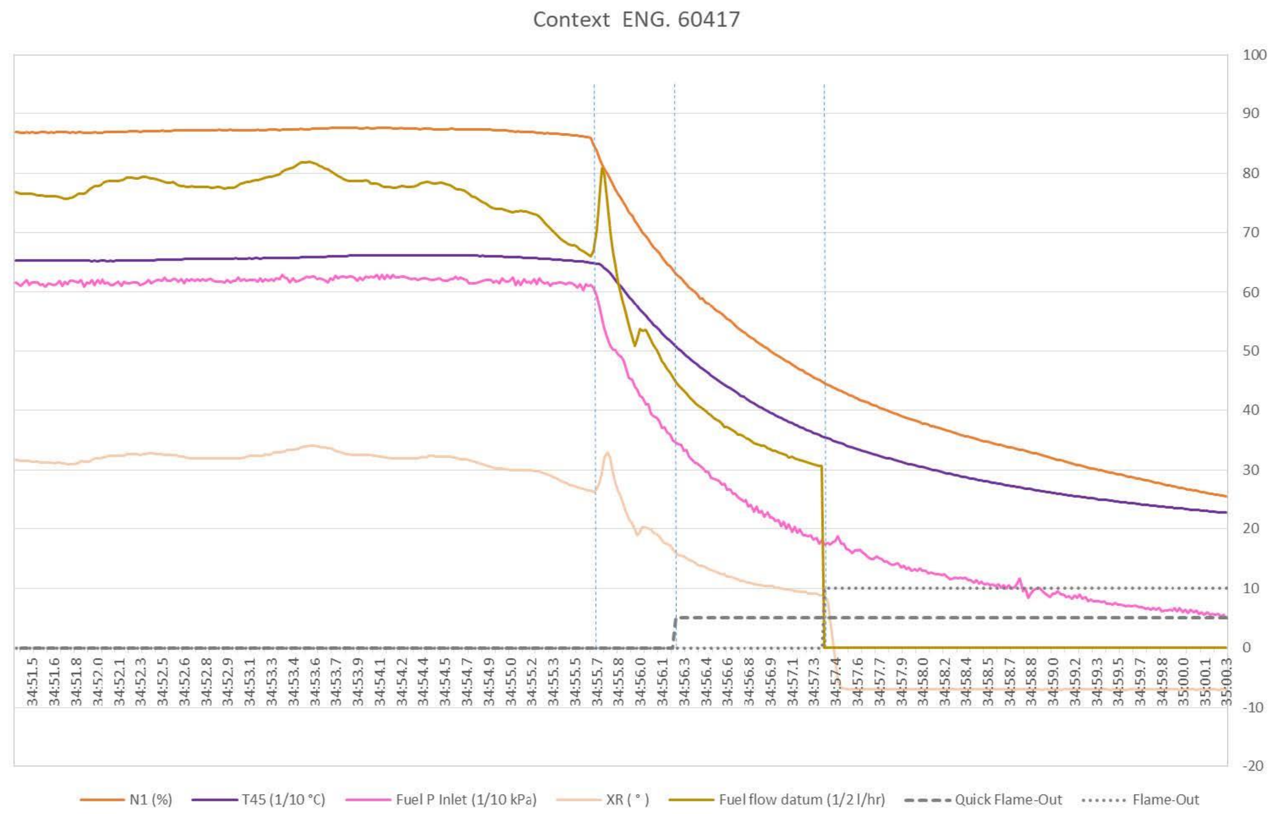

Figure 10: Some of the parameters recorded at 50 Hz when the left engine shut down. Source: Safran / NSIA

1.11.3 APPAREO VISION 1000

LN-OOS had an Appareo Vision 1000 unit installed. This unit saved photos of the instrument panel, GPS position, speeds, the orientation of the helicopter, accelerations, and rates of rotation. The NSIA used this data to create maps, as well as to confirm the sequence of events.

1.12 The incident site and the helicopter

1.12.1 THE INCIDENT SITE

The helicopter made an emergency landing on a snow-covered marsh about 60 metres above sea level. There was sufficient clearance to the woods such that the landing was performed without any issue.

