



NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

December 13, 2021

HELICOPTER SPECIALIST'S FACTUAL REPORT

NTSB No: ERA20FA074

A. ACCIDENT

Operator: Redmark Capital LLC
Aircraft: Robinson R66, registration N450MC
Location: Mechanicsburg, Pennsylvania
Date: January 9, 2020
Time: 2029 eastern standard time

B. GROUP

A group was not formed.

LIST OF ACRONYMS

EST	eastern standard time
FCC	flight control computer
HCP	HeliSAS control panel
NTSB	National Transportation Safety Board
POH	Pilot's Operating Handbook
P/N	part number
SAS	stability augmentation system
S/N	serial number

C. SUMMARY

On January 9, 2020, about 2029 eastern standard time (EST), a Robinson R66 helicopter, N450MC, experienced an inflight breakup near Mechanicsburg, Pennsylvania. The private pilot and one passenger were fatally injured and the helicopter was destroyed. The helicopter was operated under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. Night visual meteorological conditions prevailed at the time and no flight plan was filed for the flight. The flight originated from Martin State Airport, Baltimore, Maryland, about 1958 EST and was destined for Buffalo Niagara International Airport, Buffalo, New York.

D. DETAILS OF THE INVESTIGATION

1.0 SPRAG CLUTCH ASSEMBLY

Examination of the sprag clutch assembly, P/N A188-2 and S/N 12635, at the accident site found it remained installed onto the engine accessory gearbox. The engine-to-transmission shaft was fractured at its aft flange with signatures consistent with overload. The aft flange of the engine-to-transmission shaft assembly remained attached to the flange on the forward end of the clutch assembly and exhibited deformation. All attaching hardware between the clutch assembly flange and the engine-to-transmission shaft assembly was present and secure. The freewheeling and driving functionality of the clutch was verified. According to maintenance records, the clutch assembly was original to the helicopter.

On January 15, 2021, the clutch assembly was removed from the wreckage (**Figure 1**). The clutch assembly was shipped to Varex Imaging Corporation in Franklin Park, Illinois to be scanned via computed tomography (CT). The CT scan found no evidence of missing or fractured components within the clutch assembly. The CT scan also identified fluid within the clutch assembly. The detailed results of the CT scan can be found in the *Computed Tomography - Specialist's Factual Report* in the docket for this investigation.

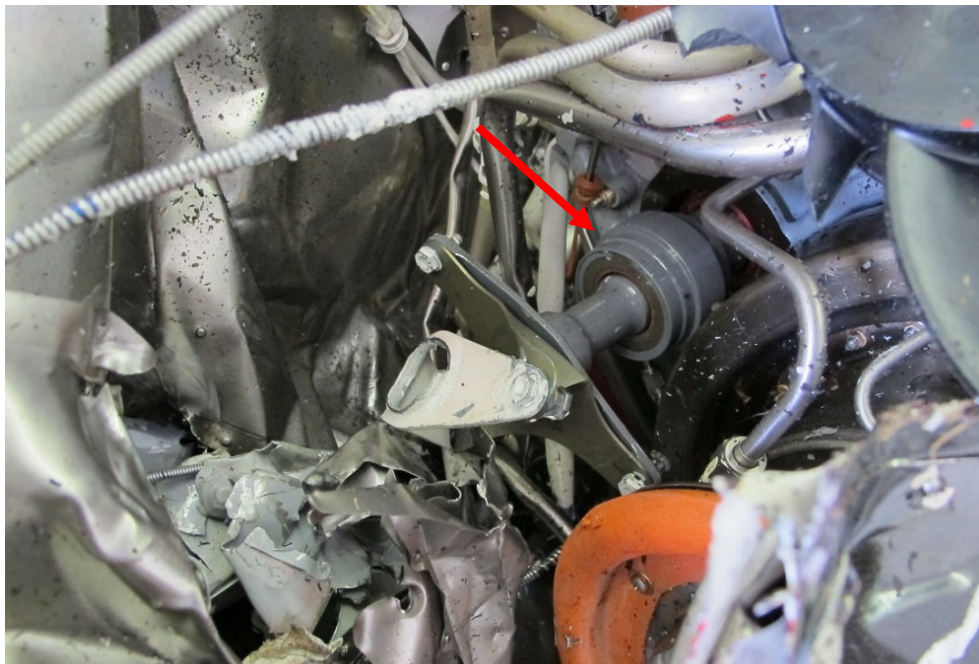


Figure 1. The red arrow points to the sprag clutch as seen in the wreckage. (Image courtesy of Robinson Helicopter Company)

