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Unstable External Load Blamed in Helicopter Water-contact Accident

The U.K. Air Accidents Investigation Branch said that the BO 105 struck water off the coast of Scotland after the external load hit the tail rotor, severing the blades. The accident report included recommendations for improved guidance on the preparation, construction and carrying of external loads.

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FSF Editorial Staff

At 1020 local time May 24, 2002, a Messerschmitt-Bolkow-Blohm (MBB; now Eurocopter) BO 105DBS-4 being flown in external load operations struck the Atlantic Ocean off the northwest coast of the Orkney Islands, Scotland. The helicopter was destroyed, and the pilot — the only person in the helicopter — was killed.

The U.K. Air Accidents Investigation Branch (AAIB), in its final report, said that "the direct cause of the accident was an external load striking the tail-rotor blades when the helicopter was transiting at approximately 400 feet and 60 knots."

The report said that the pilot probably released the load — two scaffolding frames that were held together with wire and a number of metal electrical conduit sections about two meters (seven feet) long that were tied across the scaffolding — immediately after it struck the tail rotor.

"The loss of a substantial part of the tail-rotor blades caused the helicopter to yaw to the right and then [to begin] a descending orbit to the right, which was probably assisted by the pilot trying to turn the helicopter into [the] wind," the report said. "It is unlikely that, in the short time available, the pilot was able to shut down both engines. During [the pilot's] efforts to carry out an emergency landing on the water, the aircraft rotated uncontrollably and entered the water backwards with a very high rate of descent, fatally injuring the pilot."

The report said, "The primary reason for this accident was the attempted transfer of an external load [that] proved to be unstable in flight. The load had been assembled by untrained building-contractor's staff who were remote from the actual lifting operation. Moreover, the pilot, who had the ultimate right to refuse to carry [the load], was poorly placed to observe and reject the load. Suitable written guidance on load construction was not widely available to persons tasked with assembling and assessing external loads."

The helicopter was flown to the Orkney Islands the day before the accident. Several flights were planned, including 15 external-load flights between the main island and a lighthouse two statute miles (three kilometers) northwest at the Brough of Birsay, a tidal island (i.e., ground access to the main island is impossible during high tides, when water levels rise). A licensed maintenance technician provided technical support and assistance for these flights, working either inside the helicopter or on the ground.

Messerschmitt-Bolkow-Blohm BO 105

The Messerschmitt-Bolkow-Blohm (MBB; now Eurocopter) BO 105 is a twin-turbine five/six-seat light helicopter with a four-blade main rotor and a two-blade tail rotor.

The first prototype of the BO 105 was flown in 1967; by January 2001, BO 105s had accumulated 5.66 million flight hours.

The BO 105 can accommodate two pilots or a pilot and passenger in two front seats and three passengers on a rear bench seat.

The helicopter has two Rolls-Royce (formerly Allison) 250-C20B 313-kilowatt (420-shaft horsepower) turboshaft engines, each with a maximum-continuous-horsepower rating of 298 kilowatts (400 shaft horsepower). The main rotor has a titanium head and glass-fiber reinforced polymer (GFRP) blades with a diameter of 9.8 meters (32.3 feet); the tail rotor's GFRP blades have a 1.9-meter (6.2-foot) diameter. Fuel capacity is 580 liters (153 gallons).

Maximum takeoff weight is 2,500 kilograms (5,511 pounds).

Maximum rate of climb at sea level with maximum continuous power is 1,457 feet per minute. Hovering ceiling in ground effect is 5,000 feet; hovering ceiling out of ground effect is 1,500 feet.

