SERIOUS INCIDENT

Aircraft Type and Registration:	AS365N3 Dauphin II, G-REDG
No & Type of Engines:	2 Turbomeca Arriel 2C turboshaft engines
Year of Manufacture:	2010
Date & Time (UTC):	18 April 2011 at 0837 hrs
Location:	Norwich Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	2,300 hours (of which 1,300 were on type) Last 90 days - 73 hours Last 28 days - 20 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a normal despatch and engine start for a routine offshore flight, the ground engineer monitoring the helicopter's departure noticed flames emanating from the No 1 engine. As there was no dedicated means for ground staff to inform ATC of the incident, in order to alert the crew, the ground engineer chased the helicopter along the taxiway to attract the crew's attention and communicate with them using hand signals. The crew shutdown the helicopter and the passengers were evacuated. The ground engineer extinguished a small oil-fed fire in the engine bay with a handheld fire extinguisher from the cockpit. Two Safety Recommendations have been made.

History of the flight

The crew had been tasked with a routine flight to convey passengers and freight to the Pickerill B oil platform, situated 52 nm offshore from Norwich Airport. The flight had been delayed by poor weather, but the helicopter was eventually towed from its hangar and placed on the 'pick up point' (Figure 1) facing east. The 0819 hrs actual weather report for the airport showed a 5 kt wind from 070°, with 3 km visibility.

The crew arrived at the helicopter and the co-pilot occupied his normal left seat in the cockpit. He was acting as the handling pilot. The commander occupied the right seat and was the non-handling pilot. After the crew had started the rotors, the commander vacated the helicopter, to assist the passengers, leaving the co-pilot