On March 9, 2021, the clutch assembly was examined and disassembled in the NTSB Materials Laboratory in Washington, District of Columbia (**Figure 2**). The clutch assembly's freewheeling functionality was verified. The plug on the spline-end of the clutch assembly was removed and, with the clutch upright (i.e. its rotational axis pointing up), a metal scale was inserted into the clutch assembly. The oil level within the clutch measured about 3.5 inches in height. The drawing required an oil level of about 4.3 inches. The residual oil was poured into a glass jar and had a medium-dark translucent red appearance, but exhibited no evidence of contaminants such as metallic chips or flakes and did not have an acrid odor. About 2.20 fluid ounces of residual oil was collected.



Figure 2. The recovered sprag clutch assembly.

Using a mechanical press, the shaft was separated from the housing. The sprag clutch, seal, and two bearings remained installed on the shaft (**Figures 3-5**). The inner surfaces of the clutch housing did not exhibit anomalous damage. The smaller of the two bearings rotated freely and exhibited no evidence of binding. The larger of the two bearings rotated freely but exhibited a ratchet-like feel when rotated. However, the two bearings did not exhibit thermal damage or other anomalous damage. The sprag elements were all present and did not exhibit evidence of cracks, fractures, galling, or other anomalous damage on its visible surfaces. The clutch was not disassembled further.

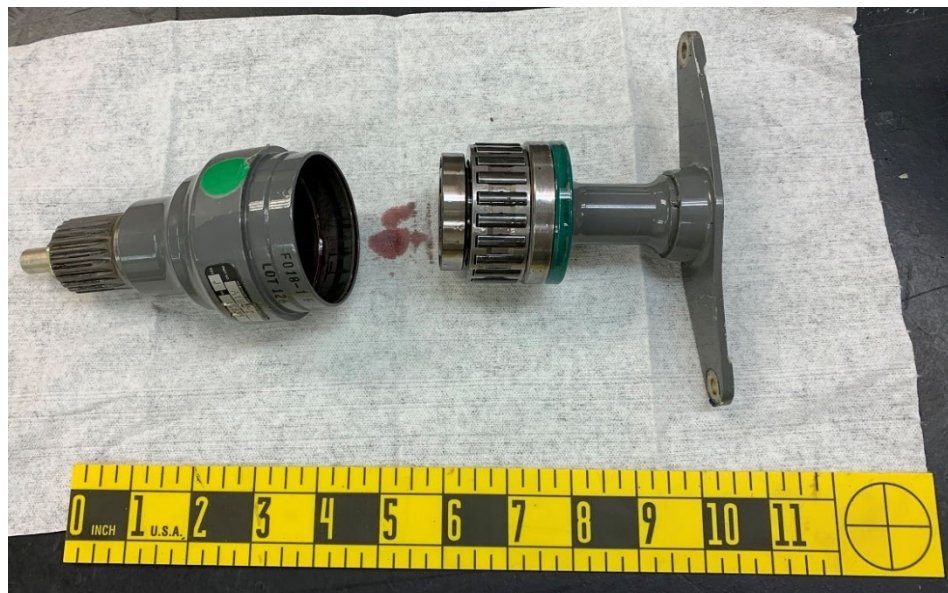


Figure 3. The sprag clutch after separation of the shaft from the housing.



Figure 4. A view of the sprag elements and a bearing.



Figure 5. A view of the clutch outer race.

