



THE REPUBLIC OF CROATIA

**Air, Maritime and Railway Traffic Accident Investigation Agency**

**Air Traffic Accident Investigation Department**

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# **FINAL REPORT**

**ON ACCIDENT OF THE HELICOPTER  
type Alouette II, SE-313B,  
registration 9A-HAT**

**Zlarin, 3 July 2018**



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## OCCURENCE INFORMATION

Type of the occurrence:	Accident
Date:	3 July 2018
Local time:	11:00 LT
Place:	Island of Zlarin, town of Zlarin
Type of the aircraft:	Helicopter, Annex II
Manufacturer / model:	Sud Aviation Aerospatiale / Alouette II
Registration:	9A-HAT
Owner:	Legal entity
Operator:	Eudora Let d.o.o
Number of persons on board:	Three (pilot, male and female passenger)
Injuries:	Two persons with minor injuries
Damage to the aircraft:	Substantially damaged



Figure 1 - Accident site marked with a red mark

## INVESTIGATION

AIA received the first information about the accident from the National Protection and Rescue Directorate (DUZS) and the Operational Communication Centre of the Ministry of the Interior (OKC MUP).

AIA investigators started the inquest on the same day, and performed interviews with people related to the accident and the investigation was opened. During the investigation, a search of a larger area around the accident site was performed for detection of parts that were separated from the helicopter during the flight and that have fallen to the ground.

A Press release was published, which provided basic information about the occurrence. One month after the accident a Preliminary Report on the subject accident was issued. One year after the accident an Interim Statement was issued.



AIA issued safety recommendations to the helicopter operator - tvrtki Eudora Let d.o.o, Croatian Civil Aviation Agency (CCAA), Maintenance organization - tvrtki Hidroplan Nord Kft, Hungarian Aviation Authority - „Ministry for Innovation and Technology Aviation Authority Supervisory Department Airworthiness Unit“, and helicopter manufacturer - Airbus Helicopters company.

## **SUMMARY**

Three persons took off by a helicopter from the heliport Gaćeze, with the intention of making a panoramic flight over the wider area of the city of Šibenik. Above the island of Zlarin, the pilot noticed that the manoeuvrability of the helicopter was getting worse and he performed a forced landing to the island, on which occasion the male and female passengers sustained minor injuries, while the pilot sustained no injuries. There was a substantial material damage to the helicopter. After landing, there was a small fire that the pilot had successfully extinguished.

## **1. FACTS AND INFORMATION**

### **1.1. FLIGHT INFORMATION**

On 3 July 2018 around 10:15 hours, the pilot with two passengers took off from Vodice heliport (place Gaćeze), with the intention of performing panoramic VFR flight over the wider area of the city of Šibenik. After the take-off, the flight of the helicopter took place in the Class G airspace over the National Park Krka (three turns) at 10:25 hours, the city of Šibenik (three turns) at 10:40 hours and the island of Zlarin at 10:43 hours (Figure 2). Around 10:43 hours, the pilot felt a strong twitch of the helicopter, followed by light vibrations. After a minute and 20 seconds the pilot noticed the occurrence of strong vibrations and decided to perform a forced landing. The helicopter landed about 800 meters aerial distance north of Zlarin, at the area covered with grass, trees and low vegetation.

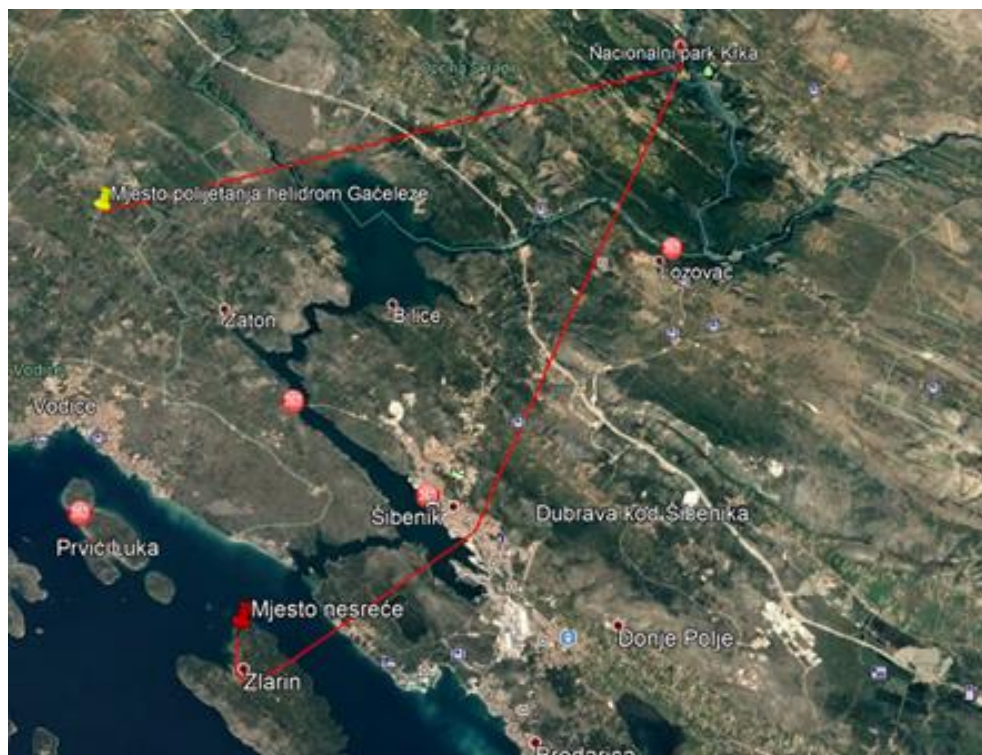


Figure 2 – Flight route of the aircraft

## 1.2. INJURIES

Injuries	Crew	Passengers	Other
fatal	0	0	0
serious	0	0	0
minor / none	1	2	0

During the accident, the pilot did not suffer any body injuries, while both passengers suffered minor body injuries in form of scratches.

## 1.3. DAMAGE TO THE HELICOPTER

In this accident the helicopter was substantially damaged (Figure 3). Damages were present on parts of the construction, landing gear, power transmission system, controls, and certain aggregates around the power plant and the main gearbox. During the landing there was a minor fire on the helicopter, which was extinguished thanks to the rapid reaction of the pilot. No signs of birds or other flying objects such as drone were found on the helicopter.



Figure 3 – Helicopter 9A-HAT at the accident site

#### **1.4. OTHER DAMAGE**

During the subject accident no other damage occurred.

#### **1.5. INFORMATION ON THE COMPANY EUDORA LET D.O.O.**

The company Eudora Let d.o.o was established in 1998 with registered office at Vodice. The company provides panoramic flights, air photography, and use of helicopters for agricultural, forestry or construction work, fire protection, hail defence, search and rescue, publicity, surveillance and patrolling, flight crew training, radio navigation equipment testing and similar.

At the time of the accident, the company possessed the Air operator certificate and the Air operator certificate for commercial operations other than commercial air transport issued by the Croatian Civil Aviation Agency (CCAA).

#### **1.6. PILOT INFORMATION**

A male person, a Croatian citizen born in 1963. The pilot is also the owner of a company that is an operator of the subject helicopter and also a responsible person on several functions at Eudora Let



d.o.o. At the time of the accident, he had possessed a helicopter pilot license issued on 15 April 2014 while the authorisation expiry date for the helicopter type SA318 / SE313 was 30 April 2019. The pilot also holds a flight instructor's license for the helicopter, expiring on 31 July 2020.

### 1.7. HELICOPTER INFORMATION

Manufacturer:	Sud Aviation
Type:	SE313B
Capacity:	1 pilot and 4 passengers
Length:	9.66 m
Height:	2.75 m
Maximum take-off weight:	1600 kg
Main rotor diameter:	10.20 m
Cruise speed:	170 km/h
Maximum speed:	185 km/h
Ascending speed:	4.2 m/s
Range:	565 km

Alouette II is a helicopter produced by the French company Sud Aviation. Production of the helicopter lasted from 1956 till 1975. In that period, 1300 helicopters were produced. For military purposes, the helicopter was mostly used for air photography, rescue and training, while in civilian use it was often used for underslung load transport, fumigation, and transport of injured persons.