1.12.2 THE HELICOPTER

Immediately after landing, the commander inspected the helicopter. There were no signs of ice or snow on the outside of the helicopter. The IBF filter was also free of snow and ice. There were, however, significant amounts of ice and slush in the main gearbox compartment. This is where the air for the engine comes from when the bypass door is open.

Visual inspection a few days later showed soft FOD[17] damage on the compressor blades in the axial compressor of both engines. There was more damage to the left engine. The right engine had minor damage that was detected using a specialist tool.

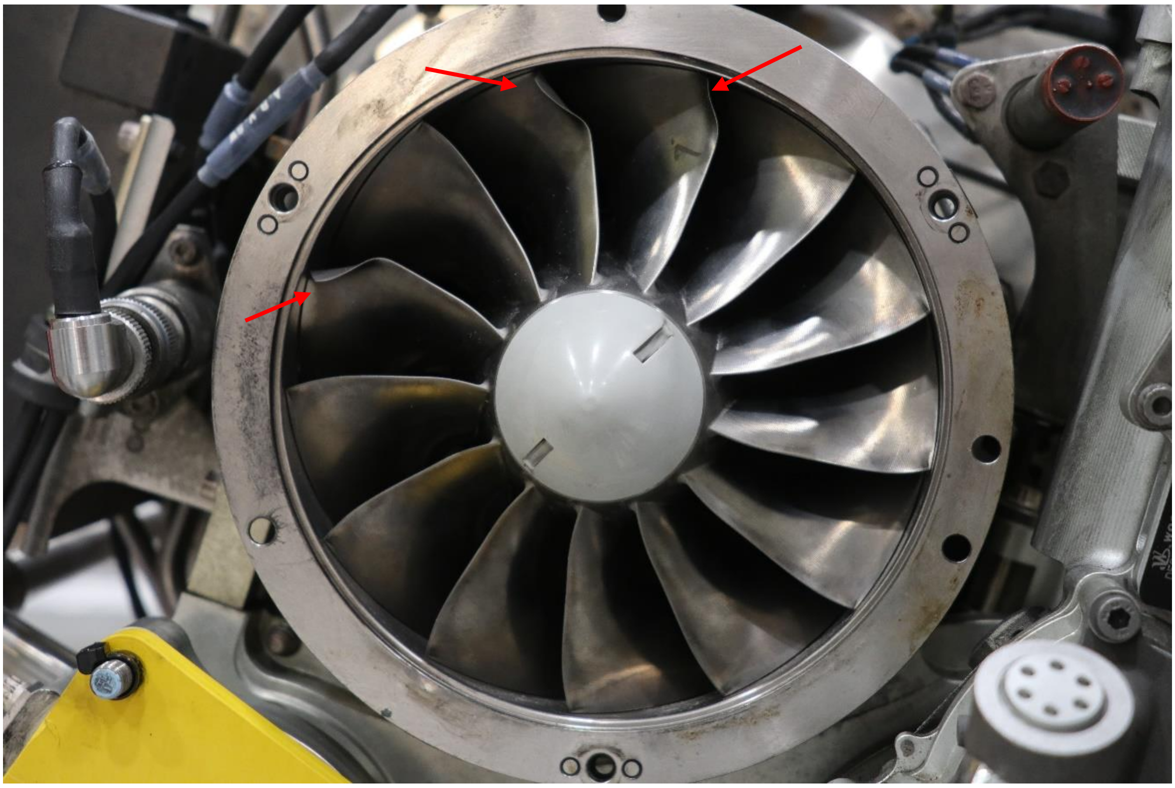

Figure 11: The left axial compressor. The arrows highlight bent compressor blades. Photo: NSIA