Maximum cruising speed at sea level is 131 knots. Range at sea level with standard fuel, maximum payload and no fuel reserve is 300 nautical miles (555 kilometers).♦

Source: *Jane's All the World's Aircraft*

Load Hook Functioned Correctly

On the morning of the accident flight, the maintenance technician conducted the daily inspection of the helicopter, including a check of the load hook, which was functioning correctly. The pilot and the maintenance technician discussed the external-load flights with two representatives of their client and four employees of a building contractor. The building contractor's employees then boarded the helicopter for a flight to the pick-up site near the lighthouse, where they disembarked to prepare the loads. From the lighthouse site, the pilot and the maintenance technician flew the helicopter to the client's headquarters, about 10 statute miles (16 kilometers) south; to another island about 25 statute miles (40 kilometers) east; back to the client's headquarters for refueling; and then to the lighthouse site, where the maintenance technician disembarked to supervise load-lifting operations.

The building contractor's employees had packed the loads into lifting bags, working with a requirement that the maximum weight should not exceed 450 kilograms [992 pounds] per load.

One of the client's representatives, who had received training from the aircraft operator in appropriate load construction and attachment of lifting strops (straps), decided — in consultation with the maintenance technician — that three loads comprised of a portable outhouse and sections of a wooden shed would not be transported because they were likely to become unstable in strong, gusting winds. The southeast winds, which had been about 15 knots to 20 knots earlier in the day, had increased to about 30 knots.

The client's representative attached two-meter (seven-foot) metal lifting straps to each of the remaining loads. These were the "lower straps."

"When the aircraft was in a low hover, the representative either attached or detached the lower [strap] to the end of the swivel-safety-hook [assembly] on the end of the upper [strap, which was] attached to the helicopter," the report said. "This process was successfully undertaken with a variety of loads, which were transported according to a list provided by the client. Witnesses described the operations as taking place normally, with all loads appearing to fly in a stable condition."

The accident occurred after the next-to-last load was picked up from the lighthouse site. The load had been attached to the swivel-safety-hook assembly by the client's representative, and the maintenance technician then had signaled to the pilot to fly the helicopter into a high hover.

"As the load cleared the ground, it began to rotate slowly, which was not unusual," the report said. "When the load was sufficiently clear of the ground, the engineer signaled to the pilot that he was clear to depart. The aircraft transitioned into forward flight, gently accelerating and climbing to an estimated height of 400 feet. The load stopped spinning and began to trail normally beneath the helicopter, swinging from side to side in a reasonably stable condition.

"The wind direction had remained at about 130 degrees, but the wind speed had increased in strength to between 30 [knots] and 35 knots. As the helicopter crossed the southern shoreline of the island, the load swung back and became unstable, swinging fore and aft, as well as from side to side in a circular spinning motion, which rapidly caused the load to contact the tail rotor."

Witnesses described the load as "exploding or breaking up, with debris falling from the aircraft." The maintenance technician said that "what remained of the tail-rotor blades" stopped rotating.

Helicopter Sank Within Seconds of Impact

After the load struck the tail rotor, the helicopter quickly turned about 90 degrees right, rolled right and pitched nose down; the fuselage rotated around the rotor head several times until the helicopter was about 30 feet above the water, and then the helicopter dropped quickly and struck the water in a banked right turn with a nose-high attitude. The helicopter sank within seconds. The pilot, who was not wearing a protective helmet (and was not required to do so), received a serious injury to the back of his head.

The 53-year-old pilot had 12,399 flight hours, including 5,000 flight hours in BO 105s. In the 28 days before the accident, he had accumulated 35 flight hours. On March 28, 2002, he completed a line proficiency check that included external-load operations, and on May 2, 2002, he completed an emergency and safety equipment check and a pilot proficiency check. The report did not include other details of the pilot's qualifications but said that he was experienced and properly qualified to conduct the flight.

The accident helicopter was manufactured in 1992. When the accident occurred, the helicopter's weight was 2,156 kilograms (4,753 pounds), including the external load; the maximum permitted takeoff weight was 2,400 kilograms (5,291 pounds). The helicopter was carrying 256 kilograms (564 pounds) of fuel, which the report said was sufficient for at least another hour of flying. The helicopter was not equipped with flight-data recorders; none were required.