During its operation until the day of the accident, the company Sud Aviation changed several owners and names. At the time of the accident, the holder of the Alouette II helicopter Certificate was the company Airbus Helicopters.

#### **Alouette II, S/N: 1841**

The subject helicopter was manufactured in 1963 under serial number 1841 and on 11 July 2011, and it was registered in the Croatian Register with the owner, a legal entity, company Eudora Let d.o.o. under the ordinal number 344 and the registration mark 9A-HAT. Mentioned company used the helicopter for panoramic flights and underslung load transport. On the day of the accident, the helicopter was airworthy. The last check of the airworthiness of the helicopter was performed on 28 December 2017 by the Croatian Civil Aviation Agency, during which no findings were determined. By inspecting the aircraft logbook, it was determined that the last flight before the subject flight was performed on 25 June 2018.

Total flight hours of the helicopter:	7302.40 hours
Total number of helicopter cycles:	3842
Total flight hours of the helicopter during the last maintenance:	7299.00 hours
Date of the last helicopter maintenance:	17.4.2018
Total flight hours of the power plant:	6919.00 hours
Total flight hours from the last general overhaul of the power plant:	918.00 hours



On the day of the accident, the total helicopter flight hours was 7302.40, with the number of cycles of 3842. At 7299 hours, the last helicopter maintenance was performed, i.e. 3 hours prior to the subject accident and 918 hours after the general overhaul of the power plant.

The documentation from the last performed helicopter maintenance indicates that the following inspections were performed:

- 25, 50, 100, 200-hour inspection
- T-1 inspection
- T-2 inspection, point 1-141
- Major inspection, point 142-183

The helicopter was equipped with the power plant Artouste C6, serial No. 782. At the time of the accident, 828 hours of engine operation remained until the next general overhaul.

## **1.8. METEOROLOGICAL INFORMATION**

At the time of the accident (around 10:15 LT), the meteorological data measured at the weather station Vodice indicate the sunny weather with intermittent low clouds, wind speed of 2 km/h from east, north-east, temperature of 26°C, humidity of 74% and air pressure of 1013 hPa. The visibility on the day of the accident was more than 10 km, satisfactory for the subject flight, and the weather conditions had no influence on the flight.

## **1.9. COMMUNICATION**

Before the flight and during the flight, the pilot communicated with the air traffic control at the corresponding frequencies. He did not communicate with other subjects through the radio.

## **1.10. AIRPORT INFORMATION**

The helicopter took off from the heliport in Gaćezezi, located in the Municipality of Vodice, about 6 kilometres north of the city of Vodice (Figure 4), along County road 8909. At the heliport there is a helicopter hangar, as well as helicopter take-off and landing area.



Figure 4 – Take-off site, heliport Gaćezezi

### 1.11. FLIGHT DATA RECORDERS

The helicopter was not equipped with the flight data recorder or the cockpit voice recorder.

### 1.12. INFORMATION ON THE IMPACT AND HELICOPTER REMAINS

The helicopter force-landed about 800 meters air distance north of the centre of the town of Zlarin, on the dirt trail connecting the centre of Zlarin to the north side of the island. During the last few moments of the flight, the mechanical parts which had completely been separated from their corresponding system, were falling from the helicopter. The Figure 5 shows the locations where the separated parts had been found in order to better understand the course of events that preceded the forced landing.

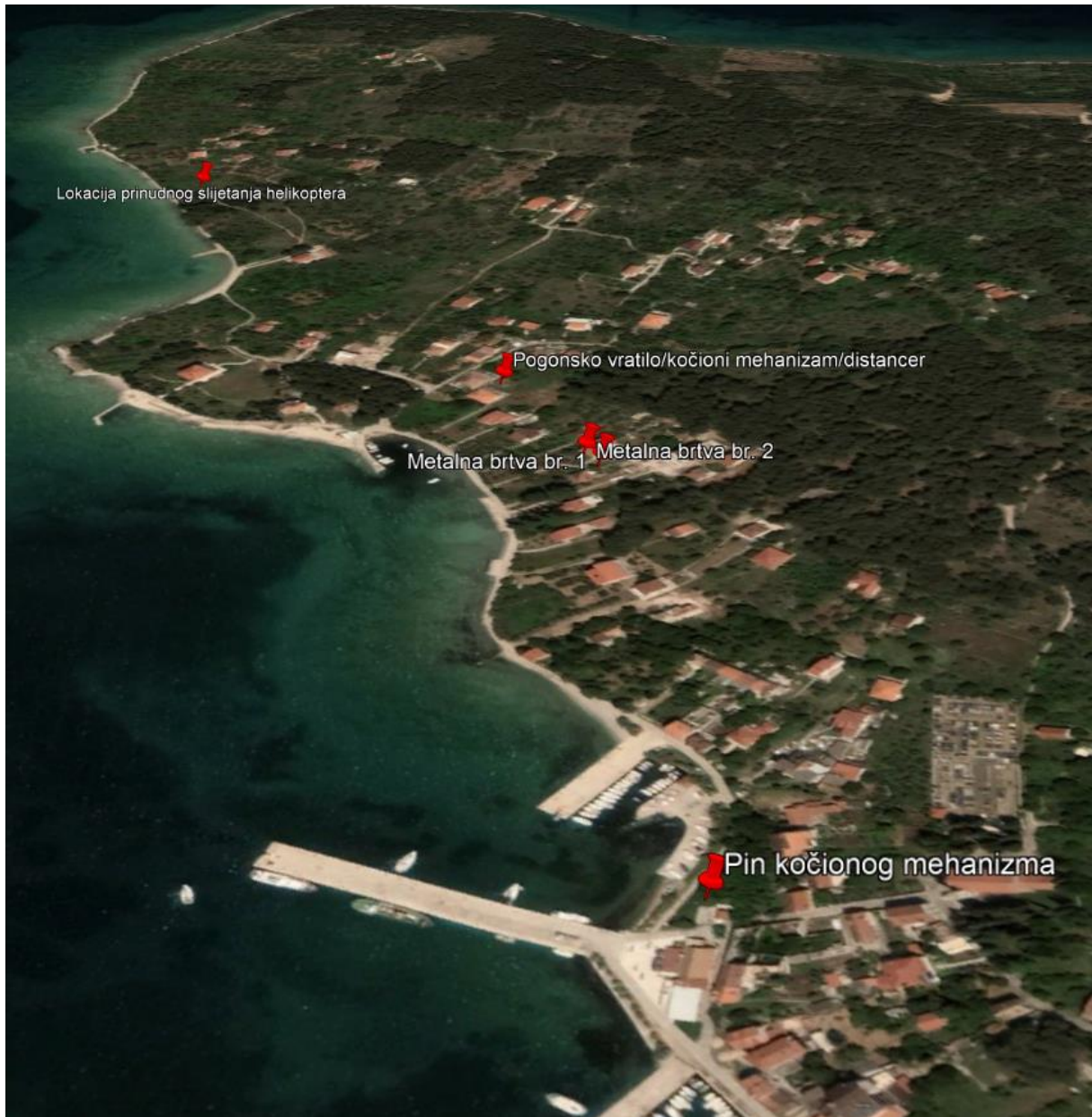


Figure 5 – Locations where helicopter parts had been found

In the last moments of flight up until the landing, the eyewitnesses noticed the smoke coming out of the helicopter. Helicopter Inspection determined that the smoke most likely occurred during leakage of the lubricating oil for the main gearbox over the heated parts of input bevel drive shaft.

#### 1.12.1. Damage to the helicopter construction

At the accident site, the helicopter was turned in the direction  $300^{\circ}$ , with the separated tail structure to which the tail rotor, tail gearbox and tail stabilizer were attached. The part of the separated tail structure was located about 7 meters away from the helicopter in the south-west direction, i.e. in the

direction of rotation of the main rotor (clockwise), (Figure 6). The tail structure which remained attached to the main structure of the helicopter was bent at the point of breakage in the direction of rotation of the main rotor (Figure 7).