2.0 HELISAS AUTOPILOT SYSTEM

A Genesys Aerosystems HeliSAS autopilot system was installed on the accident helicopter. The two-axis autopilot is composed of the flight control computer (FCC), HeliSAS control panel (HCP), and two servo-actuators – one each for the pitch and roll axes. According to the R66 Pilot's Operating Handbook (POH) Supplement for the HeliSAS, "*the primary autopilot mode is stability augmentation system (SAS) mode which maintains a steady helicopter attitude by applying corrective inputs to the cyclic. The autopilot does not provide any collective or pedal inputs. Additional modes providing heading hold, altitude hold, and navigation functionality are also selectable.*" SAS mode is engaged by either pressing the SAS button on the control panel or by pressing the cyclic-mounted trim button on the cyclic for more than 1.25 seconds. When SAS mode is engaged, the pilot can "fly through"¹ the SAS to achieve a desired attitude, and can subsequently press and release the trim button to reset the baseline attitude for the system to the current attitude. If only SAS mode is engaged, pushing the SAS button on the HCP or the "AP OFF" button on the cyclic will disengage SAS mode (for manual control) and will be accompanied by four aural beeps in the headset. Additionally, the HeliSAS is designed to automatically disengage when one of several predefined faults or malfunctions are detected by the system safety monitors, which will also produce four aural beeps in the headset to indicate autopilot disengagement.² Disengagement of an autopilot mode, such as heading or navigation, not commanded by the pilot (such as the loss of a valid navigation signal) will be accompanied by a single aural beep in

¹ According to Genesys Aerosystems, the force to push the cyclic, with the autopilot engaged, is normally less than 3.5 pounds.

² In the R66 POH Supplement for the HeliSAS autopilot system, there is a caution that states "*Due to the unstable nature of helicopters, autopilot disengagement requires immediate pilot attention. Always monitor helicopter attitude and flight controls, and be prepared to take manual control.*" Additionally, there is a note that states "*although unlikely, it is possible for certain faults to cause disengagement without the four-beep aural warning.*"

the headset, but an intentional disengagement of an autopilot mode will not trigger a beep in the headset; SAS mode will remain engaged.

The FCC, HCP, and the two servo-actuators remained installed in the cockpit wreckage (**Figures 5-9**). **Table 1** shows the part numbers (P/N) and serial numbers (S/N) for the autopilot system. According to maintenance records, the FCC, HCP, and both servo-actuators were original to the helicopter. The FCC and HCP were removed from the wreckage and submitted to the National Transportation Safety Board (NTSB) Recorders Laboratory in Washington, District of Columbia to recover stored data (**Figures 10 and 11**). The detailed results of this effort can be found in the *Flight Control System - Specialist's Factual Report* in the docket for this investigation.



Figure 5. The red arrow points to the HCP installed within the instrument panel. (Image courtesy of Robinson Helicopter Company)



Figure 6. The FCC as seen in the wreckage.

