## ACCIDENT

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|---|---|
| **Aircraft Type and Registration:** | Westland Scout AH1, G-BYRX |
| **No & Type of Engines:** | 1 Rolls-Royce Nimbus MK 10501 turboshaft engine |
| **Year of Manufacture:** | 1966 (Serial no: F9640) |
| **Date & Time (UTC):** | 29 December 2015 at 1430 hrs |
| **Location:** | Near Barn Farm, Ruddington, Nottinghamshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - 1 (Minor) |
| **Nature of Damage:** | Helicopter damaged beyond economic repair |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 76 years |
| **Commander's Flying Experience:** | 1,444 hours (of which 380 were on type)<br>Last 90 days - 44 hours<br>Last 28 days - 1 hour |
| **Information Source:** | AAIB Field investigation |

### Synopsis

While hover taxiing for takeoff, the pilot reported that the helicopter suddenly pitched nose-up and as he was unable to regain control he lowered the collective allowing the aircraft to descend to the ground where it rolled onto its side. The investigation was unable to establish the reason for the loss of control, but it is possible that there was a restriction in one of the flying control servo-jack control valves leading to higher control forces required to control the helicopter in the hover.

### History of the flight

The pilot reported that the wind was approximately 11 kt and the helicopter lifted into the hover as normal. After hover taxiing for approximately 150 m, with the wind from the right, the pilot started to experience difficulty in controlling the helicopter and attempted to yaw to the left in order to position into wind. However, the helicopter did not appear to respond to the control inputs and instead the nose rose to 45-60º above the horizon and the cyclic stick became "solid" in the aft position. The pilot instinctively lowered the collective, which resulted in the aircraft descending until the tail struck the ground and the helicopter rolled onto its right side (Figure 1). The pilot reported that the engine remained running and the centralised warning system gave no indication that a hydraulic failure had occurred. He also stated that he felt no unusual vibrations through the airframe or controls either before or during the event.

**Figure 1**
Position of helicopter after the accident

## Helicopter description

*General*

G-BYRX is an ex-military helicopter that is fitted with a gas turbine engine, a four-bladed main rotor and two-bladed tail rotor. Flying controls were provided at both front seat positions.

*Flying controls*

The helicopter is equipped with a collective lever and cyclic stick which control the main rotor, and two sets of yaw pedals which control the tail rotor. The main rotor controls are servo-assisted by hydraulic power and the cyclic stick is provided with electrically-operated trimmers. Movement of the collective lever and cyclic stick is transmitted through a series of pitch rods and bellcrank assemblies to the control spider, which controls the pitch angle of each main rotor blade (Figure 2).

*Servo-jacks*

Three hydraulic servo-jacks, one for the collective and two for the cyclic control, are mounted at the base of the main rotor gear box. Each of the servo-jacks incorporate a control valve which is connected to the relevant control rod.

With hydraulic pressure available, initial movement of the control rod opens the control valve allowing hydraulic fluid to enter and exit the appropriate sides of the jack piston. This causes the jack body to move until the valve reaches an equilibrium position and closes.

If there is no hydraulic pressure available at the servo-jack, initial movement of the control rod still opens the control valve but the jack body does not move. Instead, further movement of the control rod will move the spider assembly, with the jack body following the movement of the control rod.

A POWER CONTROL - MANUAL/POWER guarded switch mounted on the collective lever controls a hydraulic selector valve that enables hydraulic fluid to be shut off from the servo-jacks.