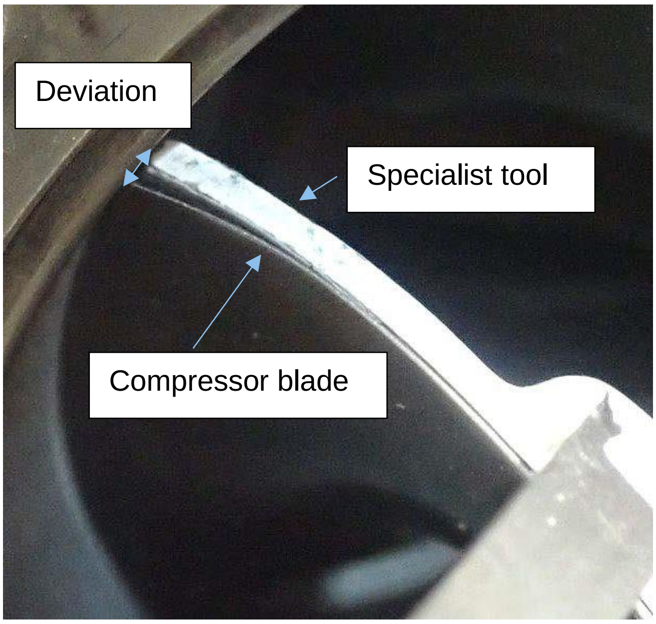

Figure 12: One blade on the right axial compressor that deviates from the specialist tool used to indicate the correct blade shape. Photo: Safran / NSIA

[17] *Soft Foreign Object Damage is damage to a turbine engine's compressor blades caused by a relatively soft object such as ice, slush, water, cloth or other soft materials.*

1.13 Medical and pathological information

Not relevant.

1.14 Fire

Not relevant.

1.15 Survival aspects

When the left engine shut down, the helicopter had low height and low speed. The commander also observed that most of the available power, both 30-sec and 2-min,[18] was used when he performed the 180° turn to turn away from the powerline crossing the valley in front of them. The terrain and the powerline could have made a possible safe autorotation[19] difficult. Only one seat with a seatbelt was available, which meant that two of the passengers did not have the possibility to be fastened and were therefore more exposed to risk.

1.16 Tests and research

1.16.1 INSPECTION OF LN-OOS AT NOLAS' TECHNICAL MAIN BASE AT GARDERMOEN

On 8 December 2021, the NSIA in collaboration with the BEA, Safran Helicopter Engines and Airbus Helicopters inspected LN-OOS at NOLAS' premises at Oslo Airport Gardermoen. The engines were inspected externally and by borescope internally. Apart from the damage to the compressor blades, nothing was found that could explain why the engines had shut down.

During the inspection some damage to the compressor blades were found and the left engine was more damaged than the right engine. All fuel lines were inspected without any sign of blockage or leaks. The NSIA also took fuel samples that were analysed, and these were found to be normal.

1.16.2 AIRBUS FLIGHT TEST

Airbus Helicopters made the decision early on and independently to perform flight tests to investigate icing of the IBF system. The flight tests were conducted in Brønnøysund from 10 to 26 January 2022. Airbus used a modified BK117 D-3 instrumented with several cameras and temperature sensors. The IBF configuration and the engine type were the same as LN-OOS.

The flight testing showed that ice can form in the IBF system and that this ice can enter the engine unhindered. Especially on the lower side of the bypass grid when the bypass door is open. If the temperature varies and goes above 0 °C, the ice can quickly melt on the contact surfaces leading to dislodging of ice or slush.

The flight tests consisted of Airbus Helicopters operating in varying snow, rain and sleet conditions to investigate how the IBF system would react. The NSIA was forwarded the results of the flight testing. The results identified a risk of significant icing in the IBF system when the air temperature is between -5 and 1 °C with high humidity (snow, sleet, rain), see Figure 13 and Figure 14.

[18] The available one engine inoperative power that can be used for 30 seconds and 2 minutes respectively before the engine must be overhauled.
[19] Autorotation is the ability of the main rotors of a helicopter to rotate without engine power by aerodynamic forces. This makes it possible to land the helicopter from a minimum safe altitude.