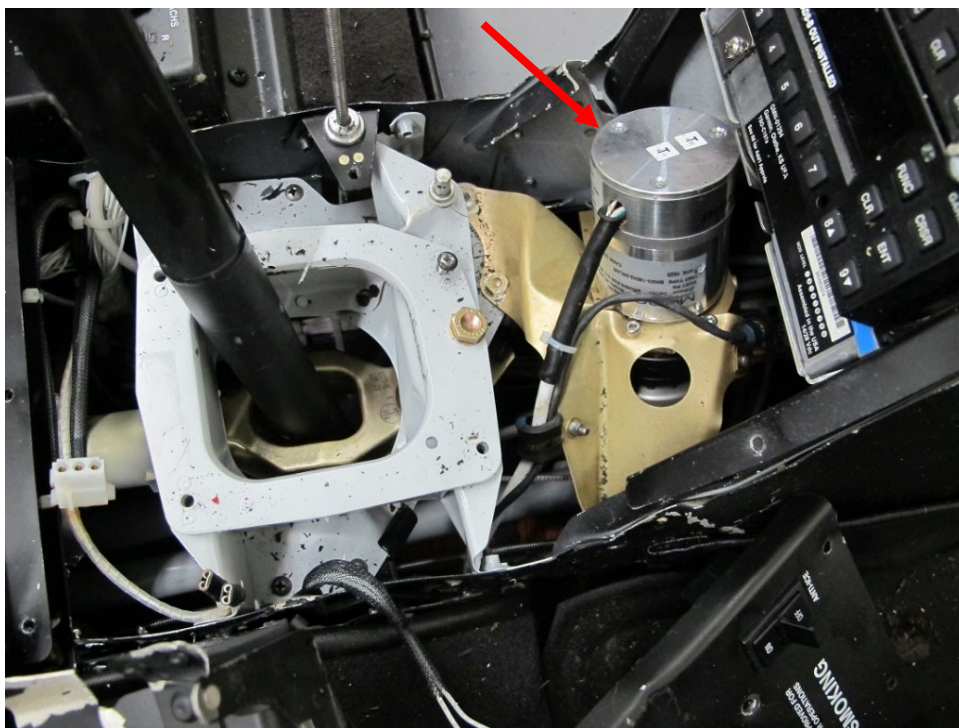


Figure 7. The red arrow points to the pitch servo-actuator installed in the wreckage. (Image courtesy of Robinson Helicopter Company)

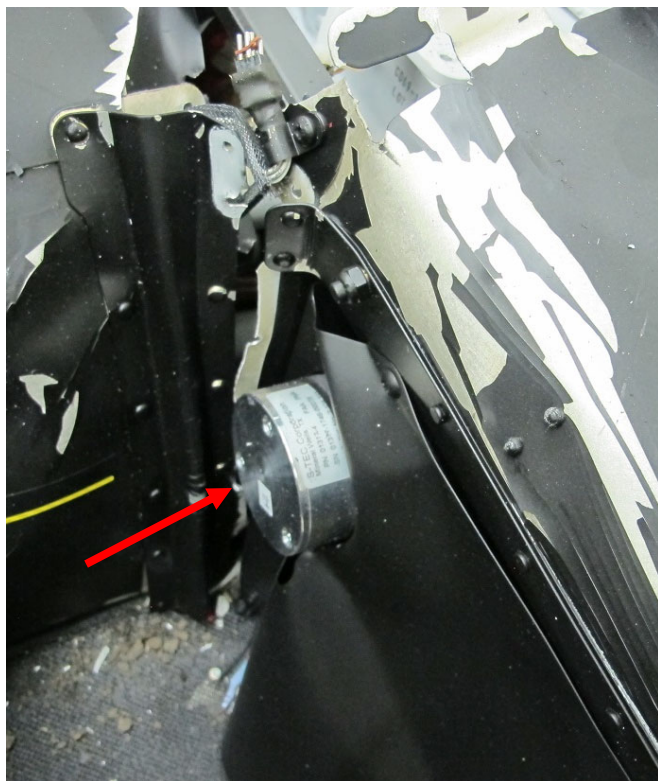


Figure 8. The red arrow points to the roll servo-actuator installed in the wreckage. (Image courtesy of Robinson Helicopter Company)