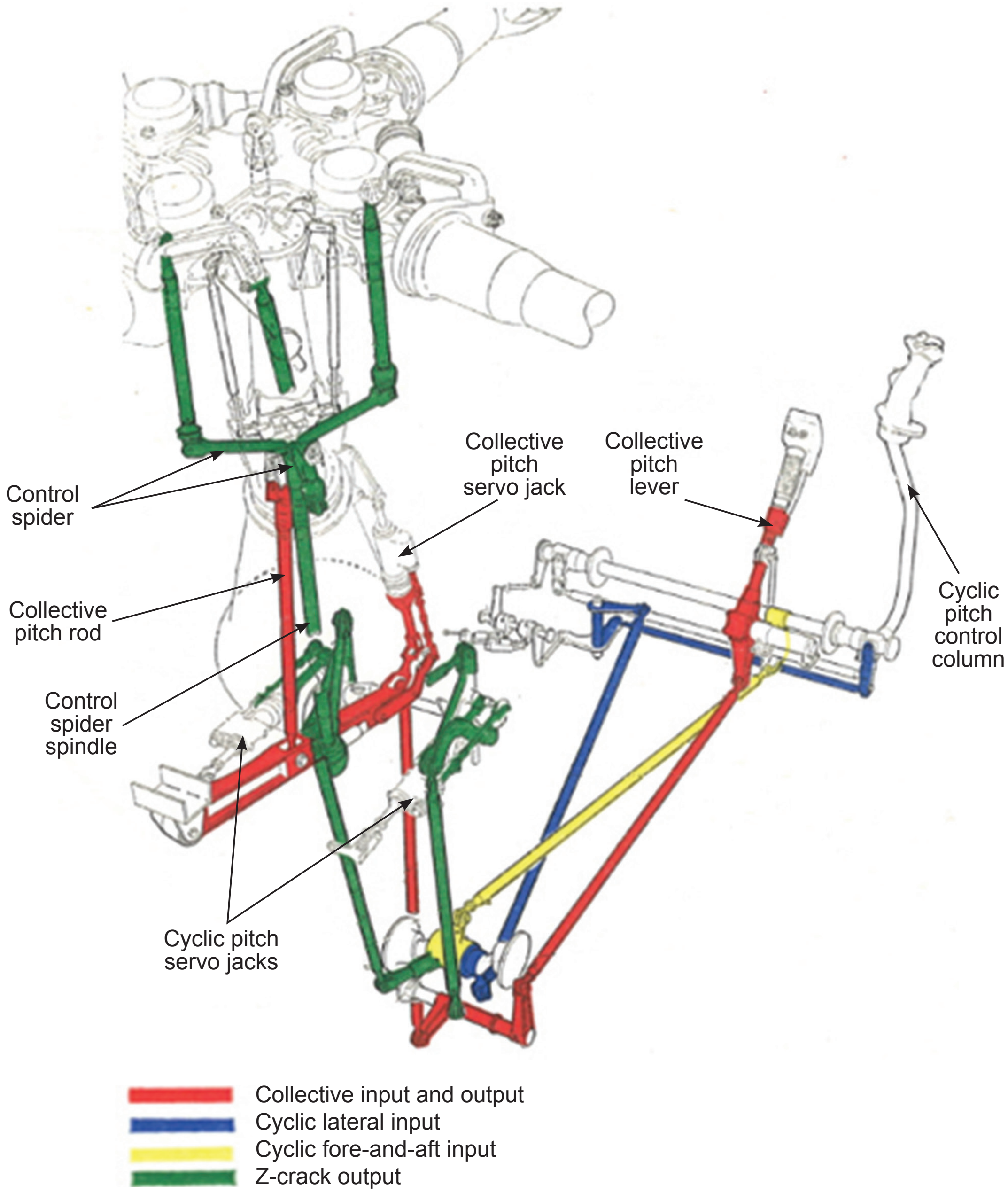


**Figure 2**

Scout main rotor control system

*Hydraulic system*

The hydraulic system uses mineral oil and operates at a pressure of 775 to 1050 (±25) psi. The system comprises a power pack, a hydraulic pump mounted on, and driven by, the main rotor gearbox, and three servo-jacks that are coupled to the main rotor control rods (Figure 3).