Figure 6 – Part of the separated tail structure with pertaining parts

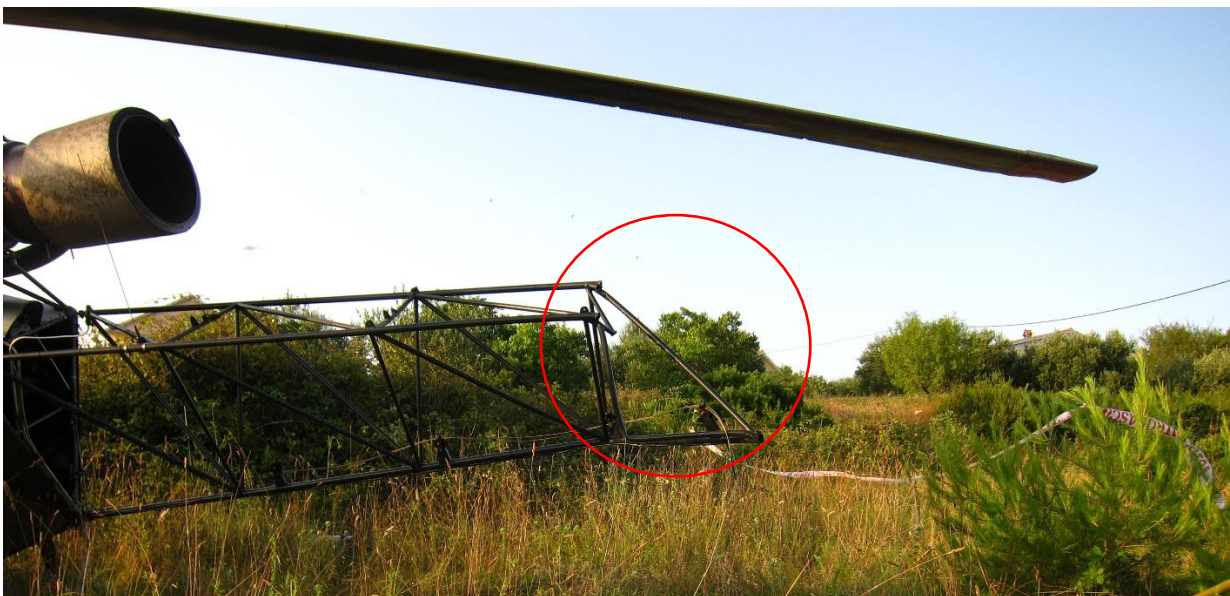


Figure 7 –Point of the breakage of the helicopter tail construction

Certain parts of the main helicopter structure were bent in several places. The left skid was completely bent as a result of the impact to the ground and was found in a horizontal position (Figure 8). At the attaching points between the skid and the helicopter structure, cracks occurred.



Figure 8 – Bent left skid with the ruptures at the junction points to the helicopter structure



Figure 9 – Bent main gearbox mount

Figure 9 shows one bent main gearbox mount rod.

### 1.12.2. Damage to main and tail rotor and main and tail gearbox

#### Main and tail rotor

During the preliminary inspection of the helicopter, on two blades of the main rotor damages were detected caused by the impact to the tail structure of the helicopter, causing tearing of the tail structure (Figures 10 and 11).



Figure 10 – Damage to the blade no. 1 of the main rotor marked in red



Figure 11 – Damage to the blade no. 2

Significant damage in the form of cracks and bending was found on both tail rotor blades which were caused by the impact to the ground and the tail structure upon its tearing.

### **Main and tail gearbox**

The oil quantity indicator indicated minimum amount of oil in the main gearbox (Figure 12). The input bevel drive shaft was broken in the area of the input bevel drive shaft assy. outer bearing. At the point of cracking of the input bevel drive shaft, there were traces of considerable material overheating in the form of deformation and discoloration (Figure 13).

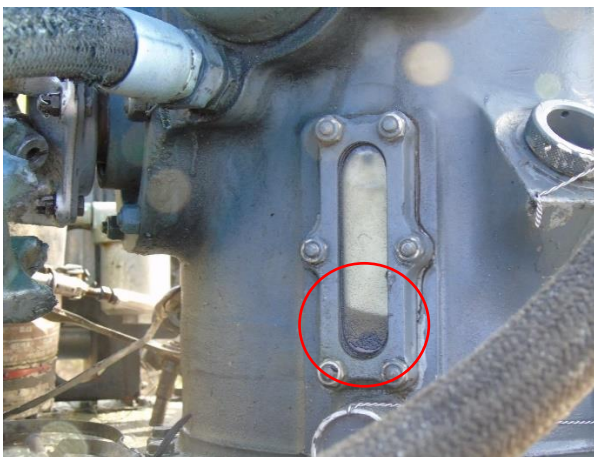


Figure 12 – Oil level in the main gearbox



Figure 13 – Point of failure of the input bevel drive shaft

No damage that would cause oil leakage was identified on the main gearbox, except for the opening of the input housing which was the result of the failure of the input bevel pinion.

No pre impact damage has been found on the tail gearbox (Figure 14). Traces of lubricating oil were found on the tail gearbox. Tail rotor gearbox oil level was found below minimum. No damage was found on the tail gearbox that could have caused the oil leakage, except for the opening which was a result of separation of the tail rotor shaft from the tail gearbox.



Figure 14 – Tail gearbox

### 1.12.3. Damage to the drive shaft assy. and tail shaft assy.

Drive shaft assy. which transmits the engine power to the input bevel drive shaft of the main gearbox, was completely separated and has fallen to the ground as the aircraft was in flight during the damaging sequence. It was found 350 m south of the accident site in the yard of the family house (Figure 15). Traces of overheating of the material in the form of deformation of material and discoloration were visible at the point of cracking (Figure 16), and traces of surface damage which occurred when the shaft touched the surrounding components during rotation were visible.



Figure 15 – Drive shaft

Beside the draft shaft assy. a mechanism of brake calliper with major damages in the form of cracks was found (Figure 17). A pin which forms an integral part of the brake calliper mechanism was found 430 m south of the location where the mechanism was found.



Figure 16 – Point of rupture of input bevel drive shaft Figure 17 – Calliper mechanism

Universal joint of the cardan shaft assy. broke at the connection of the shaft yoke with the joint axle and the visible damages occurred as a result of impact during rotation with the drive shaft assembly (Figure 18).



Figure 18 –Cardan shaft drive assy. at the cracking point

The last segment of the shaft for transmission from the main gearbox to the inclined drive shaft assy. was not found at the accident site, or in the vicinity of the accident site during the two-day search.

#### 1.12.4. **Damage to control commands**

Two rods for controlling the main rotor blades angle of attack has failed by overload during the accident sequence in the area of the main gearbox. The two broken rods were part of the mechanism for controlling the cyclic and collective steps of the main rotor blades (Figure 19).



Figure 19 –Cracking points of the two levers for controlling the main rotor blades

Tail rotor pitch cable controls were found broken by overload at the point where the tail structure was cut off upon the impact of the main rotor (Figure 20).

The main rotor brake command rod around the main gearbox area was found detached at the connection with the mechanical transmission (Figure 21), and the brake callipers were not found at the accident site.



Figure 20 – Damaged tail rotor cable controls



Figure 21 – Main rotor brake control lever

#### 1.12.5. Damage to other helicopter systems

In the power plant section significant damage to the starter-generator was detected. Damage caused by contact of the starter generator rotor and stator was visible on the rotor (Figure 22). The stator flange was broken at its root and was completely mechanically separated from the engine (Figure 23).



Figure 22 – Starter generator rotor



Figure 23 – Stator housing and starter generator stator



Figure 24 – Broken starter-generator shaft

The starter generator shaft was found broken at the point intended for it, due to the increased resistance which was a result of contact of the stator and rotor when the stator flange broke off (Figure 24).

### 1.13. MEDICAL INFORMATION

In the subject accident, the pilot did not suffer any injuries while the male and female passenger suffered minor body injuries during moving through the low vegetation when they were exiting the helicopter, in form of surface scratches on legs. None of the participants of the accident had requested medical assistance.