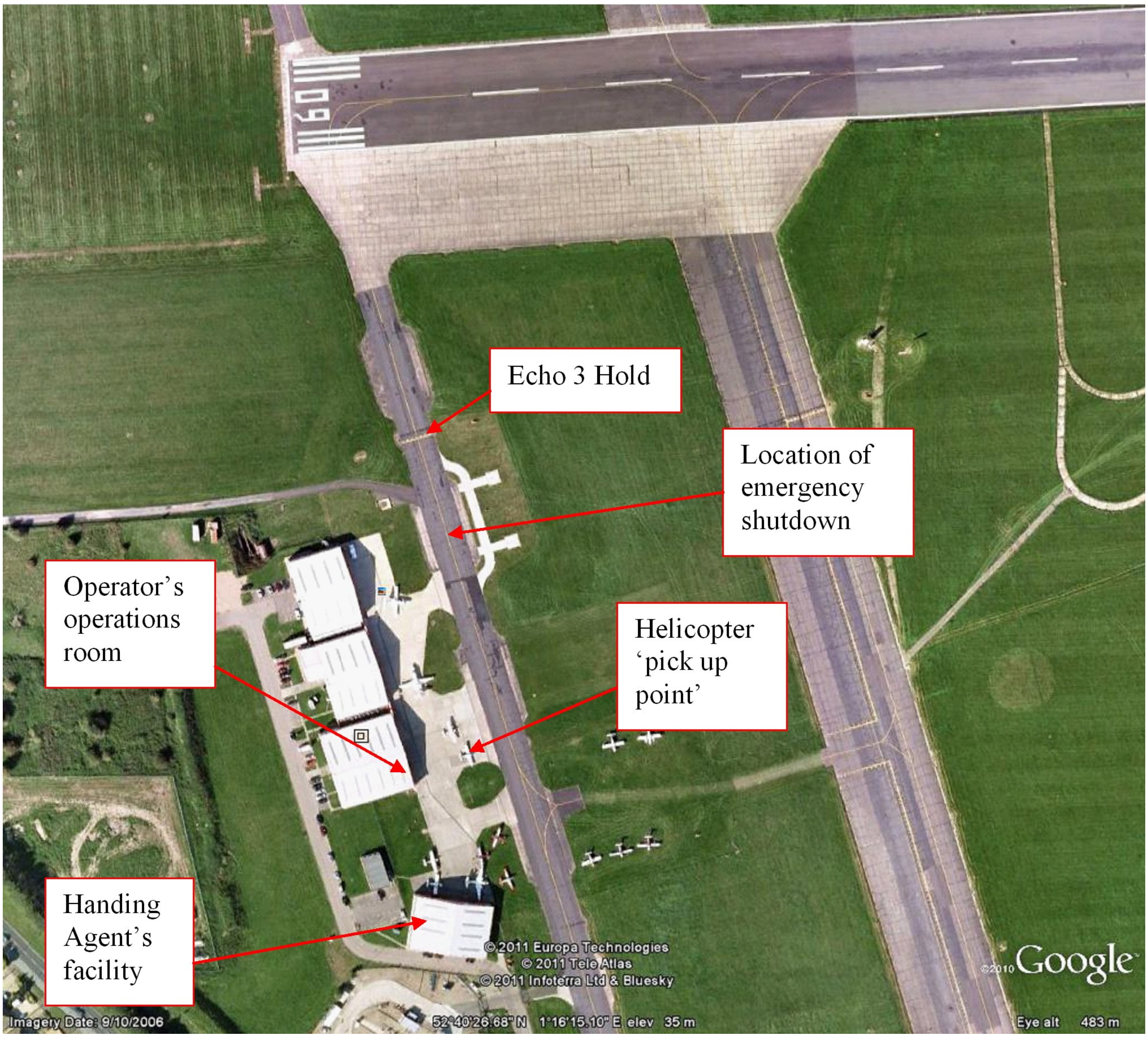

Figure 1

Location of the incident

to complete the final pre-flight checks, which included validating communication frequencies, navigation aids and inserting the route into the navigation system. The co-pilot reported that he then detected a smell in the cockpit similar to that following a chemical wash of the engines, so he opened his window. After completing his checks, he awaited the arrival of the passengers.

The operator's ground engineer, monitoring the engine start, stated there had been no indication of any problem with the helicopter. On completion of the start, he positioned himself on the right side of the helicopter to assist with passenger loading and securing of the helicopter prior to departure. Passenger doors were available on both sides of the helicopter. The commander led the passengers to the helicopter, where they boarded through the right side door. The commander also noticed a smell in the cabin that he attributed to either a cleaning agent or a recent chemical wash of the engines. However, he did not detect the presence of the smell in the cockpit. After the passengers were strapped in, the engineer secured the door, removed the chocks, and then withdrew to the operations room in the hangar where he could monitor the helicopter during departure through the window (Figure 1 and 2).

The engineer reported that as the helicopter taxied away, he observed flames coming from the 7 to 11 o'clock position on the No 1 (left) engine, between the engine and the engine cowling (Figure 2). He did not recollect seeing any smoke at this time. The engineer informed the operator's base manager, who was also in the operations room, to contact the flight crew by radio and tell them to shut the engines down. The base manager attempted to contact the crew but was unsuccessful.

The Duty Air Traffic Control Officer (DATCO) had cleared the helicopter for taxi and so it was ground taxiing northwards along Taxiway Echo to stop at holding point Echo 3 prior to taking off on Runway 09 (Figure 1). At the same time, an employee of the handling agent saw the helicopter from the handling agent's facility. He stated that whilst he had not noticed any smoke when the helicopter was on the 'pick up spot', as it taxied away, he saw blue/black smoke emanating from the exhaust of the No 1 engine, but no flames. He had also tried to contact the crew on the company frequency but with no success.

After leaving the operations room, the engineer ran after the helicopter in an attempt to alert the crew to the fire, which was now evidenced by smoke emanating from the engine compartment. The crew were unaware of the engineer until the passenger behind the co-pilot informed them. Having attracted the crew's attention,

Figure 2

View of the helicopter from the operations room (helicopter pointing east) the engineer gave the hand signal for 'shutdown', which caused confusion, as the crew were unsure of the nature of the problem. The commander gesticulated downwards with his fingers in an attempt to identify if the engineer wanted them to shut down where they were. The engineer nodded and again gave the 'shutdown' signal; he then pointed at the No 1 engine and gave the hand signal for 'fire'. At 0838 hrs, the co-pilot reported to ATC that he had received instructions from the operator to shutdown in his present position. The DATCO asked if they required any assistance, but this was declined.