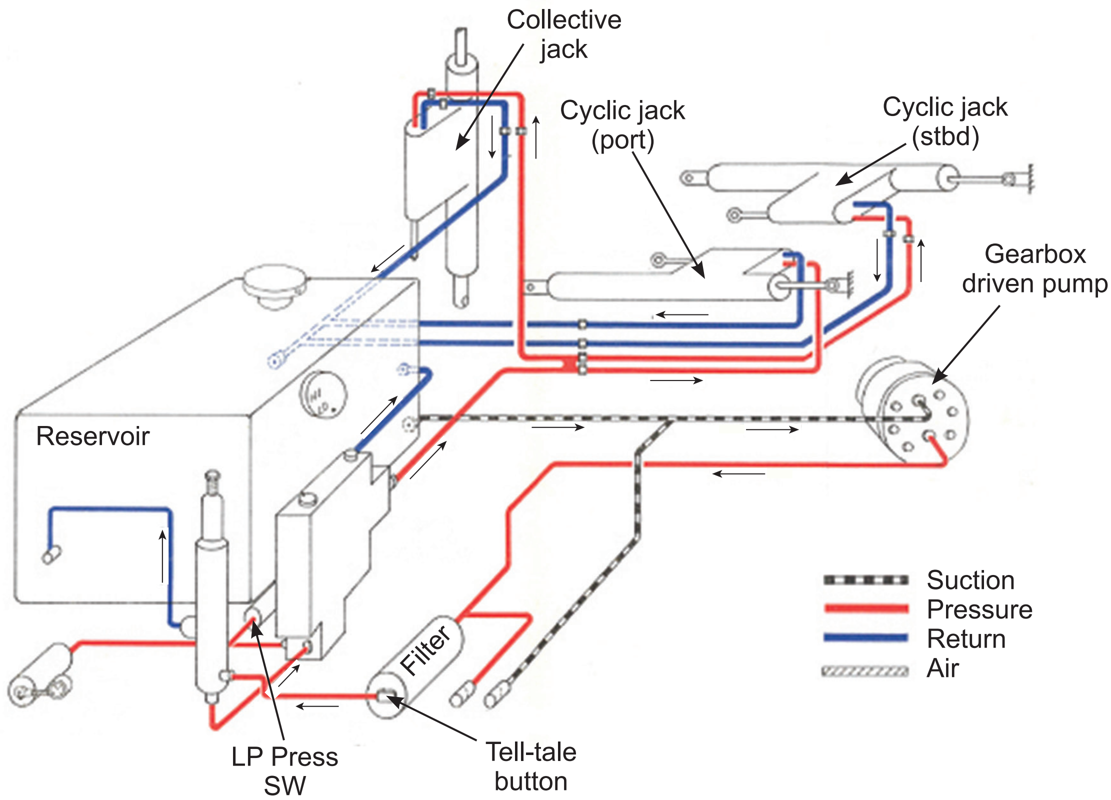


**Figure 3**

Hydraulic system

The power pack includes a reservoir with a capacity of 5.2 pints of oil; a high-pressure filter fitted with a tell-tale button, which protrudes when the filter begins to clog; an accumulator that is charged with air or nitrogen to 400 psi; and a power / manual selector valve which enables hydraulic fluid to be diverted from the servo-jacks and returned to the reservoir, thereby allowing full manual control.

In comparison to flying the helicopter with power control, manual control requires the pilot to apply significantly more force to move the flying controls.

*Centralised warning system*

G-BYRX is equipped with a centralised warning system consisting of two attention lamps and an indicator unit containing eight warning captions. A pressure switch in the hydraulic pack operates when the hydraulic pressure falls below 660 ± 60 psi, causing the HYD caption to illuminate.

## Helicopter handling characteristics

The aircrew manual[1] for the Scout makes the following statements about flying in manual control:

> *'The cyclic stick forces are light with powered controls selected…on reversion to manual control the collective lever is difficult to move in either direction; yaw control is unaffected. At low forward speeds the aircraft tends to pitch nose up; at speed above 60 knots the aircraft may pitch nose up or nose down but the force required to overcome either condition should not exceed 10 lb.'*

## Examination by the AAIB

The AAIB undertook a brief visual examination of the helicopter at the pilot's farm complex after it had been recovered it from the accident site.