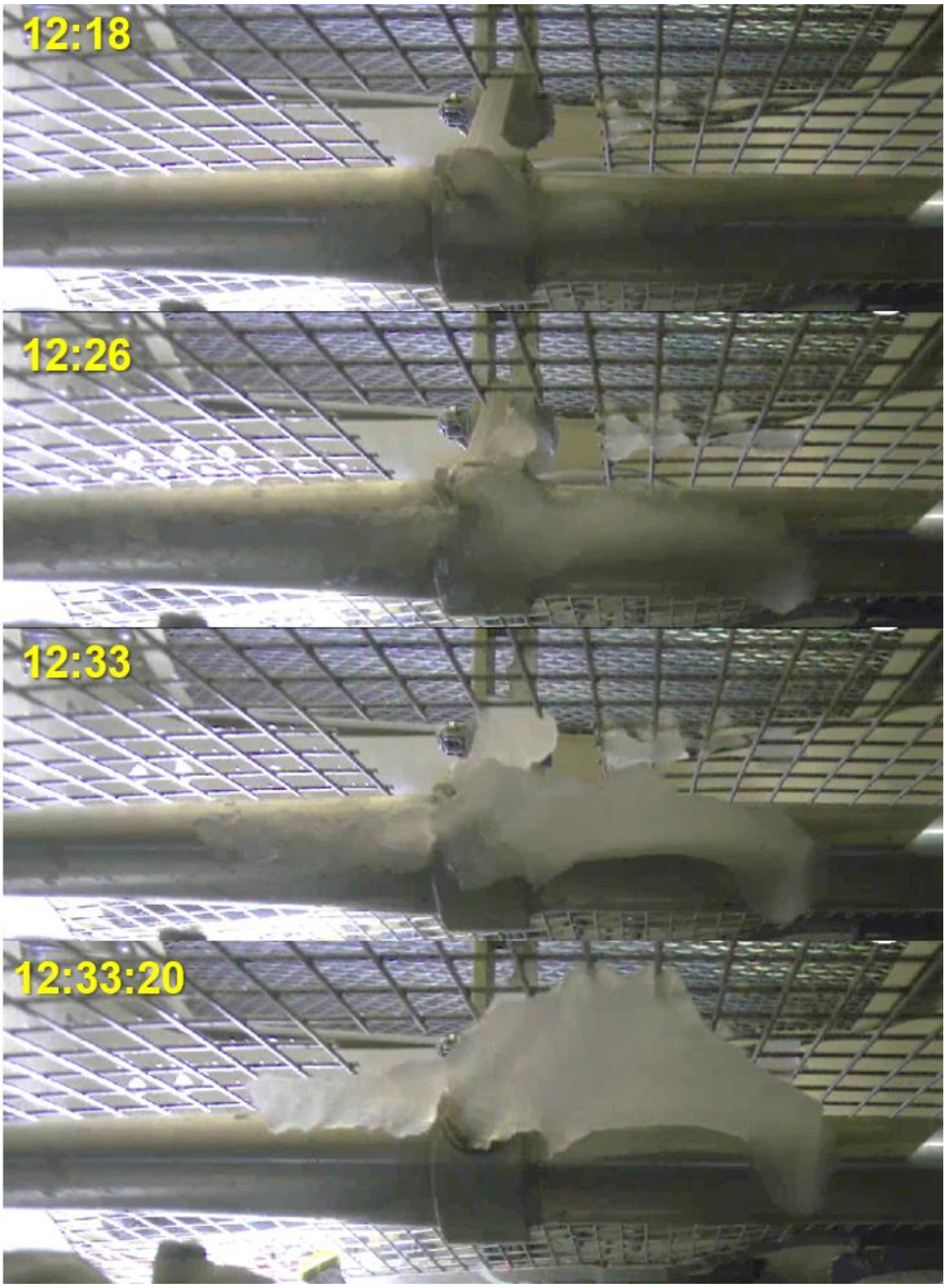

Figure 13: Ice build-up on the bypass door actuator. The photo is taken from the underside of the IBF filter tray. Photo: Airbus Helicopters / NSIA