The engineer approached the helicopter, re-affirmed the requirement to shutdown in-situ, before vacating the area of the rotor disc until the shutdown was complete. The co-pilot admitted he had not recognised the hand signal for 'fire', but understood the shutdown requirement and referenced the abbreviated checklist to commence the normal procedure. The commander, who had recognised the 'fire' signal, actioned the emergency checklist drill for an engine bay fire on ground. The commander partially removed his headset and turned round to the passengers to brief them to remain in the helicopter until the rotors had stopped. There was no internal indication to the pilots of the fire by the aircraft fire warning system. Additionally, the pilots did not observe any abnormal engine indications.

At 0839 hrs, the crew contacted the DATCO and informed him that the helicopter had an engine fire. The Duty Air Traffic Services Assistant (DATSA) contacted the Rescue and Fire Fighting Service (RFFS) and put them on 'local standby'. One minute later the DATCO upgraded the incident to an Aircraft Ground Incident (AGI) and deployed the RFFS. Local procedures state that, in the event of an AGI, ATC should alert the Duty Airfield Operations Officer (DAOO) to the incident. The DAOO is responsible for marshalling the 'passengers and safely transferring them to the airport terminal'. This DAOO was not informed of the incident and at the time he was assisting in the recovery of a broken-down vehicle on the airfield.

When the rotors stopped, the engineer approached the left side of the helicopter, opened the side sliding door and cockpit door, and directed the passengers to evacuate the helicopter and move to a safe distance. The engineer stated that he used the left door to allow him to evacuate the passengers whilst continuing to monitor the status of the engine.

The engineer then opened the No 1 engine cowling and reported seeing a large plume of smoke and a single flame about 6 to 8 inches long on the underside of the engine, with oil dripping from the flange between the gas-generator turbine and power turbine modules onto the transmission tube (Figure 3).

The commander joined the engineer at the open cowling and passed him a handheld fire extinguisher from the cockpit which was used to extinguish the flames. The RFFS, having been dispatched by the DATCO, arrived at the scene at 0843 hrs by which time the fire had been extinguished and all the passengers had returned to the handling agent's facility. The RFFS was stood down at 0845 hrs and the helicopter was recovered to the hangar.

Radio communications

The operator's normal practice at Norwich Airport was for the helicopter's No 2 VHF radio to be selected to the handling agent's company frequency. On first entering the helicopter, prior to the incident, the commander saw that the No 2 VHF radio was selected to the ATC tower frequency. The commander reported he was aware that