### 1.14. FIRE

During the last moments of the flight, the eyewitnesses noticed the smoke coming out of the helicopter. In their statements, they did not specify precisely from which part of the helicopter the smoke had been coming from. After the forced landing and exiting the helicopter, the pilot noticed the fire in the opening of the main gearbox caused by cracking of the drive shaft (Figure 25). Also he noticed

that the fire had caught the dry grass in area of the left skid (Figure 26). The pilot successfully extinguished the fire using a fire extinguisher located in the helicopter.

We can assume that the fire around the main gearbox opening occurred due to the leaking of oil vapours and the lubricating oil of the main gearbox over the cracked input bevel drive shaft of the main gearbox, which occurred due to the high temperature of the material and sparks generated by the damaged starter generator. The grass in the left skid area caught fire due to the fall of the metal seal from the drive shaft system, which at that moment was significantly heated, very likely incandescent, on the dry grass.



Figure 25 – Opening on the main gearbox



Figure 26 – Seal in the fire site near the skid

#### **1.15. RESCUE AND SURVIVAL ASPECTS**

Considering the fact that the place of the forced landing was close to the inhabited area and that the accident participants did not suffer severe bodily injuries, there was no need for search and rescue action.

#### **1.16. TESTING AND RESEARCH**

##### **1.16.1. Preliminary inspection of the helicopter**

By arriving at the accident site, the helicopter was inspected on 3 July and 4 July 2018 by the AIA investigators and the employees of the Ministry of the Interior.

It was found that the helicopter was not moved from the landing site, that it was tilted to the left side due to the breakage of the left skid and that some components on the helicopter were completely missing, namely:

- Drive shaft assy. with associated parts,
- Inclined drive shaft assy. with associated parts,
- Rotor brake disc assy. with associated parts.



The helicopter's main battery was found a few meters away from the helicopter, taken out by the pilot after landing to prevent fire. A part of the tail structure with the tail rotor and its associated parts was found several meters from the helicopter.

Traces of fire occurrence and extinguishing of the fire were found on the ground next to the left skid, and on the helicopter itself, i.e. at the emerged opening in the main gearbox.

The amount of oil in the main gearbox was at the minimum. The amount of oil in the tail gearbox was below minimum.

Since the pilot suspected that a bird or a drone stroke during the flight, the helicopter was inspected for possible traces of impact. No traces of impact of birds or drone were found.

Based on the notices from citizens and search of the terrain during those days, some of the missing parts were found.

The preliminary inspection also defined the course of the subject accident.

#### 1.16.2. Detailed inspection of the helicopter and its components

Considering the nature of the accident, a detailed inspection of the helicopter and its individual components was performed by AIA investigators and the employees of the PART 145 maintenance organization, engaged by AIA for the purposes of the subject investigation a week after the accident, and it included the following helicopter systems and component:

- Oil system
- Fuel system
- Components of the dynamic power transmission system

##### Oil system

During the inspection of the components of the oil system, the presence of lubricating oil in all components was found. A small amount of impurities of an unknown composition was found in the oil filters (pressure and return oil lines). No signs of rupture were found on the oil lines, and the oil line connections with associated components were found tightened and secured. The oil injector openings were not blocked. On the chip detector no metal chips were found.

##### Fuel system

The inspection of the fuel system included inspection of the fuel filters and fuel lines. No significant defects that could have affected the course of the accident were found on all components of the fuel system.

##### Components of the dynamic power transmission system

The inspection of the components of the dynamic power transmission system included the following components:

- Drive shaft assy. with freewheel assy.
- Input Bevel Drive shaft
- Drive shaft bevel gear
- Input bevel drive shaft Inner bearing
- Input bevel drive shaft flange (Figure 27)

- Clutch unit
- Cardan shaft assy.

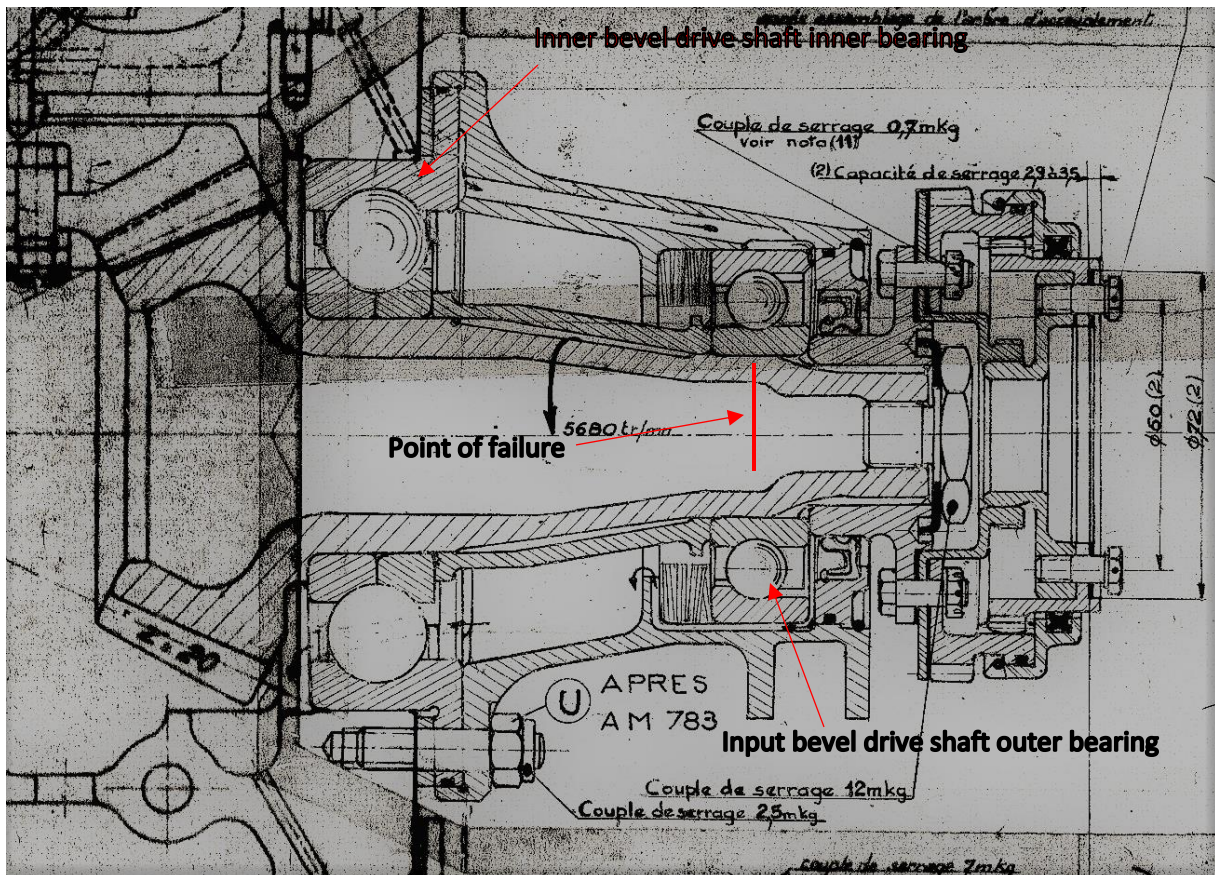


Figure 27 – Input bevel drive shaft flange with attaching components

For the purposes of investigation, the drive shaft was disassembled into individual parts. By the inspection of the drive shaft, it was established that the “freewheel” function of the shaft was serviceable and that particular components in the “freewheel” mechanism were not damaged (Figures 28 and 29). Lubricating oil was found in the “freewheel” mechanism. The serrated cracked part of the input bevel drive shaft remained stuck and welded into the drive shaft.



Figure 28 – Drive shaft



Figure 29 – “Freewheel” mechanism,

The inspection of the input bevel drive shaft established its failure at the position of the outer bearing. At the point of cracking, the material was completely distorted with traces of discoloration (Figures 30 and 31). Damages in the form of overheating and mechanical damages were found on the input bevel drive shaft gear.