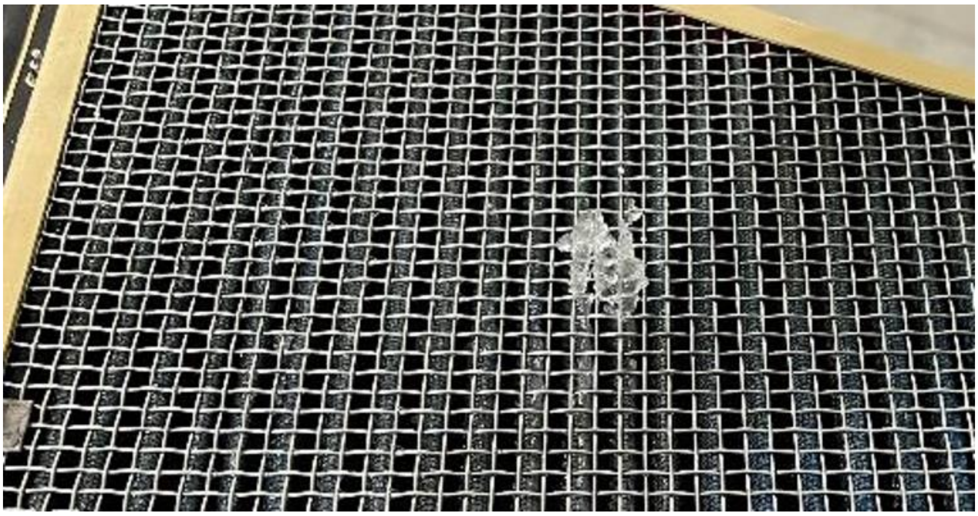

Figure 14: Ice build-up on the underside of the IBF filter. Photo: Airbus Helicopters / NSIA

1.16.3 TESTING OF THE ENGINES AT SAFRAN HELICOPTER ENGINES

During the period 22–24 February 2022 both engines were run through a test programme at the test facility at Safran Helicopters Engines in Tarnos, France, with the NSIA present. The purpose was to determine whether there was anything wrong with the engines that had not been found either during the inspection at NOLAS or during analysis of the technical data recordings.

Both engines were put through the same test programme which consisted of:

- mounting in the test bench
- preliminary checks and initial start up
- vibration tests
- performance tests
- acceleration tests
- transient tests
- final inspection

Both engines passed the tests without any issue. Nothing was found that could explain why both engines had shut down. The left engine had performed worse than the right, which is to be expected due to the damage to the axial compressor.

1.17 Organisational and management information

1.17.1 NORSK LUFTAMBULANSE AS

Norsk Luftambulanse AS was founded in 1977 and is a fully owned subsidiary of the Norwegian Air Ambulance Foundation. The company provides air ambulance services in Norway and in Denmark. In Norway, the company is contracted to Air Ambulance Services of Norway, which has 13 bases all over the country. Its head office is in Oslo while its main technical base is at Oslo Airport Gardermoen. The company had 216 employees at the end of 2020.

1.17.2 OPERATIONS MANUAL-A

Operations manual-A (OM-A) states company-specific guidelines and requirements for the execution of operations, including requirements for visibility. OM-A 8.1.4 (e) HEMS Operating

Minima states the requirements for conducting HEMS/SAR at night with the use of NVG. The cloud ceiling should be a minimum of 1,200 ft and the visibility minimum 3,000 m.

1.18 Additional information

1.18.1 INCIDENT INVOLVING LN-OOU

On 30 March 2020, another NOLAS MBB-BK117 D-2, LN-OOU, was on a medical mission from Brønnøysund to Sandnessjøen hospital and back. There was light snow, the temperature was around zero and there was reduced visibility. The flight was conducted under instrumental flight rules.

On the way from Brønnøysund, the crew noticed light icing on the wire-cutter[20]. They reduced the flight altitude and the icing stopped. The flight then continued as normal and LN-OOU landed at Sandnessjøen hospital. After a ground stop of about 30 minutes, the crew removed some light snow from the stabilisers and the Fenestron. It was snowing lightly, but the commander had good visibility when he lifted off.

After about 15 minutes of normal flying the left engine suddenly stopped without warning. The crew declared MAYDAY and analysed the situation. They decided that it was best to try and restart the engine in flight. The engine started without issue and the rest of the flight was performed with no problems.

NOLAS conducted an internal investigation after the incident with the support of Safran and Airbus. The investigation did not reveal any technical issues with the engine that could explain why it had stopped. They identified minor soft FOD damage to the compressor, but it was not possible to unambiguously determine why the engine stopped.

1.18.2 PREVENTIVE MEASURES AFTER THE INCIDENT

Shortly after the incident involving LN-OOS on 20 November 2021, Airbus Helicopters published a Safety Information Notice (SIN 3515-71-Rev1) concerning flights in winter weather for helicopters with IBF installed. This prohibited flights in snowy weather for helicopters with the IBF installed. It also set out that flights should be avoided when the temperature was below 5 °C and there was visible moisture.