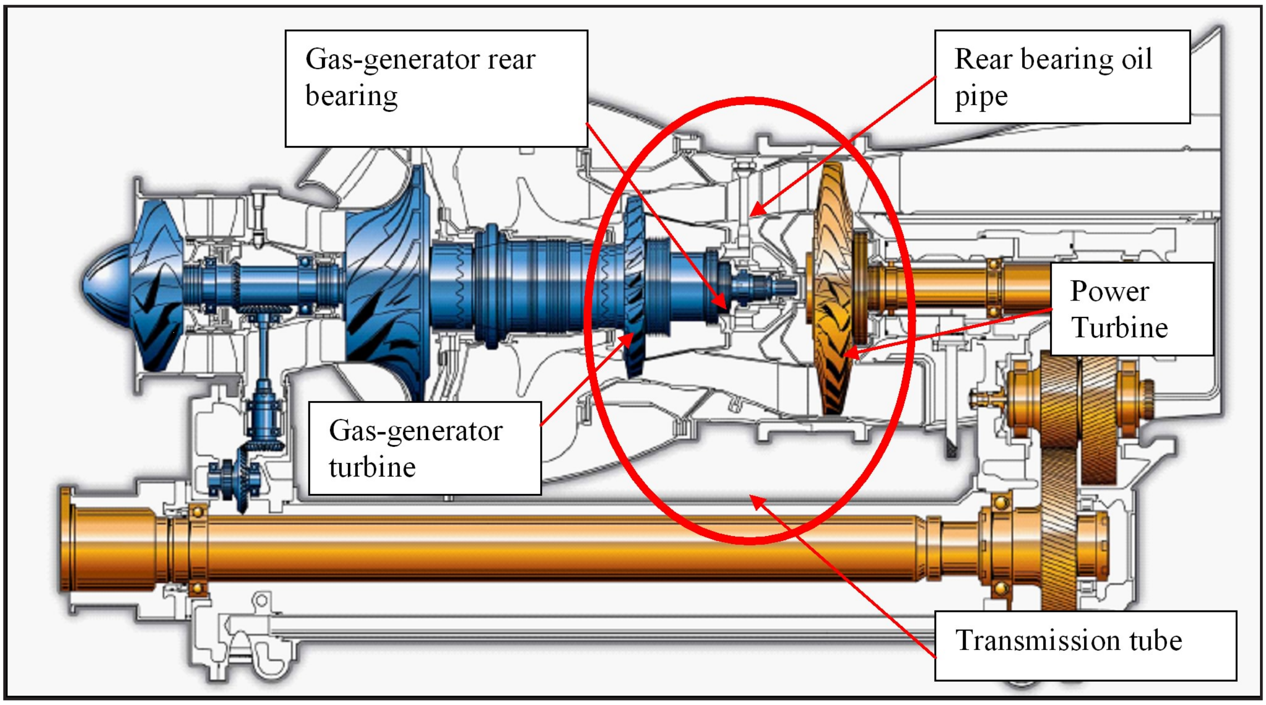

Figure 3

Location of the oil leak and fire

there had been issues with the quality of the audio on the No 1 VHF radio and assumed this was the reason for this selection. Additionally, the crew stated the handling agent's company frequency was frequently busy and, at such times, they tended to deselect it in order to concentrate on ATC communications.

Airport information

The DATCO normally controls aircraft movements from the ATC visual control room, using VHF frequencies. The DATSA answers incoming telephone calls and communicates with airside vehicles on a single UHF frequency. They utilise each form of communication if required, but the normal procedure is for the DATSA to relay communications from the UHF users and telephone to the DATCO. There is a dedicated, direct telephone line between the visual control room and the RFFS control room. However, when RFFS personnel leave the fire station, their only means of communication with ATC is via the UHF radio. This UHF radio frequency is not a dedicated emergency channel and is also used by other airside vehicles. In the event of an incident, radio silence can be imposed on all users except RFFS vehicles, until emergency messages have been passed and acknowledged.

If a member of airport staff witnesses an aircraft incident they can communicate using UHF radio or contact ATC or RFFS via a routine switchboard number.

Aerodrome licensing

CAP 168, chapter 9, paragraph 6.1 states that:

> *'Emergency Orders should be drawn up detailing the lines of communication that will ensure all the agencies (or services) appropriate to the emergency are notified and alerted.'*

Paragraph 6.4 states that:

> *'Each department, section or individual should have on display, or immediately to hand, the Emergency Instructions that apply to their role in each emergency procedure.'*

The Aerodrome Manual contains communications procedures that are to be followed when ATC is aware of an aircraft in distress. The Manual does not contain any procedures for other airport staff to follow to alert key aerodrome personnel, such as ATC or RFFS, should they witness an aircraft emergency.

Maintenance

The helicopter had undergone its first 600 hr maintenance check in the days immediately prior to the incident. During this check, the operator completed maintenance work on both engines to replace the external seals on the gas-generator rear-bearing oil feed, scavenge and breather ducts (Figure 4). Appropriate critical task safeguards had been adhered to including duplicate and independent inspections. Post-maintenance, the helicopter underwent two ground runs and an air test. The first ground run, which lasted approximately seven minutes, identified an oil