Figure 30 – Input bevel drive shaft with gear



Figure 31 – Point of rupture of the input bevel drive shaft

Damages to the inner bearing were considerable. Due to the high temperature, the inner track of the inner bearing changed its shape, cracked and remained welded to the input bevel drive shaft. The bearing cage was cracked in several places and completely changed its colour. The ball bearings have changed their colour, had surface damages, and had been deformed in several places ( Figure 32). The outer race of the internal bearing was damaged as the result of spalling (Figure 33). The external bearing located in the same plan than the input bevel gear drive shaft was not found.

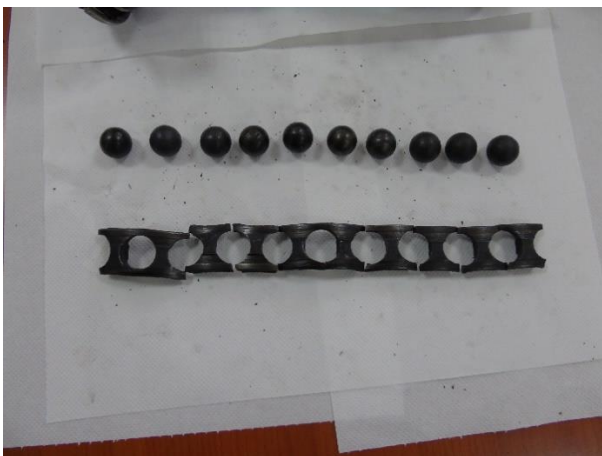


Figure 32 – Elements of inner bearing



Figure 33 – Outer track of the inner bearing

The cardan shaft was broken by overload at the universal joint, and was significantly damaged in the form of dents (Figure 34). The clutch unit inspection identified no technical defects (Figure 35).



Figure 34 – Cracked cardan shaft universal joint



Figure 35 – Clutch unit

Considering the established defects to the components of the dynamic power transmission system, a detailed inspection was carried out at the Faculty of Mechanical Engineering and Naval Architecture.

### 1.16.3. **Inspection of components of the dynamic power transmission system**

Considering the traces of increased temperature found on the input bevel drive shaft and the inner gear, individual elements were sent to the Faculty of Mechanical Engineering and Naval Architecture for detailed analysis.

The following elements were analysed:

- Input Bevel Drive shaft,
- Input bevel drive shaft Inner bearing

The analysis included:

- Measurements of dimensional tolerances,



- Chemical analysis of individual elements (SEM+EDS),
- Non-destructive testing of cracks by penetration,
- Testing of hardness of individual elements,

Following the above analysis, a conclusion was reached. The input bevel drive shaft cracked due to torque overload with a characteristic inclination of the cracking surface at an angle of 45° to the transverse level. The cracking of the input bevel drive shaft consequently caused destruction of the outer bearing.

If the power flow is taken into account, the absence of cracks near the cracking surface, the found damages on certain elements, and the position of the outer ball bearing, it can be concluded that the shaft cracking occurred due to the inability of rotation of the inner or outer ball bearing of the input bevel drive shaft.

By analysing the cracking surfaces of the elements of the inner ball bearing, it can be concluded that the cracking occurred suddenly, and that a foreign body with a large share of copper passed through the bearing. This particles could be separated from the installed shims, or the inner or outer bearing cage.

## **1.17. ADDITIONAL INFORMATION**

### **1.17.1. 9A-HAT helicopter maintenance**

At the time of the accident, the subject helicopter was maintained in accordance with the Aircraft Maintenance Program, 2nd Issue, 3rd Revision, dated 28 December 2015 approved by the Croatian Civil Aviation Agency (CCAA). The approved Helicopter Maintenance Organization that was contracted was Hidroplan Nord, HgCAA. MF.0082, of Hungary, which holds Part 145 approval for the subject helicopter type. On 9 June 2016 the Croatian Civil Aviation Agency issued a Certificate of recognition of Hungarian national approval to the Maintenance Organization.

The last helicopter maintenance work was carried out in the period from 16 March 2018 until 17 April 2018 by the company Hidroplan Nord. After the completed work, the helicopter had a total of 7299.00 flight hours.

The last work included performance of the following:

- Major / Special inspections in accordance with the Maintenance program
- Directive AD F-1977-065-035 (B) (Servo control unit)
- Directive F-1985-189-046R1(B)
- Replacement of "Freewheel" mechanism
- Replacement of oil in the engine, tail and main gearbox
- Other tasks in accordance with the Work Report 2018 II Major/01/9A-HAT

By reviewing the helicopter maintenance documentation issued by the Maintenance Organization the following was identified:



- The Maintenance Organization accepts the Work Order of Annex II CAMO Organization, although it does not have the manufacturer's approval to perform some of the required work.
- The Maintenance Organization performed maintenance work on the components of the Dynamic Transmission System without the manufacturer's approval in accordance with ITE Directive 05.090, Chapter 1, Paragraph 1.D.
- The Maintenance Organization issued Certificates of release to service (so-called Form 1) for the components, without specifying which work has been performed, or specifying the references of the Work Reports where the performed work has been listed, and did not state the total operation hours of the components, even though the status of the Certificate was "INSPECTED", not "NEW".
- The Maintenance Organization used forms which include tolerance values, without specifying the references according to which tolerances were approved. The same forms did not contain revision numbering, so it was not possible to determine whether they were subject to a quality control system.
- The Maintenance Organization replied that it did not have copies of the subject helicopter maintenance records for the past 3 years.
- Maintenance Organization has performed three-year inspections of the components of the Dynamic Transmission System in a manner that was not described in Chapter 5 of the Maintenance Manual or Maintenance Program.
- The Organization performed maintenance of the transmission components without C-11 authorization.

By reviewing the TLB Technical Log Book the following was identified:

- CRS – Certificates of release to service Operator's Certificates of Release to Service (CRS) issued by the operator did not contain a description of the work performed before the flight, therefore it was not known which work had been performed before the flight.
- There were no records of the performed lubrication after the last flight of the day in accordance with the Maintenance Program, Section 4.1, and the Maintenance Manual, Section 5.2.
- There were no records of the removal and installation of the main rotor blades before and after the transport of the helicopter by trailer, which was a standard procedure during helicopter operations.
- There were no records of helicopter maintenance in accordance with special atmospheric maintenance procedures, in accordance with an approved Maintenance Program, Section 5.1.C.

#### 1.17.2. **Annex II Maintenance Organization**

The contracted Maintenance Organization for the subject helicopter was Hidroplan Nord, HgCAA. MF.0082, with headquarters at the Hajmáskér repülőtér Airport, Hungary. The organization possessed national Approval for SE313B Alouette II helicopter maintenance. The Croatian Civil Aviation Agency had issued a Certificate of recognition to the Hungarian Maintenance Organization. The Maintenance



Organization did not have the approval to maintain the transmission components (the so-called C-11 rating).

### 1.17.3. **9A-HAT helicopter continuing airworthiness**

At the time of the accident, the continuing airworthiness of the helicopter was performed by the company Eudora Let d.o.o., as an approved Annex II CAMO organization by CCAA.

By reviewing the Annex II CAME manual, the following was identified:

- Zadar was listed as the main operating base even though the operator was not based in Zadar.
- The same individual was listed as Accountable Manager, Quality / Safety Manager and Continuing Airworthiness Manager. The person is also the company shareholder and the pilot in the subject case.
- Certain sentences in the CAME manual have no grammatical and descriptive meaning, such as: „*Quality/Safety Manager has direct access is only responsible to the Accountable Manager*“.