The damage to the helicopter was consistent with the pilot's account of it having landed heavily on its tail before coming to rest on its right side. The tail boom and skids had broken away, and the main and tail rotor blades had been destroyed. The damage to the tail rotor assembly and main rotor system dynamic components was consistent with the rotor being driven under power when the main rotor blades struck the ground.

The main rotor control system was examined as far as possible. The control rods were correctly connected and there was no evidence of a control restriction having occurred. The collective control was free to move through its full range. The cyclic control was in the fully aft position and with some force could be moved left and right; however, due to distortion of the airframe, it could not be moved forward from the fully aft position. The control rods to the main rotor were disconnected at the servo-jacks and it was possible to move the cyclic control throughout its full range of travel. The control rods at the servo jacks were manually operated and the servo jacks and the spider operated through their full range of travel,

The hydraulic pack was intact, the accumulator pressure, with the hydraulic pressure dissipated read just over 400 psi and the tell-tale button on the filter had not operated. There was heavy staining on the hydraulic reservoir contents sight glass up to the 'HI' mark; however the level of the fluid was at the bottom of the sight glass. There was no evidence of a hydraulic leak from any of the components. The pilot advised that the fluid was at the correct level prior to the flight and that fluid had leaked out when the helicopter rolled onto its side.

## Detailed examination of the helicopter

The helicopter was recovered to the AAIB where a detailed examination of the main rotor control system was carried out. The controls all moved through their full range of travel and there was no evidence of a control restriction having occurred.

**Footnote**

[1] Scout AH Mk1 Aircrew Manual AP 101C-0701-15 (2nd edition),Part 3, Chapter 2 – Handling in flight.

A hydraulic fluid sample (220 ml) was taken from the pressure pipe at the collective servo-jack. The sample was a dull red colour and there was no visible sign of suspended material.

The hydraulic pump was rotated using an electric drill and the pressure on the gauge read 900 psi. The control input linkages were manually operated and all three servo-jacks operated normally. The hydraulic reservoir was replenished with fresh hydraulic fluid and the tests were repeated. Apart from an occasional drip from the right cyclic servo valve, there was no evidence of a hydraulic leak from any part of the hydraulic system. The pressure in the accumulator was reduced and the pressure switch operated at approximately 650 psi.

The hydraulic system was removed from the helicopter intact and along with the hydraulic fluid sample was sent to 1710 Naval Air Squadron, Material Investigation Group for further analysis.

### Detailed examination of servo jacks

A detailed examination of the servo-jacks carried out by 1710 Naval Air Squadron established that there was:

- Evidence of a build-up of fine black coloured deposits within all three servo jacks
- Longitudinal wear marks on the large pistons in two of the jacks, possibly caused as a result of wear and a slight misalignment between the piston and cylinder
- Light oxidisation (surface corrosion) on the servo valve control valves; however the location and extent of the oxidisation would not have affected the operation of the servo control valves
- No evidence of a blockage of the servo control valves

### Analysis of hydraulic fluid

Analysis of the hydraulic fluid determined that it was of the correct grade and the physical properties such as density and total water content were within the expected parameters. Elemental analysis did not indicate any anomalous wear conditions or elevated levels of barium[2]. Gas chromatography highlighted degradation of the hydraulic fluid, but in the opinion of the laboratory it was not sufficient to degrade the oil to a level where it was not capable of operating.

Debris was found in the hydraulic filter; however it was considered to be normal for the age of the filter.

**Footnote**

2 In 1710 NAS experience, elevated levels of barium can cause formation of aggregates within the hydraulic fluid which form 'sticky' residues. The fluid itself is not specifically degraded, but the residues can result in problems within the system.