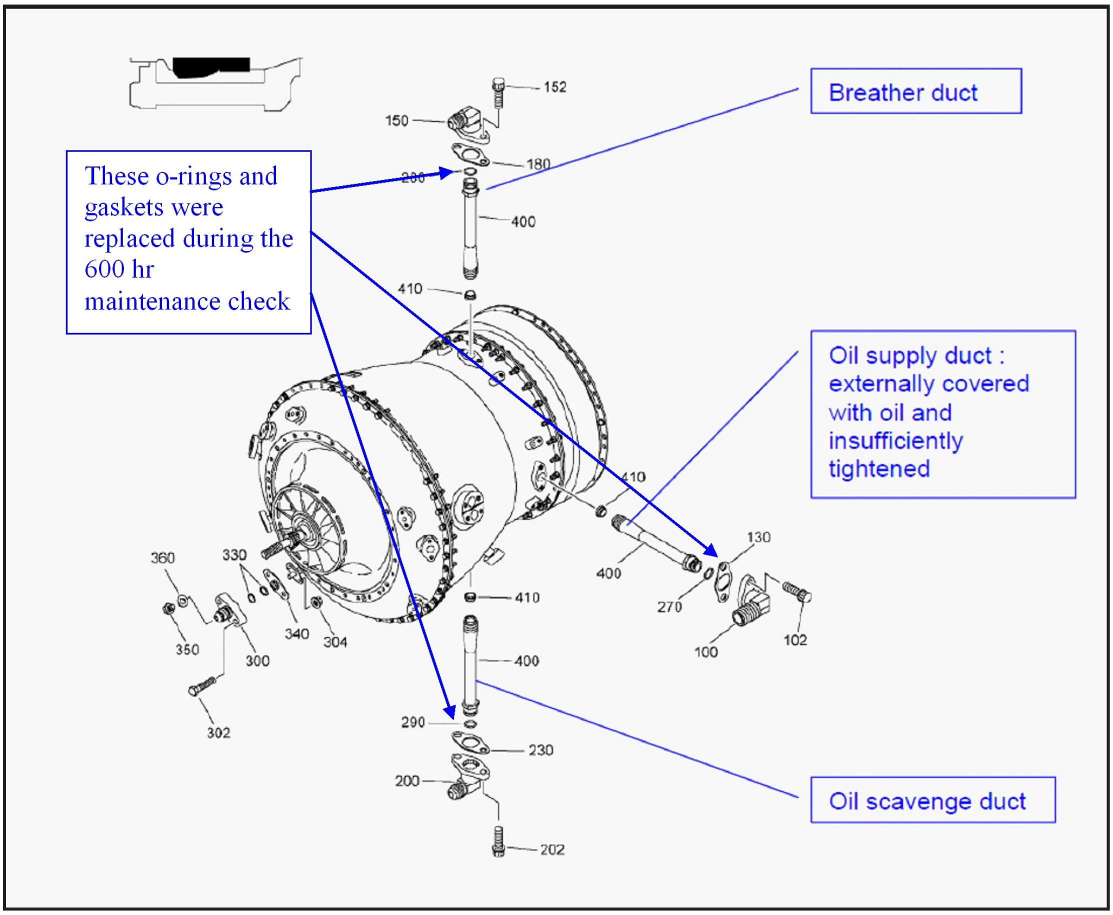

Figure 4

Engine strip findings

leak on the No 2 engine. The oil-feed duct o-ring seal, which had been replaced during maintenance, was again replaced and a second ground run lasting ten minutes was undertaken. During this run, further leak checks and auto-cycle checks were completed[1]. The operator's report stated there had been no evidence of any oil leaks on either engine after this second ground run or after the 15 minute air test, which was to carry out rotor track and balancing on the helicopter.

The operator reported that, during the pre-flight inspection, there was no indication of any fluids leaking onto the helicopter's engine bay decks.

Engine strip findings

The operator removed the engine following the incident and returned it to the manufacturer, who carried out a detailed strip examination. This identified evidence of oil leaking around the split line of the module three and four casings, the lower thermocouple probe ports, and the lower area of the exhaust. Oil contamination was also found in the air cooling system. This indicated that oil was likely to have entered the gas path whilst the engine was operating. During disassembly, the lower connection of the gas-generator rear-bearing oil supply duct was found to have a torque of 10 Nm rather than the required 20 Nm. The outside of the duct was also wet with oil (Figure 4).