After a professional discussion this SIN was revised to SIN 3515-71-Rev2 which did not contain as strict requirements. EASA also published an Airworthiness Directive based on this SIN. The current limitations stated in SIN 3515-71-Rev2:

> *Purpose of Revision 2 of this SIN is to inform flight crews of updated protective measures for helicopters with IBF installed:*
>
> *Flight in the following environmental conditions is prohibited:*
>
> - *Flight in falling snow and sleet with visibility due to snow/sleet less than 1500 m*
> - *Hover or flight in blowing snow for longer than 1 minute*
> - *Flight in fog/clouds when visibility is less than 800 m and OAT ≤ 5 °C*
> - *Flight in icing or ice crystals conditions*

[20] *A sharp device at the front of the helicopter that helps to cut wires in the flightpath.*

There are no additional limitations if the helicopter is equipped with the standard mushroom grid air intake. NOLAS therefore chose to remove the IBF system from all its MBB-BK117 D-2 helicopters.

Following the flight testing described in Section 1.16.2, Airbus Helicopters has proposed several changes. One change is to place an extra grid in the Air Inlet Tube which located after the IBF tray but before the compressor. This is to prevent ice from reaching the engine. It is also proposed to change the grid that covers the bypass door to make the hole for the actuator smaller.

Whether the selected improvement ideas are appropriate or will be successful in terms of removing the probability of ice accretion is to be verified by further flight test campaigns.

1.19 Useful or effective investigation techniques

This investigation has not used any method that requires special mention.

2. Analysis

2. Analysis

2.1 Introduction

This investigation has had access to a lot of high-quality, relevant information. This has enabled the NSIA to form a good understanding of the sequence of events to determine possible factors that may explain why both engines on LN-OOS stopped.

The analysis starts with the sequence of events. Then it discusses the reuse of data as part of the aviation type certification procedure. HEMS operations and winter conditions are discussed before the analysis concludes with an assessment of auto ignition.

The investigation has not found any technical fault with the engines that could explain why they stopped, and this is not further analysed.

2.2 Sequence of events

The incident in the Kongsvikdalen valley illustrates some of the unique factors search and rescue and air ambulance services must consider. These kinds of missions might often have to operate with smaller safety margins than other types of operations. The company procedures shall ensure that the operation is as safe as possible and that it does not exceed the limitations of the rotorcraft or the crew.

The weather that LN-OOS operated in are conditions which can be expected along the Norwegian coast in winter. The crew have explained that they were aware of the snow showers in the area and that they did not pay much attention to this. They were used to flying in these weather conditions. They had just returned from another mission in the same area where the weather had not affected the flight or the mission.

Icing conditions were not forecast outside the snow shower clouds, and the helicopter was not prohibited from operating in snowy weather. An assessment of the weather conditions must be made to determine if icing is suspected or not. The crew did not suspect icing and visibility was the limitation they focused on most. While the helicopter waited for the party in distress the visibility was, at times, below the NOLAS requirements for HEMS operations at night. At the same time, they had visual contact with the terrain around them and a possible landing site if something were to happen to the helicopter. The nature of the mission entails a desire to help other people, and it is understandable that the crew decided to stay in the area. Especially as the visibility was not good enough to fly out of the area and because the party in distress used the lights and noise of the helicopter to navigate down the mountain.

It is not possible for the NSIA to unambiguously determine when the ice built up. However, it is likely that this happened while the helicopter operated in hover or on the ground while it waited for the party in distress. After the helicopter had landed and had a lower power setting, the air flow would have been less, and the air flow would thus have had a higher temperature. In addition, the heat from the oil cooler would also have heated up the main gearbox compartment. This may have led to the ice starting to melt, become softer and loosening. When they took off again the higher air flow might have sucked some of this ice into the engine. This corresponds with the time when the acoustical irregularity appeared and the difference in engine performance occurred.

Another three minutes passed before the left engine stopped, which can be explained by the fact that the ice may have come loose in several rounds. The right engine did not stop until the engine was set to idle power, which may be explained by the fact that this situation leaves a smaller margin to the self-sustaining speed. Less is then required stop the engine. The fact that there is less damage to the right compressor blades can be explained by the reduced rotation speed when the engine was set to idle. The NSIA cannot exclude that the ice in the right air inlet was also sufficient to cause an inflight shutdown of the right engine.