By reviewing the Helicopter Maintenance Program the following was identified:

- The maintenance program is based on the manufacturers SA313B Maintenance Manual, Revision 54, of June 2014. The revision of the listed document which was in force at the time of the accident was Revision 56 of June 2017. Accordingly, the Maintenance Program had not been revised in accordance with Chapter 2.11 of the Maintenance Program.
- The Maintenance Program was based on the SA313B Flight Manual, Revision 25. The revision of the listed document which was in force at the time of the accident was Revision 28.
- The Maintenance Program did not specify a document based on which maintaining of the helicopter engine and its components was planned.
- Maintenance intervals of the engine components whose life span was based on the number of cycles, operating hours or calendar days was not in accordance with the manufacturer's intervals as specified in the Engine Maintenance Manual MM 223 00 936, Revision 35, of November 2016, Chapter 5-10 -3, Paragraph 4.
- The tables of status lists of components which are subject to overhaul, under the section “TBO hours” (time between overhauls) show the total time, which includes the allowed tolerance.
- The Maintenance Program does not include manufacturer's instructions for extending the three-year calendar interval of transmission components in accordance with the manufacturer's Maintenance Manual, Section 5.8, and in accordance with the manufacturer's ITE Technical Directive No. 05.090, Revision 2, of April 1998.

Acceptance of the helicopter by the Annex II CAMO organization after the maintenance:

- The Annex II CAMO organization issues a work order to the Maintenance Organization, including certain tasks, which it cannot perform since it did not have the required manufacturer's approval in accordance with the Maintenance Manual, Section 5.8.
- The Annex II CAMO organization accepts the helicopter after the performed work during which components had been installed in the helicopter that had not been maintained in



- accordance with the manufacturer's instructions stated in the Maintenance Manual, Section 5.8, and the manufacturer's ITE Technical Directive No. 05.090. Revision 2, from April 1998.
- The Annex II CAMO organization created a Status list of helicopter components which did not comply with the Work Report and pertaining documentation of the Maintenance Organization after the last helicopter maintenance.
  - During the last helicopter maintenance, in the period between 10 March and 15 March 2018, the Annex II CAMO had audited the approved Maintenance Organization. It was not clear from the attached documents whether the Maintenance Organization had met the criteria of the Annex II CAMO organization. Since the form did not list the criteria references, it is unknown which criteria is required.
  - The Annex II CAMO organization accepted the installation of components on the helicopter whose Certificates of Return to Service did not contain the necessary information based on which it could be concluded which work was performed and in accordance to which procedures.
  - The Annex II CAMO organization extended the calendar life of the dynamic system components without manufacturer's approval as in accordance with the Maintenance Manual, Section 5.8.

#### 1.17.4. **Manufacturer's instruction for maintenance of the dynamic system components**

During the last 25 years, the helicopter manufacturer has issued three documents with associated revisions in order to inform helicopter operators and owners regarding necessity to introduce a calendar inspection of the dynamic transmission system and to inform them of the possibility to extend the components calendar life time. Calendar life extension of the dynamic system components by 3 years is possible after the initial calendar life of 10 years had elapsed, if the component had not exceeded the defined number of operating hours. Such way of extension of the calendar life of these components is possible until the total number of operating hours has expired.

Calendar life extension of the dynamic system component shall be performed by the manufacturer or an individual and/or manufacturer-approved organization.

##### Service Bulletin No.05.82

The first such document was issued in 1989 by the company Eurocopter France under the code SB No.05.82 in order to introduce a calendar time interval to the dynamic system TBO. In the following revisions No.2 SB No.05.082 provided possibility of obtaining a 3 year calendar time extension for dynamic systems reaching 10-year overhaul, but which have not reached the maximum number of operating hours. The document had a total of 5 revisions, and as of 30 April 2014 is no longer valid given that the procedures outlined in the document have been implemented in the Helicopter Maintenance Manual and in the document TD No. 05.090 (VNIP corrosion application on helicopters Alouette II and III).

##### TD No. 05.090

The company Eurocopter issued a Technical Directive TD No. 05.090 dated 27 April 1998, in which describes the procedure for calendar life extension of the dynamic system component. This document has undergone 2 revisions.



#### Service Letter SL No. 1292-05-96

Between the two documents mentioned above, in 1996 Eurocopter issued the document under No. 1292-05-96 (Required procedures for Dynamic System Components listed in SB No.05.82). In this document, the manufacturer stated that the emergence of components of the dynamic transmission system on the black market had been noticed and referred to the procedures for such components. Within the company, an Inspection Department had been established for the components whose history cannot be determined or is unclear.

The procedures outlined in the aforementioned documents have been implemented in the Helicopter Maintenance Manual, Section 5.8.

#### 1.17.5. **Main gearbox**

The subject helicopter has two gearboxes, main and tail gearbox. The role of the gearbox is to transfer the power from the drive shaft assy. to the main and tail rotor in certain proportions. This is achieved by a series of transmission gears inside the gearboxes themselves, as well as the drive shaft assy. and input bevel drive shaft.

The main gearbox input bevel drive shaft flange (Figure 36) contains two bearings, internal and external, whose role is to centre the shaft itself and allow the shaft to rotate freely. The shaft itself is also located in the flange and the lubrication of these bearings is accomplished by two oil injectors.

MGB magnetic plug and filter are dedicated to detect the MGB production of particles (including the internal bearing spalling phenomenon). This indicators are further on used to detect parts failure inside the MGB.

The main gearbox (PN: 3130.62.40.000, SN: 1153) was installed on the helicopter in 2014 by the Hungarian Annex II Maintenance Organization. The gearbox was delivered to the Maintenance Organization by the helicopter operator and installed with a total of 199 operating hours since overhaul and 5722 operating hours since new.

The inspection of the available technical documentation of the main gearbox showed that the same was removed from another helicopter (serial number: 1351) with a total of 10767.35 operating hours. It is also apparent that in 2014 and 2017 the Annex II Maintenance Organization carried out a three-year calendar inspection prior to installation to the subject helicopter.