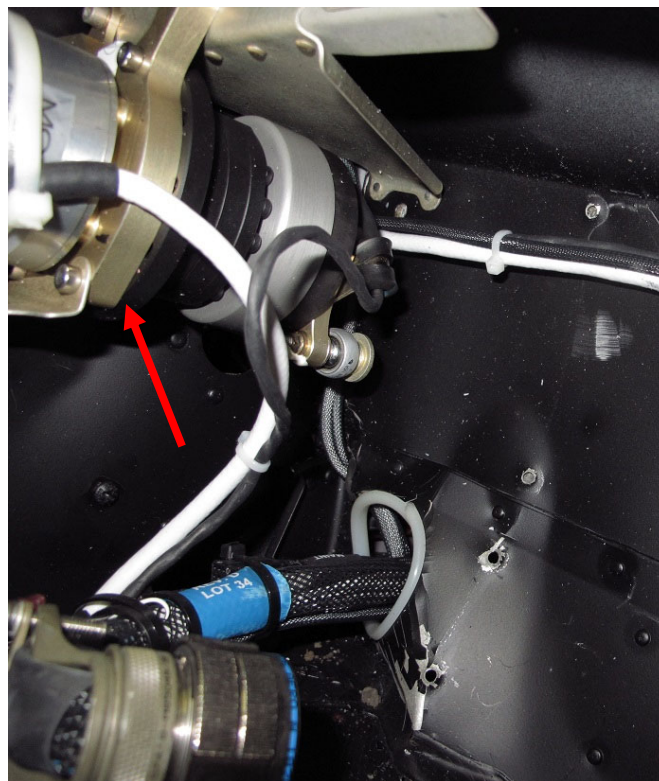


Figure 9. A different view of the roll servo-actuator (red arrow) installation. (Image courtesy of Robinson Helicopter Company)

Table 1. N450MC HeliSAS Component Information.

FCC	P/N 01311-03-11	S/N 01311-1746-00030
HCP	P/N 01309-01-01	S/N 01309-1746-00016
Pitch servo-actuator	P/N 01317-3	S/N 01317-1746-00034
Roll servo-actuator	P/N 01317-4	S/N 01317-1746-00078

**Figure 10. The recovered FCC.****Figure 11. The recovered HCP.**

On March 18, 2021, the pitch and roll servo-actuators were removed from the wreckage (**Figure 12**). The FCC, HCP, and both pitch and roll servo-actuators were shipped to Genesys Aerosystems in Mineral Wells, Texas to bench test the components for functionality. The FCC and HCP functioned normally. Bench testing of the pitch servo-actuator was not possible, likely due to damage observed on a wire within a wire bundle leading to the motor. Bench testing of the roll servo-actuator was performed and the servo passed the resolver test and the acceptance test protocol. The roll servo-actuator was connected to an FCC and an HCP (both bench units) and a system-level test was performed. The roll servo-actuator failed the system-level test, which included driving the servo clockwise and counterclockwise as well as manually back-driving the servo clockwise and counterclockwise. There was no obvious visual damage to the servo-actuator motor's wire bundle, but internal damage to the wires could result in a failure of the system-level test. On June 14, 2021, the pitch and roll servo-actuators were disassembled at Genesys Aerosystems' facilities in Mineral Wells, Texas.

**Figure 12. The roll (left) and pitch (right) servo-actuators after removal from the wreckage.**

Pitch Servo-Actuator Disassembly

The retaining nut for the clutch remained secured to the tanged washer. The clutch magnet was able to be removed from the friction plate (**Figure 13**). The magnet and friction plate had evidence of surface corrosion.³ The adapter did not exhibit looseness when removed. Grease was present within the gearbox and had a clean, beige-colored appearance (**Figure 14**). The quantity of grease observed was typical for the component. The bearing was removed, rotated smoothly, and exhibited no anomalous damage. None of the removed screws exhibited evidence of looseness. The motor shaft turned smoothly when rotated by hand. The [shrink-wrapped] wire bundle sleeve was partially dislodged from the motor housing, exposing some of the wiring, one of which was cut. The motor cover was removed and a white-colored sealant was present on the motor wiring, but no other internal damage was observed.



Figure 13. Pitch servo-actuator magnet and friction plate.