The NSIA would like to acknowledge the crew's swift action of the when the left engine shut down. LN-OOS was in a narrow valley, in darkness and did not have visual confirmation of a known power line. Establishing one engine inoperative flight, locating the power line, and afterwards continuing flight would have been challenging. Given the situation they found themselves in, performing an emergency landing seems to be a good decision.

If both engines had stopped in flight the crew would have had to autorotate to the ground. The height, speed and terrain around LN-OOS would have made it challenging for the commander to establish correct flight conditions for safe autorotation. Since the passengers did not have safety belts, a hard landing or crash, could have led to personal injury.

2.3 Type certification and reuse of previous certification data

Certifying components and aircraft is a time-consuming and expensive process. It is therefore common for data and results from previous certifications to be re-used as much as possible if certain similarity criteria are fulfilled. This presents several challenges and puts an extra responsibility on the manufacturer and the certifying organisation. A critical review of previous assumptions is essential, as it is not given that these still hold. This, however, can be difficult to recognise.

During the certification of MBB-BK117 D-2, the consequences a new engine would have for icing in the air induction system were evaluated for the standard mushroom grid. The main focus was on the effect of increased mass flow rate through the engine. This leads to a higher air stream velocity, and how much extra water the air intake would be subject to per unit time, and the effect of this on ice build-up, were evaluated. The conclusion was that the standard intake still satisfied the certification requirements.

No such evaluation was performed for the IBF system. The assumption was that the C-2 testing was still valid. This engineering judgement was based on similarity aspects since the IBF system for C-2 and D-2 are identical. The results of that analysis showed that the IBF system had a further positive effect on reducing icing. With the IBF installed and the bypass door open, it was presumed that the air has a more tortuous path to the engine than with the standard mushroom grid. This was further assumed to lead to more water and ice being removed and drying out the air going to the engine. In addition, the presumption was that the close proximity to the warm oil cooler that radiates heat would be beneficial.

The flight tests conducted by Airbus Helicopters after the incident involving LN-OOS have shown that this assumption is not necessarily valid. The increased air flow also lowers the temperature of the air stream. This leads to the possible creation of a local area where the conditions for icing are present, even though the overall conditions are not conducive to icing. The NSIA is of the opinion that Airbus Helicopters did not do a thorough enough verification of their assumptions about the IBF system and if they were still valid during the certification process of the MBB-BK117 D-2.

The NSIA sees it as unlikely that the standard mushroom grid air intake has the same issues as the IBF system. In the case of LN-OOS, neither the crew nor manufacturer were aware of the possibility of ice forming that could go unhindered into the engine.

The NSIA is aware that both Airbus Helicopters and EASA have taken the problem seriously. Based on the expected completion of the solutions that Airbus Helicopters have presented, the NSIA does not propose any safety recommendations.

2.4 HEMS operations and winter conditions

The Norwegian coast is prone to low-pressure systems forming along the polar front. Warm humid maritime air hits the Norwegian coast results in lots of precipitation. The humid air can, with temperatures of around 0 °C during winter, lead to a combination of rain, sleet and snow that in turn causes high humidity. The humidity decreases at lower temperatures and the problem subsides. High humidity increases the risk of icing. The flight tests conducted by Airbus have shown that these conditions can lead to icing in the IBF system.

It is important that operators in Norway, in consultation with manufacturers properly assess how conditions that are normal in Norway can affect operations. A manufacturer might not be aware of these, so it is up the operators to inform them of this. The manufacturers also have a special responsibility to take the conditions the operators inform them of seriously.

The search and rescue and air ambulance services are especially vulnerable to these issues. However, it is nevertheless important that helicopters are operated within their limitations even when life and health are at stake. Operators handle the increased risk through procedures and requirements of the operation, but they must also trust the aircraft they operate. When an operation is conducted within the limitations set out in an aircraft's flight manual, the operation is expected to be safe. The incident with LN-OOS has shown that the IBF system did not fulfil the stipulated requirements.

The NSIA nevertheless have some considerations about aspects of the mission. Extended operation in the weather that LN-OOS operated in was unfortunate. Moderate icing was forecast inside the snow shower clouds, so extended operation under the clouds increased the risk of an undesirable situation. The weather varied in intensity and was also bordering on the margins when LN-OOS left the area. This means that the crew had the possibility to leave earlier.