The helicopter was equipped with engine-speed-selector levers (SSLs) designed to be set full forward during normal flight, with engine power controlled automatically to maintain appropriate rotor speed; to be moved to the idle position for the engines to run at low power settings; and to be moved fully back to the cut-off position to shut down the engines. The idle position and the cut-off position were intended for use in some in-flight emergencies.

The helicopter's load hook was operated electrically by the pilot; a load-release trigger was located on the collective control, and an emergency release was operated mechanically with a foot control. An adjustable external mirror permitted the pilot limited observation of the load.

Operator Issued 'Comprehensive' Guidance on External-load Flights

The helicopter operator — not identified by the report — had developed written operating procedures for external loads that included "comprehensive guidance and requirements," the report said. Those operating procedures required ground staff members to check preparation of the loads and attachment slings at pick-up sites, manage the dispatch of loads and the delivery of loads, communicate departure instructions and landing instructions to the pilot with marshaling signals and/or radio communication, and ensure that the sling was in an appropriate vertical position and that the load hung correctly.

In addition, a helicopter landing officer was in charge of the lifting operation and usually conducted marshaling of the helicopter. The client — not identified by the report — provided staff members who had been trained to perform the helicopter landing officer's duties; the maintenance technician also performed those duties.

The contractual agreement between the helicopter operator and the client said that the pilot ultimately was responsible for determining whether a load was suitable for carrying.

The operator's communication policy, which was contained in the operations manual, said that although standard marshaling signals were acceptable, "safety and efficiency can be significantly improved by providing the ground crew with … air-to-ground VHF [very-high-frequency] radio sets linked to a helmet-mounted headset."

The report said that communication radios had been issued at the client's headquarters and that the helicopter landing officer on the main island had a radio; the maintenance technician, who was acting as the helicopter landing officer at the lighthouse, did not have a radio.

Investigators Analyzed Replica of External Load

The wreckage was found on the ocean bottom at a depth of about eight meters (26 feet). The helicopter was damaged substantially but was relatively intact, although the straps and the external load were not attached to the helicopter and could not be located amid the dense underwater plant growth at the accident site.

Examination of the wreckage revealed that the tail-rotor blades had separated "in a manner consistent with having struck a firm object" — not as a result of impact with the water. All other parts that had separated from the main wreckage did so as a result of the impact — or during the salvage operation. There was no indication that either engine or the main-rotor gearbox had failed before impact.

The building contractor's employees who had assembled the load being carried by the helicopter at the time of the accident constructed a replica load to be examined by accident investigators. The replica load weighed 68 kilograms (150 pounds) and was 2.4 meters (7.9 feet) wide; the distance from the load-hook connection to the bottom of the load was 6.95 meters (22.80 feet). The replica load was examined by the Ministry of Defence (MOD) Joint Air Transport Evaluation Unit (JATEU), which typically checks loads before they are flown beneath MOD helicopters.

"Their assessment of the replica load was that it would not be flown as an external load beneath a military helicopter due to the flat profile and lack of mass, which, in combination, would cause the load to be highly unstable," the report said. "If, for operational reasons, it was imperative to transport the scaffolding sections and electrical conduit, [the load] would probably have been carried as internal freight. If it was not possible to carry [the load] as internal freight, the items would either have been placed in a net with some heavy ballast, or the scaffolding sections would have been suspended from each corner and ballast [would have been] placed on the platform made by the load to give it stability. JATEU considered that the load as prepared would not only be unstable both longitudinally and laterally but also [would] tend to twist around the swivels."

The report said that the building contractor's employees who assembled the loads were "sufficiently remote from the actual transfer task as not to be specifically trained in relation to helicopter lifting operations" and that they had received little guidance. The maintenance technician and the client's representative who performed the duties of a helicopter landing officer had been "extensively trained and had acquired practical experience of external-load transfer," the report said. Nevertheless, the report said, "from his position hovering overhead the load, the pilot, who had the ultimate right to refuse to carry it, was poorly placed to observe and reject the load.