The oil ducts have a thread at the lower end, which screws into the bearing housing, with the torque loading sealing the duct against a copper seal. This is achieved by means of a hexagonal collar at the external end of the duct (Figure 5). The right-angle flanged union that caps the duct has a star-shaped fitting, which prevents the duct rotating in service. The flanged union is located by two screws, which screw into a boss on the engine casing. The duct is sealed with the flange by a viton o-ring on the duct and a copper gasket between the flange and the casing. The flange therefore, has to be removed to allow replacement of the o-ring and gasket, which is required every 600 hrs. As a consequence of the star-shaped fitting, if the flanged union is refitted, such that the screw holes do not line up with the casing, the duct has to be rotated clockwise to ensure torque in the lower fitting of the duct is increased rather than reduced. If the duct is rotated anti-clockwise, the torque will be reduced and the duct would no longer seal properly on the copper seal, potentially resulting in an oil leak. The manufacturer advised that there had been no previous experience of a leak caused by loss of torque on the duct. Their experience of oil leaks at the upper connection of the duct immediately after installation, indicated the cause to be damage to the o-ring during its replacement.

The operator considered that the leaking oil from the lower duct connection had pooled in the bottom of the casing, then exited at the split line between the gas-generator and power turbine modules before igniting on the hot engine casing. However, they stated that the torque on the duct had not been changed during the maintenance check. The operator stated that in their opinion the internal oil leak was supplemented by a leak at the o-ring seal (the same o-ring that had been replaced during the maintenance check), as evidenced during the engine strip inspection by oil streak marks on the outer casing, originating from this area. They considered that the o-ring might have been damaged during installation.

Footnote

[1] Auto-cycle checks ensure that the helicopter can function correctly during single engine operation, by reducing each engine to idle in turn and assessing the performance of the higher power engine.