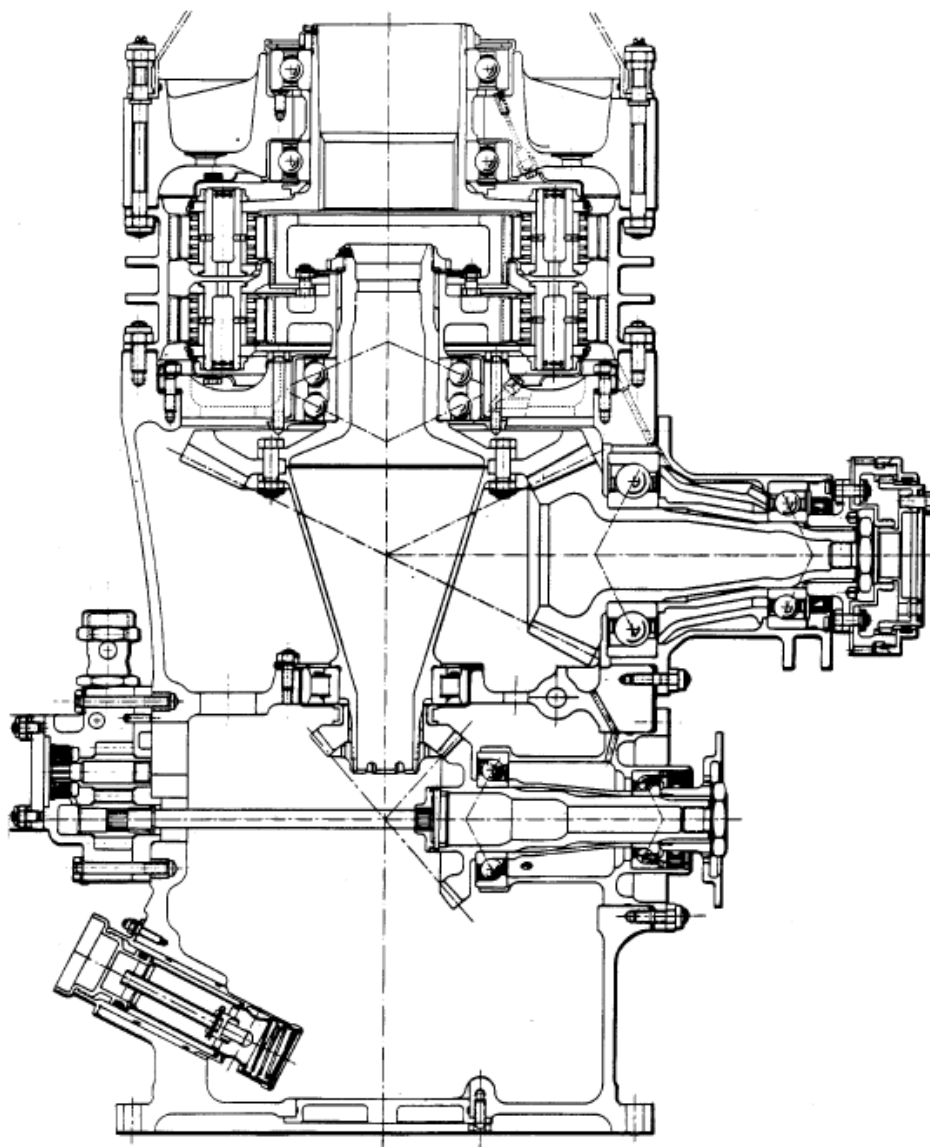


Figure 36 – Main gearbox

## 2. ANALYSIS

### 2.1. ANALYSIS OF THE COURSE OF EVENTS

By analysing all gathered information AIA identified the root causes of the subject event. Unfortunately due to the fact not all parts were found during the investigation we cannot confirm 100 % either of two possible theories. First possibility is the failure of the input bevel drive shaft inner bearing, and the second one is failure of the input bevel drive shaft outer bearing.



Failure of either bearing resulted in the development of high temperature of the bearings itself, and the input bevel drive shaft due to increased friction. Then, due to high temperature and torque, the input bevel drive shaft cracked at the point of the smallest diameter, i.e. at the point of contact with the input bevel drive shaft outer bearing. At that moment, the outer bearing was destroyed and the brake disc and brake callipers were detached from the input bevel drive shaft flange. Lubricating oil exiting the injectors passed through substantially heated input bevel drive shaft and inner bearing which resulted in smoke.

Considering the location of the crack, the main rotor continued to rotate freely driven by the air flow due to the horizontal movement of the helicopter, while the drive shaft continued to rotate eccentrically since the engine continued to operate, causing considerable damage by impacting the surrounding components (the cardan shaft, starter generator, hydraulic oil tank). In the resulting damage, the cardan shaft broke at the universal joint, which made the rotation of the tail rotor no longer dependent on the rotation of the main rotor, i.e. the rotation of the gears in the main gearbox. At that moment, the inclined tail rotor drive shaft was most probably fully separated.

The reduced rotation or total loss of rotation of the tail rotor did not spin the helicopter to the large extent around the vertical axis because the torque of the freely rotating main rotor was low.

The low rotation speed of the main rotor contributed to increase in blade flapping when the helicopter touched the ground, and during the rotation, the main rotor blades made contact to the tail of the helicopter, cutting it off. Considering the angle of contact with the ground, the left skid broke at the junction points with the fuselage, and the rigid controls of the cyclic and collective steps of the main rotor arms broke.

## **2.2. ANALYSIS OF THE DYNAMIC SYSTEM COMPONENTS DAMAGE**

Considering all collected data, AIA developed two possible theories for the failure two occur.

Theory 1:

By looking at the direction of the power, the absence of cracks near the cracking point, the determined damages on certain elements, and the position of the outer ball bearing, it is possible that the fracture of the input bevel drive shaft resulted from the inability of normal rotation of the inner ball bearing. Such state resulted in the development of high temperature of the input bevel drive shaft whereby it cracked at the point of the smallest diameter, i.e. in the area of mounting on the outer ball bearing.

By analysing the cracking surfaces of the elements of the inner ball bearing, we can conclude that the cracking of the elements occurred suddenly and that the foreign body with a large amount of copper passed through the bearing. In the immediate vicinity of the inner bearing copper washers (shims) whose role was to take over a part of the load were located.

Theory 2:

The origin of the scenario could be a damage (spalling phenomenon) of the internal ball bearing which has produced some particles. These particles could have damaged the external ball bearing or affect its lubrication and ultimately caused it jamming. The jamming of this bearing is able to explain all the resulting damages. The exact root cause of the external ball bearing jamming is not possible to confirm due to the fact that this part has not been found.



Low level of lubricating oil was found in the main gearbox at the scene of the accident. No damage was found on the main gearbox, which would have caused the oil to leak, apart from the opening emerged after the cracking of the input bevel drive shaft. During the investigation, it was not possible to determine whether the oil was missing before the accident or was it leaking after the input bevel drive shaft cracked. The amount of oil found in the main gearbox after the accident was sufficient to prevent cavitation of the oil pump.

### **2.3. ANALYSIS OF THE CONTINUING AIRWORTHINESS OF THE HELICOPTER (ANNEX II CAMO ORGANIZATION)**

The role of the Continuing Airworthiness Organization among other was to:

- Ensure a safe environment in which the status of the helicopter itself and its individual components will be known.
- Develop and/or monitor the Helicopter Maintenance Program.
- Monitor the resources of individual helicopter components.
- Follow the instructions issued by the manufacturer or the competent authorities for the type concerned, such as service bulletins or AD's.
- Issue work orders and procedure references to the Maintenance Organization indicating which work has to be performed.
- Ensure that maintenance of the helicopter and the individual components was performed in accordance with the issued work order, i.e. in accordance with the approved maintenance program.

In the subject event, the continuing airworthiness of the helicopter was conducted by the company Eudora Let d.o.o. as an approved Annex II CAMO organization, also the operator of the subject helicopter. At the time of the accident, the company had one employee who performed all the functions defined in the Annex II CAME manual. The same person was also a helicopter pilot and the company's director.

During the safety investigation, a discrepancy was identified between the approved Helicopter Maintenance Program and the manufacturer's helicopter maintenance instructions defined in the Helicopter Maintenance Manual and other issued documents issued by the manufacturer defining the maintenance procedures and standards.

The Annex II Continuing Airworthiness Management Organization accepts the helicopter after the maintenance work, based on the work reports from the Maintenance Organization, from which it is not clear what exact work was performed. Certificates of Return to Service for helicopter components do not contain the necessary information for updating their status on the status list. It is not clear on which maintenance work, the component status lists are based upon.

Acceptance of the helicopter after maintenance by the Annex II CAMO organization was not in accordance with the procedures specified in Annex II CAME manual.

### **2.4. ANALYSIS OF HELICOPTER MAINTENANCE**

The role of the Helicopter Maintenance Organization, in the case of the company Hidroplan Nord, was among other to:



- Perform work specified in the work orders issued by the Continuing Airworthiness Organization (in the subject case, Annex II CAME organization) in accordance with the existing Organization Approval issued by the competent supervisory authority, in the subject case the Hungarian Ministry for Innovation and Technology - Aviation Authority Supervisory Department Airworthiness Unit.

By reviewing the available maintenance documentation issued by the Maintenance Organization a number of discrepancies were found.

The Maintenance Organization accepts the work order from the Continuing Airworthiness Management Organization, which contained the maintenance of the individual components of the helicopter, although it does not possess the Manufacturer's approval to perform these work in accordance with the Maintenance Manual.

The Organization performed maintenance of the transmission components even though it does not hold C-11 authorization.

It is not possible to make a conclusion from the maintenance documentation which exact work has been performed on the components of the Dynamic Transmission System, and according to which procedures and standards.

Furthermore, the Certificates of the Return to Service (CRS-Form 1) for the components does not contain all the necessary information, in Field 12, from which their status could be known, especially the remaining component life time and the description of the performed work.

In more than a few cases, the description of the performed work did not contain references to the procedures according to which the work was performed.

The oil samples from the main gearbox obtained during the routine maintenance were not analysed by the Organizations approved by the manufacturer in accordance with the Maintenance Manual.

## **2.5. APPROVAL OF THE DYNAMIC SYSTEM COMPONENTS MAINTENANCE**

The helicopter manufacturer, Airbus Helicopters, defined in Chapter 05 of the Maintenance Manual and other instructions described in Chapter 1.17.4 of this Report, the procedure for performing the three-year calendar inspection and the procedure for extending the three-year calendar life time. These procedures describe which work has to be performed, how and by whom. The procedures do not describe how an individual or organization are approved by the manufacturer to perform the mentioned work.