Load Preparation Was 'Unsuitable'

"The fact that the light load of scaffolding frames and electrical conduit sections was likely to be highly unstable was not appreciated by anyone [involved with the external-load operation]. Had the load been assembled and ballasted in accordance with military practice, this accident is unlikely to have occurred. The unsuitable preparation of the load could have been avoided if officially approved guidance on the correct methods for constructing aerial loads, targeted specifically at those persons who typically construct such loads, had been supplied to the client's staff (particularly the load dispatchers) and to the building contractor's staff."

The report said that such information was not widely available within the helicopter industry.

Checklists Did Not Discuss Loss of Tail-rotor Blades

The operations manual contained an explanation of techniques used by the operator for moving external loads, including warnings that "light loads or loads with a large surface area can become very unstable with very little warning" and that the pilot should be prepared to reduce airspeed in the event of "undesirable oscillations" or to jettison the load if the load becomes uncontrollable.

The report said that the BO 105 emergency checklists did not address the loss of tail-rotor blades but did describe "to a limited extent" the effects of failure of the tail-rotor drive shaft. The checklist for failure of the tail-rotor drive shaft in flight said that indications of the failure were a right yawing motion and that the procedures were to adjust the collective lever and cyclic stick "to obtain minimum sideslip angle and, if possible, level flight," to maintain an airspeed of at least 60 knots and to conduct an autorotative landing at a suitable landing site. The checklist did not specifically say that the pilot should shut down the engines.

A review of previous BO 105 accidents that occurred during cruise flight at medium altitude, at low speed and at low altitude, and that involved failure of the tail-rotor drive shaft, gearbox and/or tail-rotor blades, showed that common factors were the rapid yaw and roll to the right, the downward movement of the nose and the continuing slow orbit to the right, even when the collective control was fully lowered. In accidents in which pilots tried to raise the collective control or reduce airspeed, the yaw increased and airspeed decreased. Pilots succeeded in shutting down both engines in only two accidents; the pilot of another accident helicopter said that he had been unable to remove his left hand from the collective lever long enough to move the overhead SSLs to shut down the engines.

The report said that investigators could not determine whether the pilot of the accident helicopter had moved the SSLs to the cutoff position before the helicopter struck the water, and the report said that the pilot probably was unable to shut down both engines during the 10 seconds to 15 seconds before impact. The pilot probably also was unable to maintain an airspeed of 60 knots.

The report said that, after the initial 90-degree yaw to the right, the continuing right turn probably was "a combination of the pilot trying to continue the right turn into [the] wind, which, following the loss of the tail rotor, was the easier direction; low airspeed, possibly below 40 KIAS [knots indicated airspeed]; and possibly needing to raise the collective lever. This could have been necessary both to contain main-rotor RPM [revolutions per minute], which could have risen, and … to conserve height in order to turn into the strong wind.

"The pilot would have commenced the flare for landing at between 75 [feet] and 100 feet above the water or lower if he had not achieved 60 knots. The surface of the sea was choppy, with whitecaps on the waves providing a reasonable visual cue to assist depth perception. Despite the visual cues, judging height above the water is still difficult."

The report said that although adequate guidance material and training should help reduce tail-rotor damage caused by external-load strikes, pilots also should be provided with more information from helicopter manufacturers to help them cope with decreased tail-rotor effectiveness.

"The flight characteristics of a helicopter following the loss [of tail-rotor effectiveness] should be predicted as accurately as possible during the certification process," the report said. "This information should be promulgated in the rotorcraft flight manual for the type with any emergency or abnormal procedures and limitations. Any advisory areas in terms of height and velocity where recovery from the loss of a tail rotor may not be possible should also be published in a diagram."