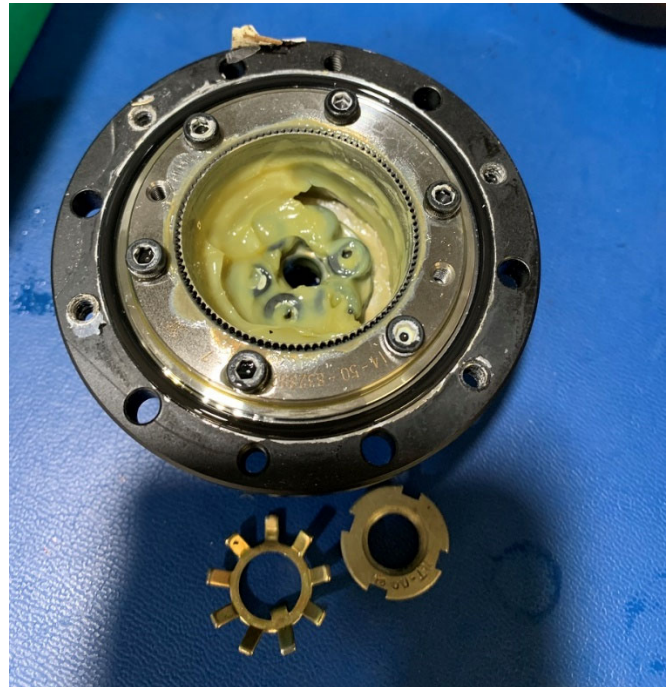


Figure 14. Pitch servo-actuator gearbox.

Roll Servo-Actuator Disassembly

The retaining nut for the clutch was secured to the tanged washer. The clutch was stuck onto the housing and was tapped out. Once removed, the surfaces between the clutch magnet and friction plate did not exhibit anomalous damage (**Figures 15 and 16**). The adapter did not exhibit looseness when removed. Grease was present within the gearbox and had a clean, beige-colored appearance (**Figure 17**). The quantity of grease observed was typical for the component. The bearing was removed and exhibited smooth rotation and no anomalous damage. None of the removed screws exhibited evidence of looseness. The motor shaft turned smoothly when rotated by hand. The cover for the motor was removed and a white-colored sealant was present on the motor wiring. No anomalous damage was observed on the visible internal surfaces. The motor wiring bundle had a sharp bend at the motor housing, but the wiring zip-tie remained secure.

³ The pitch servo-actuator was not bench tested and thus surface corrosion would not have been rubbed off during testing.

There was no visual damage to the wire bundle, but Genesys Aerosystems' facility did not have the capability to perform electrical testing of the motor and its wire bundle.



Figure 15. Roll servo-actuator friction plate.



Figure 16. Roll servo-actuator magnet.

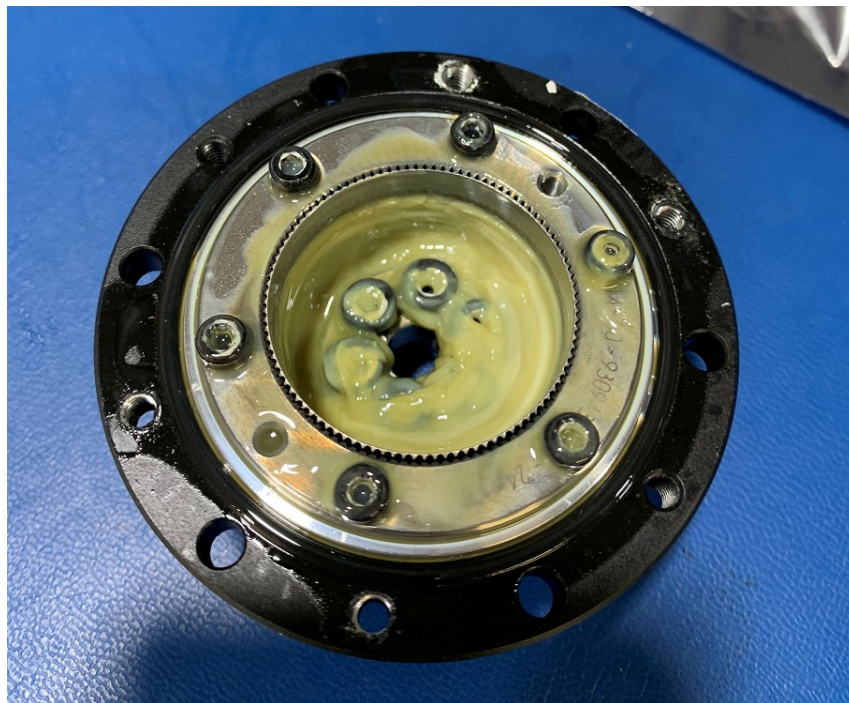


Figure 17. Roll servo-actuator gearbox.

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