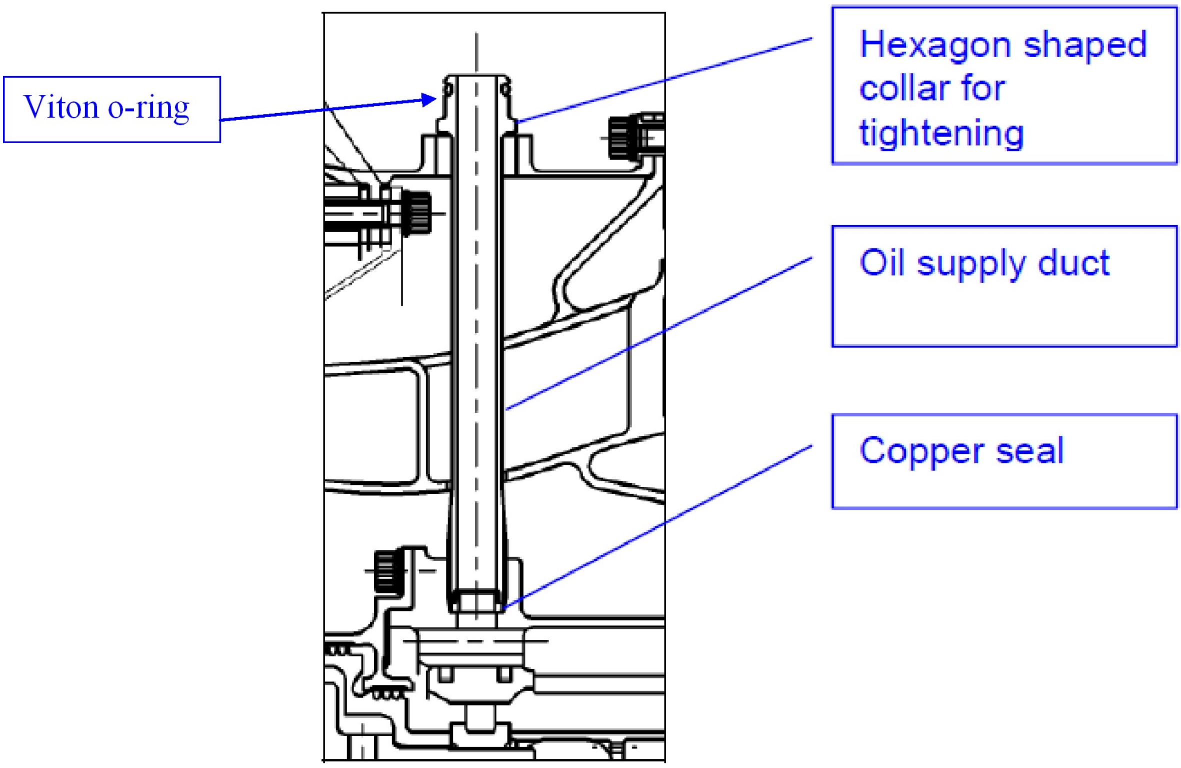

Figure 5

Bearing oil supply duct

Analysis

Emergency reporting and response

The engineer, when he detected the fire in the helicopter and before he left the operations room, requested that his base manager contact the helicopter crew by radio to tell them to shut down. The base manager was unsuccessful in alerting the crew, as the helicopter's radios were not selected to the handling agent's company frequency. He did not call ATC, via the routine switchboard number, at this time. The handling agent employee who witnessed smoke coming from the No 1 engine, also tried to alert the crew using the company frequency but without success.

Having noticed that there was an engine fire, there was a delay in communicating this to the crew. As the helicopter had already departed the pick up point, the engineer took time to reach it. There was an additional delay due to his inability to attract the crew's attention, followed by confusion over the hand signals used. The crew were then made aware of the fire and were able to inform the DATCO. The investigation estimated that over three minutes elapsed between the engineer initially observing the flames and the DATCO alerting the RFFS.

After the helicopter was shut down, the engineer approached and initiated the emergency evacuation of the helicopter, without consultation with the commander. By using the left cabin door to evacuate the passengers, both he and the evacuating passengers were on the same side as the reported fire, despite doors being available on both sides of the helicopter.

Once the passengers were clear of the helicopter, the engineer opened the cowling of the No 1 engine where he had seen signs of the fire. At the time he opened the engine cowl, he was not aware of the extent or origin of the fire. His only means of dealing with the fire was the cockpit fire extinguisher which was provided to him by the commander once he had already opened the cowling.

Whilst the engineer's actions were well intentioned and considered appropriate by him during the incident, had a dedicated system been available for personnel witnessing this incident to rapidly inform ATC, then the DATCO would have received information of the possible fire in the helicopter in a timely manner. The DATCO could have immediately and unambiguously informed the crew of the fire, allowing them to initiate promptly their emergency procedures. Simultaneously, the DATSA could have despatched the RFFS to the scene. This would have negated the perceived need for the engineer to chase after, and approach, the helicopter. When the engineer ran towards the helicopter, he was exposed to unnecessary risk. He was on an active area of the airfield where crews would not expect personnel to be. Additionally, the risk was increased due to his proximity to a helicopter that appeared to be on fire.

Since this incident, the airport has installed a dedicated telephone line, and associated procedures, for airside personnel to use to report anything that could endanger the safety of an aircraft. The investigation found that some other UK regional airports do not have a dedicated emergency system whereby airport staff, on witnessing an aircraft incident, can immediately notify key aerodrome personnel, such as ATC or the RFFS, to the incident. This is now being addressed by the CAA.

The airport emergency plan identifies that in the event of an emergency evacuation of an aircraft on the airfield, the DAOO is responsible for marshalling the evacuated passengers and transferring them to a safe facility. The DAOO was not informed of the incident by ATC and at the time of the incident, he was assisting with the recovery of a broken-down vehicle on the airfield. As a consequence, the emergency plan was not carried out and the passengers were escorted back to the handling agent's departure building by staff from the operator.

As a result of the investigation into this incident, the Airport Operations Director stated that he has reviewed the airport procedures and imposed a requirement that routine procedures will only be conducted when there are at least two AOO staff on duty to ensure that the emergency response capability is maintained at all times.