The report said that neither the flight manual nor the emergency checklist for the accident helicopter indicated the "severity of the yaw to the right, with the associated rolling, pitching nose down and loss of airspeed."

Changes Recommended in Load Stability, Emergency Procedures

As a result of the accident investigation, the AAIB issued the following safety recommendations:

- The U.K. Civil Aviation Authority (CAA), in consultation with the helicopter industry, should "produce guidance for the preparation, construction and carriage of external loads. This guidance should include methods of improving the stability of loads that have poor or unpredictable flight characteristics."

  In its report on follow-up actions, the CAA said that it had accepted the recommendation and that the subject was discussed on June 12, 2003, at the first meeting of the CAA/British Helicopter Advisory Board (BHAB) Onshore Liaison Committee. The board was developing guidelines to form the basis of a revision of Civil Aviation Publication (CAP) 426, *Helicopter Underslung Load Operations*; the revision was expected to be completed in 2004;[1]

- The CAA should propose to "appropriate helicopter manufacturers and type-certification bodies that the flight characteristics of a helicopter following the loss of tail-rotor effectiveness should be promulgated in every helicopter type's flight manual."

  The CAA accepted the recommendation and said in the follow-up report that it would propose that European Aviation Safety Agency (EASA) standards be amended to require helicopter manufacturers to promulgate the information in all helicopter flight manuals;

- The CAA should consider providing all helicopter pilots and helicopter operators with a tail-rotor-failure safety information package designed to improve awareness of the effects of a loss of tail-rotor thrust.

  The CAA accepted the recommendation and said in the follow-up report that a proposal has been submitted to the European Joint Aviation Authorities Rotorcraft Steering Group for "the latest analysis and validation techniques" to be used in providing improved emergency procedures for tail-rotor failures;

- Eurocopter should review emergency procedures for "Tail-rotor Drive Failure — Flight" in the BO 105 flight manual and should consider three aspects:

  – "Whether the procedure regarding use of the collective lever and cyclic stick, in order to *'if possible maintain level flight'* is realistic, [because] it may, in fact, destabilize the aircraft";

  – "Emphasize the importance of carrying out a double-engine emergency shutdown after a tail-rotor failure in forward flight before attempting an autorotative forced landing"; and,

  – "[Ensure] that all the actions required within the emergency drill are memory items."

  Eurocopter is reviewing the matter and plans to develop and publish a revised procedure;[2]

- The CAA should "consider recommending two-way radio communication between a pilot undertaking external-load-lifting operations and persons at the pick-up and drop points when another crewmember is not available onboard the helicopter to monitor the behavior of the external load."

  The CAA accepted the recommendation and said in the follow-up report that it was advising operators of "the safety benefits of radio communications" and recommending that they provide operating instructions on the use of two-way radio communications with ground personnel "when appropriate to the circumstances of the task"; and,

- The CAA should consider recommending flight helmets for flight crewmembers involved in external load operations.

  The CAA accepted the recommendation and said in the follow-up report that the BHAB Onshore Liaison Committee had begun consultations with the industry on the matter.♦

[FSF editorial note: This article, except where specifically noted, is based on U.K. Air Accidents Investigation Branch accident report EW/C2002/07/07. The 19-page report contains a photograph.]

Notes

1. U.K. Civil Aviation Authority (CAA), Safety Regulation Group, Safety Investigation and Data Department. *Follow-up Action on Occurrence Report,* CAA Factor No. F28/2003. Sept. 10, 2003.

2. Gotzhein, Christina. E-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., Jan. 14, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Gotzhein is representative of Eurocopter Media Relations.

Further Reading From FSF Publications

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Harris, Joel S. "Object Strikes, Complete Loss of Thrust Were Leading Causes of U.S. Turbine-engine Helicopter Tail-rotor Accidents, 1988 Through 1993." *Helicopter Safety* Volume 22 (May–June 1996).

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