NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

June 25, 2020

Group Chairman's Factual Report

AIRWORTHINESS

ANC20MA010

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AIRWORTHINESS GROUP FACTUAL REPORT

A. ACCIDENT

Operator: Safari Aviation Inc

Aircraft: Airbus AS-350 B2, N985SA

Location: Lihue, Hawaii

Date: December 26, 2019

Time: 1657 Hawaii standard time

B. GROUP

Group Chairman:	Van S. McKenny IV National Transportation Safety Board Washington, DC
Member:	Juan Sanchez Federal Aviation Administration Flight Standards District Office Honolulu, Hawaii
Member:	Seth Buttner Airbus Grand Prairie, Texas
Member:	Bryan Larimore Safran Helicopter Engines Grand Prairie, Texas

LIST OF ACRONYMS

AC	Air conditioning
Alt	Altitude
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FCU	Fuel Control Unit
FFCL	Fuel Flow Control Lever
FOD	Foreign Object Damage
FSDO	Flight Standards District Office
FSOL	Fuel Shut Off Lever
IIC	Investigator-in-Charge
MGB	Main Gear Box
msl	Mean Sea Level
PD	Police Department
PHLI	Lihu’e Airport
PMRF	Pacific Missile Range Facility
STC	Supplemental Type Certificate
TRGB	Tail Rotor Gear box

C. SUMMARY

On December 26, 2019, about 1657 Hawaii standard time, an Airbus AS350 B2 helicopter, registration N985SA, was destroyed by impact forces and a postcrash fire when it collided with terrain about 24 miles northwest of Lihue, Hawaii. The commercial pilot and six passengers were fatally injured. The helicopter was registered to SAF LTD and operated by Safari Aviation Inc., doing business as Safari Helicopters, as a Title 14 *Code of Federal Regulations* (*CFR*) Part 135 on-demand commercial air tour flight. Company flight following procedures were in effect for the visual flight rules flight, which departed Lihue Airport (PHLI), Lihue, Hawaii at 1631 local time.

The accident flight was the pilot's eighth and final scheduled 50-minute aerial tour flight of the day. About 1632, the pilot radioed Safari Helicopters' headquarters reporting a departure time of 1631. About 1731, ten minutes after the accident helicopter was due to arrive back at PHLI, the flight follower for Safari Helicopters notified the company's director of operations that the helicopter was overdue, and search procedures began. On December 27, about 0932, the accident site was located within the Koke'e State Park, at an elevation of 2,900 feet.

A Barking Sands, HI, (PABK) special weather observation at 1718 reported wind from 350° at 10 knots; 2 ½ statute miles visibility in rain and mist, overcast clouds at 3,000 ft; temperature 73°F; dew point 72°F; and an altimeter setting of 29.90 inches of mercury.

D. DETAILS OF THE INVESTIGATION

On Sunday, December 29, 2019, investigation team members arrived on Kauai. The NTSB investigator-in-charge (IIC) conducted the organizational meeting. An Airworthiness Group was formed consisting of representatives from Airbus, Safran Helicopter Engines, the Federal Aviation administration (FAA) Honolulu Flight Standards District Office (FSDO), and the National Transportation Safety Board (NTSB).

On Monday, December 30, 2019, the Airworthiness Group met at the Kauai Emergency Management Agency (KEMA) Operations Facility. The Kauai Fire Department and Police Department briefed the on-scene situation. The IIC, Airworthiness Group Chairman, and Airbus representative conducted an aerial survey of the accident scene. The Airworthiness FAA representative collected the helicopter maintenance records from the operator.

On Tuesday, December 31, 2019, Members of the Airworthiness Group hiked the ridge trail (Nu'alolo trail) opposite the accident site in search of a reported rotor-tree strike. The reported tree strike was found and it was confirmed not to be a tree strike but damage most likely resulting from wind.

On Wednesday, January, 1, 2020, the Airworthiness Group Chairman reviewed accident site police photos, accident site aerial drone video footage, and maintenance records.

On Thursday, January, 2, 2020, the Airworthiness Group, plus, additional personnel from Airbus and FAA were repositioned to Barking Sands (Pacific Missile Range Facility- PMRF) to prepare for the wreckage layout. No investigative team members accompanied the recovery personnel to the accident site. PMRF provided an open hangar, forklift, and worktables for the team. The recovery crew arrived with a MD500 and a UH-1 helicopter. The recovery crew was able to set up a staging area near the wreckage and prepared the site for wreckage recovery. Day light and weather prevented the movement of the wreckage.

On Friday, January, 3, 2020, the Airworthiness Group plus additional personnel from Airbus, and the FAA, staged at the PRMF hangar and began examining and laying out the wreckage as it arrived from the accident site via helicopter. All wreckage was recovered by the end of the day.

On Saturday, January, 4, 2020, the Airworthiness Group, plus additional personnel from Airbus and the FAA returned to the PMRF hangar. The wreckage was laid out and photo documented the wreckage and completed written documentation.

On Sunday, January, 5, 2020, the Airworthiness Group completed group field notes, exchanged photos, and other investigative material.