It is also unfortunate that it was not possible to secure all the passengers. When a passenger is not secured, one is exposed to increased risk, and one is a hazard to other onboard the helicopter. The NSIA is of the opinion that the operation at times had reduced safety margins. Since the operation was conducted within the regulatory framework and due to the technical aspect of the incident this has not been a focus of the investigation.

2.5 Auto Ignition

Arriel 2E does not feature an autonomous restart of the engine in the event of a flameout. A manually commanded restart is therefore required.

Although MBB-BK117 D-2 is not certified for flight in icing conditions, situations may arise whereby the helicopter unknowingly enters such conditions. The responsibility of the commander is then to leave the area as soon as possible, but this still takes time. Snow is not automatically defined as icing conditions and the investigation has shown that the IBF system is vulnerable to icing in snowy weather. Icing in the air intake is then possible even though the operation is not being conducted in forecasted icing conditions.

When the flame went out the DECU registered that both the temperature and the rotational speed of the gas generator fell. It declared a flameout 1.6 seconds after the engine parameters started to drop. The way the system functions today the commander must manually initiate the relight sequence. This can be done before the RPM of the gas generator falls below 20% and the engine control system will then automatically restart the engine when the engine parameters indicate that a restart is possible. This nevertheless demands vigilance and mental capacity of the pilot.

In the case of LN-OOS, regaining engine power almost immediately would have lessened the severity of the situation. Since the helicopter was in a situation with small safety margins an auto ignition function or a manual restart would have provided the commander with more room for action.

Since the helicopter is not certified for flight into known icing conditions, and the engine should be protected from ice by the air induction system and that the engine manufacturer previously, without luck, have tried to find a technical solution, the NSIA does not propose any safety recommendations.

3. Conclusion

3. Conclusion

3.1 Main conclusion

Both the engines on LN-OOS most likely stopped due a flameout caused by the ingestion of ice. The investigation has shown that this ice most likely came from the IBF system. Flight tests conducted by Airbus Helicopters after the incident have revealed that under certain weather conditions, significant amounts of ice can build up in the IBF system and this ice can then enter the engine unhindered.

3.2 Investigation results

A. The weather was clear and there was good visibility when LN-OOS lifted off in Harstad.

B. No technical faults or issues with the helicopter have been found.

C. The helicopter encountered the snowy weather when it reached the Kongsvikdalen valley.

D. Icing conditions were not forecast except for inside the snow shower clouds.

E. It took longer than the crew anticipated for the party in distress to reach the helicopter.

F. While the helicopter operated in hover, the snow showers varied in intensity.

G. While operating in hover, the crew received IBF clogging warning for the right-hand engine.

H. At some points, visibility was below minima required by NOLAS.

I. The crew had visual contact with the terrain around them and a possible landing site the entire time.

J. The crew had decided to leave if they found a good opening in the weather.

K. The flight was normal until the left engine stopped suddenly.

L. Two of the passengers did not have the possibility to sit in a seat with a safety belt.

M. The helicopter landed without problems and without anyone sustaining an injury.

N. The investigation has found that the IBF system does not fulfil the certification requirements for icing protection.

O. Under unfavourable weather conditions, significant amounts of ice can build up in the IBF system and this ice can enter the engine unhindered.

P. The Norwegian coast is exposed to winter conditions that are conducive to icing in the IBF system.

Q. The investigation has not found any technical faults with the engines.

R. The engines do not have an auto ignition function that can autonomously start them if they were to stop.

4. Safety recommendations

4. Safety recommendations

The Norwegian Safety Investigation Authority does not propose any safety recommendations.

Norwegian Safety Investigation Authority
Lillestrøm, 14 November 2022

Abbreviations

Abbreviations

AMK	Emergency medical communications centre
ARC	Airworthiness Review Certificate
CVFDR	Cockpit Voice / Flight Data Recorder
DECU	Digital Engine Control Unit
EDR	Engine Data Recorder
EFB	Electronic Flight Bag
FOD	Foreign Object Damage
HEMS	Helicopter Emergency Medical Services
HTAWS	Helicopter Terrain and Warning System
IBF	Inlet Barrier Filter
NOLAS	Norsk Luftambulanse AS
NSIA	Norwegian Safety Investigation Authority
NVG	Night Vision Goggles
OM-A	Operations Manual-A
SEV	Stop Electro Valve
SIN	Safety Information Notice