## **3. CONCLUSION**

Compliance with the manufacturer's instructions during the helicopter maintenance process is a key segment of the helicopter air operations safety. The compliance with the manufacturer's instructions is of great importance when it comes to components critical to the safe operation of the helicopter, such as components of the dynamic transmission system.



In the subject event, the helicopter manufacturer has been improving the maintenance programme of the dynamic transmission system components through number of documents during a period of 25. In the issued documents, the manufacturer issued instructions on how the subject components need to be maintained.

Companies, which perform commercial air operations, in which the same person is the owner, the pilot and the responsible person in all functions within the Maintenance Organization, are specific in terms of organization structure. In such cases, proper quality control by an external organization and/or national supervisory authority is essential to maintain the required level of the prescribed standard.

### **3.1. FINDINGS**

During the investigation, AIA determined the following:

- The flight took place in the Class G airspace.
- The flight was reported to Croatia Control.
- Several components of the dynamic system were completely separated from the pertaining system during the flight.
- During the flight, the input bevel drive shaft ruptured at the input bevel drive shaft outer bearing point.
- Signs of spalling and overheat were found on the inner bearing of the input bevel drive.
- Particles with great percentage of copper were found in the inner bearing of the input bevel drive.
- Found particles with great percentage of copper could be separated from installed shims, inner or outer bearing cage.
- The tail of the helicopter was cut off by the main rotor blade when the helicopter touched the ground.
- At the time of landing, the helicopter engine was operating, but there was no power transmission to the main and tail rotor.
- The helicopter maintenance program was not developed in accordance with the manufacturer's instructions as defined in the Helicopter Maintenance Manual.
- Dynamic transmission system components were not maintained in accordance with the manufacturer's instructions.
- The Annex II CAMO organization issued the work order to the Maintenance Organization for work that was not accurately defined and did not state the procedures under which the work needs to be performed.
- The Maintenance Organization performed maintenance for which it did not hold the manufacturer's approval, in accordance with the Maintenance Manual.
- The Maintenance Organization performed maintenance for which it did not hold C-11 rating for maintenance of the transmission components.
- By the insight to the technical documentation it was not possible to determine the exact traceability of the components of the dynamic transmission system.



### 3.2. CAUSE

#### Immediate cause

The immediate cause of the subject accident was the loss of main and tail rotor power caused by the transmission failure.

#### Contributing factors

The factors that led to the immediate cause of this accident were:

- The Maintenance Organization did not perform the maintenance work on the helicopter in accordance with the procedures specified in the manufacturer's Maintenance Manual.
- The CAMO organization did not maintain the continuing airworthiness in accordance with the CAME manual and the maintenance instructions defined in the Maintenance Manual issued by the manufacturer.
- The maintenance program approved by the CCAA did not comply with the manufacturer's instructions stated in the Maintenance Manual.

## 4. SAFETY RECOMMENDATIONS

Safety recommendation shall in no case create a presumption of blame or liability for an accident, serious incident or incident.

During this safety investigation, AIA issued the following safety recommendations.

#### Recommendations to the company Eudora Let d.o.o.

Considering the findings of this safety investigation, AIA issued the company Eudora Let d.o.o. the following safety recommendations:

##### AIN04-SR-03/2019

The company Eudora Let d.o.o., as the helicopter operator and the Annex II CAMO organization responsible for maintaining the continuing airworthiness of helicopters, should revise the Alouette II Helicopter Maintenance Program, in accordance with the manufacturer's documentation on helicopter and power plant maintenance.

##### AIN04-SR-04/2019

The company Eudora Let d.o.o., the Annex II CAMO organization responsible for maintaining the continuing airworthiness of helicopters should revise the CAME manual and pay particular attention to procedures regarding accepting a helicopter and its components after performed maintenance.

##### AIN04-SR-05/2019

The person responsible for the continuing airworthiness defined in the Annex II CAME organization should undergo education related to the Helicopter Continuing Airworthiness.



### **Recommendations to the Croatian Civil Aviation Agency**

Considering the findings of this safety investigation, AIA issued the Croatian Civil Aviation Agency the following safety recommendations:

#### **AIN04-SR-06/2019**

The Croatian Civil Aviation Agency should, during its supervision of operator and the Annex II CAMO organization, perform follow up of the Alouette II Helicopter Maintenance Program Revision, in accordance with Safety Recommendation AIN04-SR-03/2019.

#### **AIN04-SR-07/2019**

The Croatian Civil Aviation Agency should, during its supervision of operator and the Annex II CAMO organization, check the competencies of the responsible person, Quality / Safety Manager and Continuing Airworthiness Manager, in order to determine the level of knowledge required to conduct continuing airworthiness and quality control.

### **Recommendations to the Helicopter Maintenance Organization, the company Hidroplan Nord Kft**

Considering the findings of this safety investigation, AIA issued the company Hidroplan Nord Kft the following safety recommendations:

#### **AIN04-SR-08/2019**

The company Hidroplan Nord Kft should identify for which dynamic transmission components it had issued a Certificate of Return to Service, which were not maintained in accordance with the manufacturer's instructions defined in the Helicopter Maintenance Manual. Further procedures should be agreed with the helicopter manufacturer.

#### **AIN04-SR-09/2019**

The Maintenance Organization, the company Hidroplan Nord Kft, should obtain Manufacturer's Approval (Airbus Helicopters) for the future performance of the three-year calendar inspections of the dynamic transmission components, in accordance with the manufacturer's instructions in the Helicopter Maintenance Manual and the associated directives. Accordingly, the Maintenance Organization should adjust its approved scope of work approved by the Hungarian Aviation Authorities.

#### **AIN04-SR-10/2019**

The Maintenance Organization, the company Hidroplan Nord Kft, should revise its company's procedures for issuing the Certificate of Return to Service for the components after maintenance, paying particular attention to the content and information stated in the Certificate.

### **Recommendation to the Hungarian Aviation Authorities – „Ministry for Innovation and Technology Aviation Authority Supervisory Department Airworthiness Unit“**

Considering the findings of this safety investigation, AIA issued the Hungarian Aviation Authorities (Ministry for Innovation and Technology Aviation Authority Supervisory Department Airworthiness Unit) the following safety recommendations:



#### **AIN04-SR-11/2019**

The Hungarian Aviation Authorities should during their regular supervision, support obtaining the Manufacturer's Approval (Airbus Helicopters) by the company Hidroplan Nord Kft, in accordance with the Safety Recommendation **AIN04-SR-09/2019**.

#### **AIN04-SR-12/2019**

The Hungarian Aviation Authorities should, during their regular supervision, support changes to the Maintenance Organization's procedures in accordance with the Safety Recommendation **AIN04-SR-10/2019**.

#### **Recommendations to the helicopter manufacturer, Airbus Helicopters company**

Considering the findings of this safety investigation, AIA issued to the helicopter manufacturer, the company Airbus Helicopters the following safety recommendations:

#### **AIN04-SR-13/2019**

Airbus helicopters company should additionally highlight the importance of the dynamic system components maintenance by replacing the existing text in the Alouette II Maintenance Manual, Chapter 5.8, Note 2, with the following one:

*“Alouette Maintenance manual Chapter 5.8 Note 2: Transmission components that have reached the end of the 10 year calendar period but not of their TBO (in operating hours), may be granted renewable calendar time extensions each of no more than 3 years, until the end of the TBO is reached, ONLY by the Airbus Helicopters Company Repair Station Authorization Department in Marignane. Each TBO extension is subject to an inspection that has to be performed in accordance with the appropriate Technical Directive (ITE) No. 05.090, by the Airbus helicopters approved repair facility or approved individual. All requests for such inspection should be ONLY addressed to the Airbus Helicopters Repair Station Authorization Department in Marignane. On completion of this inspection a report must be sent to the Airbus Helicopters Repair Station Authorization Department in Marignane for review.”*

Investigator in Charge  
Dejan Ćurik