## Approval basis

G-BYRX was granted approval[3] on 11 February 2000 by the Civil Aviation Authority (CAA) for G-BYRX to operate on a National Permit to Fly based on the provisions of BCAR Chapter A3-7, paragraph 3.1(d)[4]. In the Airworthiness Approval Note (AAN), the CAA agreed a maintenance policy based on the existing military maintenance schedule[5] with the addition of calendar limitations to the servicing check intervals.

Paragraph 4.8 of the AAN states:

> *'Flying Controls*
> *In the event of a hydraulic system failure full manual mechanical control is available.'*

The validity for the Permit to Fly was last issued by the CAA on 5 November 2015 and was valid until 6 November 2016.

## Maintenance

*Hours flown on civil register*

The maintenance records show that since January 2001 the helicopter had flown approximately 310 hours and since 24 October 2004 had flown 210 hours, flying between 11 and 26 hours per year.

*Check flight*

The last check flight was carried out on 24 October 2015 using the CAA check flight schedule 'CFS 289, Issue 3.' The pilot reported that the performance was *'SATIS'* and commented *'a smooth and well looked after aircraft.'*

*Scheduled maintenance*

The helicopter was maintained on its previous military Basic Servicing Schedule, which consisted of five servicing periods identified as B1 to B5. The servicing intervals were

B1 inspection: 25 flying hours.
B2 inspection: 75 flying hours.
B3 inspection: 150 flying hours, with a 24 month calendar backstop.
B4 inspection: 300 flying hours, with a 48 month calendar backstop.
B5 inspection: 600 flying hours, with a 48 months calendar backstop.

The last scheduled maintenance, a B2 inspection, was completed on 2 October 2015 at 5,676.50 flying hours. No significant faults were identified during the maintenance.

**Footnote**

[3] Airworthiness Approval Note No 27163 Addendum 1.
[4] Applicable to ex-military origin helicopters.
[5] AP101C-0701-5A1 (Master Servicing Schedule).

*Maintenance of hydraulic components*

The component log cards and aircraft records show that the hydraulic filter has a life of 900 flying hours and the servo-jacks have a life of 3,600 flying hours. The dates that these components were fitted to the helicopter and the life used at the time of the accident are shown in Table 1. There was no requirement in the maintenance documents for the hydraulic fluid to be regularly tested and there was no calendar life for the overhaul or testing of the servo-jacks.

| Component | Life of component | Date repaired / tested | Date installed | Life used at installation | Total Life used |
|---|---|---|---|---|---|
| **Hydraulic filter** | 900 hours | N/A | 14/10/03 | 0 hours | 228 hours |
| **Servo Jack (Port)** | 3,600 hours | 8/8/83 | 12/10/90 | 544.7 hours | 1,655 hours |
| **Servo Jack (Starboard)** | 3,600 hours | 15/1/86 | 12/10/86 | 1,497.6 hours | 3,278 hours |
| **Servo Jack (Collective)** | 3,600 hours | 7/6/86 | 7/11/86 | 0 hours | 1,745 hours |

**Table 1**

Life and usage data for the hydraulic filter and servo jacks

## Analysis

The damage to the helicopter was consistent with the pilot's account that the helicopter descended tail first to the ground while the engine was running. The investigation could not identify any evidence that a mechanical restriction of the flying controls had occurred and the hydraulic and warning system all operated normally after the accident.

Immediately after the accident, the fluid level in the hydraulic reservoir was found to be below the minimum mark, which the pilot explained was a result of the fluid leaking out of the reservoir when the helicopter rolled onto its side. The pilot also reported that the Power Control Switch was in the POWER position and the HYD caption had not illuminated during the flight. Therefore, there should have been sufficient pressure to operate the flying control servo-jacks.

It is possible that there was a temporary restriction of a servo-jack because of debris blocking a servo control valve. Such a restriction could have led to the loss of control as it would have been disorienting and challenging for the pilot with the increased control forces required while operating at low level in the hover.