Engineering analysis

The oil leak from the damaged o-ring on the oil supply duct of the No 2 engine was quickly identified during the first post-maintenance ground run. Given the multiple ground runs and inspections on the No 1 engine, and reports by the operator that there was no evidence of oil leakage at that time, it is unlikely that the o-ring seal on the No 1 engine oil supply duct was the source of the later oil leak. The findings from the engine strip examination identified that the oil leak was from the lower connection of the oil supply duct. If the leaking oil had become entrained in the engine cooling airflow, it is possible that the majority of this oil was expelled from the engine via the gas path during the post-maintenance ground runs. This would have reduced the likelihood of external evidence of a leak and may also explain why the oil leak was not identified during the post-maintenance activity. The presence of oil in the engine airflow is supported by the eyewitness account of blue-black smoke from the engine exhaust observed during the incident, and may have been the cause of the cockpit smell identified by the flight crew prior to the incident. However, if the oil continued to leak overnight, from the lower oil supply duct connection, and pooled in the lower casing of the engine, as the engine was started prior to the incident flight and began to reach operating temperature, a leak path would have developed between the module casings, thus leaking oil onto the transmission tube.

Given that the engine had been operated for 600 hrs without a reported oil leak and the star-shaped fitting prevents rotation of the duct in normal operation, it is unlikely that the low torque on the oil supply duct existed prior to the maintenance input. It is, therefore, possible that the oil supply duct was rotated anti-clockwise during removal or refitting of the flanged union, lowering the torque on the duct from the required 20 Nm to 10 Nm and reducing the contact pressure on the copper seal, thus creating the leak path.

The engine manufacturer advised that they have amended the maintenance manual to include a note identifying the need to rotate the oil ducts in the direction that increases torque on the lower connection rather than reducing it, when aligning the screw holes of the flanged union with the casing. The note states:

> *'Note: If the passage holes of the attaching screws of the flange union and the turbine casing are not aligned, increase duct tightening, refer to task 72-43-10-900-801'*

The note refers to the deliberate action of rotation of the duct during refitting of the flanged union. It does not, however, sufficiently caution against or provide information to highlight, the consequences of reducing the duct torque, and the potential oil leakage if the duct is rotated in the anti-clockwise direction whilst removing or refitting the union. The following Safety Recommendation is made:

Safety Recommendation 2011-095

It is recommended that Turbomeca add a caution to the Arriel 2C Maintenance Manual to highlight the consequences of rotating the gas-generator rear-bearing oil ducts during removal or refitting of the flanged unions and to publish suitable technical advice to operators to raise awareness of this risk.

The manufacturer has advised that they are responding to this recommendation and are in the process of updating their documentation.

The maintenance task of replacing the o-ring on all three oil ducts is scheduled every 600 hrs and was accomplished on both engines during the same maintenance check. In addition, the normal critical maintenance task safeguards, of duplicate inspections and a post-maintenance ground run, did not identify the No 1 engine oil leak. As such, there was little mitigation against the risk of an oil loss leading to engine shutdown or possible fire on both engines during a subsequent flight. The following Safety Recommendation is made:

Safety Recommendation 2011-096

It is recommended that Turbomeca amend the approved maintenance program for Arriel 2C engines, to ensure that the concurrent replacing of the o-rings on the gas-generator rear-bearing oil ducts is not performed on both engines of a helicopter, in order to reduce the risk of an oil loss on both engines during a flight.

Safety Actions

Airport authority

The airport authority advised that they have taken the following action since the incident.

1. The airport authorities have installed a dedicated telephone line, and associated procedures, for airside personnel to use to report direct to ATC anything that could endanger the safety of an aircraft.

2. A review has been conducted into the airport procedures and a requirement has been introduced so that routine AOO procedures will only be conducted when there are at least two AOO staff on duty to ensure that the emergency response capability is maintained at all times.

CAA

The CAA advised that they have taken the following actions since the incident.

1. The CAA issued an Information Notice requesting Aerodrome Licence Holders to review their arrangements for actions to be taken in emergency situations, in particular the alerting procedures.

2. The CAA revised the Aerodrome Inspectors routine inspection checklist to include a check that the aerodrome has an effective system for summoning assistance, which can be used by any person who identifies an aircraft incident or other emergency on the aerodrome.

Helicopter Operator

The helicopter operator has introduced into their maintenance programme, a visual check, following the disturbance of the rear bearing oil supply, scavenge and breather duct o-rings during the 600 hr inspection. After ground runs and leak checks, following the replacement of the o-rings, a boroscope check via the T4 thermocouple port will be carried out to ensure there is no evidence of oil on the ducts or their lower connections to the bearing.