On Monday, January, 6, 2020, the Airworthiness Group concluded the field phase of the investigation.

E. FACTUAL INFORMATION

1.0 HELICOPTER INFORMATION

1.1 HELICOPTER DESCRIPTION

The Airbus (formerly Eurocopter) AS350 B2 is a traditional helicopter design consisting of a main rotor and tail rotor (Figure 1). It has a three-bladed main rotor system that provides helicopter lift and thrust, and a two-bladed tail rotor system provides antitorque and directional control. The helicopter flight controls are hydraulically assisted by a single hydraulic system. It was configured for six passengers and a single pilot occupying the left seat. The helicopter was equipped with a low skid-type landing gear and a 712-shaft horsepower Safran Helicopter Engines (formerly Turbomeca) Arriel 1D1 turboshaft engine. The AS350 B2 helicopter is type certificated under FAA Type Certificate Data Sheet (TCDS) No. H9EU.

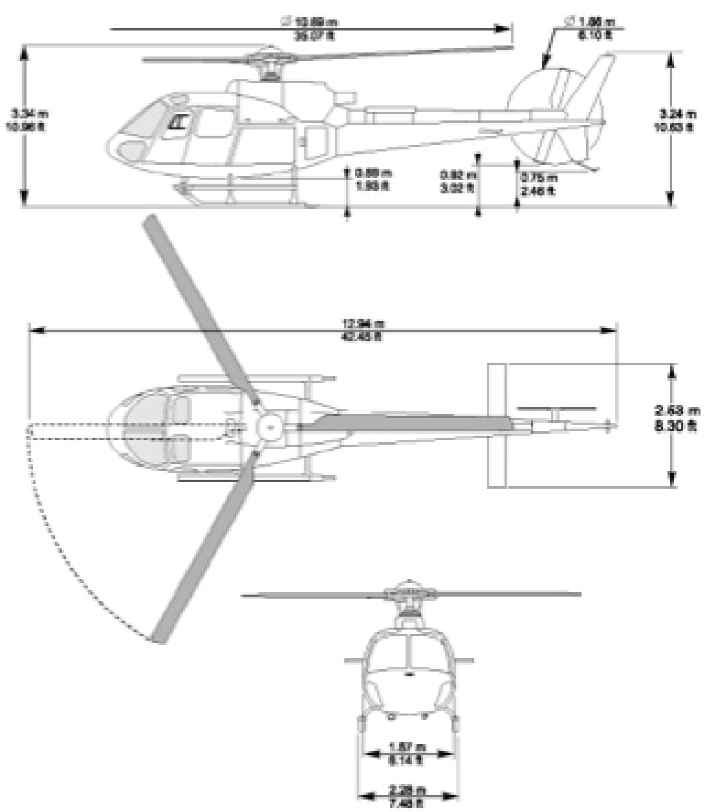

Figure 1 - AS 350 B2 3-view drawing.

1.2 HELICOPTER HISTORY

The accident helicopter, serial number (S/N) 3111, was manufactured in 1998. According to helicopter records, the airframe had accumulated 21,854.1 flight hours (aircraft total time) at the time of the accident. The Arriel 1D1 engine, S/N 19648, was installed on the accident helicopter and had accumulated 2,155.2 hours total time.

2.0 WRECKAGE DOCUMENTATION

The wreckage was located in tropical mountainous terrain at about the 3,003-foot level (Figure 2). Evidence of terrain impact was against a 33º vertical face of a ridge that transitioned to a 64º angle where the wreckage came to rest about 100 feet below the ridge. The impact area was on the north face of a ridge that descends to a small canyon running east-west with disturbed terrain evident slightly below the ridge top (Photo 1). The impact area dimensions were about 100 feet vertical distance and 30 feet wide, with the wreckage halfway between the ridge top and valley below. Aerial observation of the wreckage confirmed a post-crash fire (Photo 2).

On December 30, 2019, Kauai Police Department (PD) and the Kauai Fire Department lifted by helicopter and long lined personnel into the crash site to preform recovery operations. A Kauai PD Criminologist photo documented the entire accident site.

Figure 2 - Map location of the accident site

Photo 1 - Terrain surrounding the accident site. Accident indicated by the red circle.

Photo 2 - Arial view of the accident site.

Photo 3

Photo 4

Photos 3 & 4 – The initial impact zone where surface soil has sloughing away revealing the underlaying rock.

Photo 5 - Rotor cut, viewed looking from the accident slope towards the center of the canyon.

Photo 6 - View from near the accident site looking west, descending terrain leading to the ocean.

2.1 FUSELAGE/AIRFRAME

Airframe Structure Description

The helicopter structure consists of the main fuselage, tailboom, and landing skids. The main fuselage comprises: 1) the central body structure, primarily supporting the fuel tank, main transmission, and landing skid; 2) the rear structure, primarily supporting the engine and baggage compartment; 3) the bottom structure, primarily supporting the main cabin; and 4) the windscreen/canopy primarily supporting the doors and windows. The tailboom is attached to the rear structure and supports the tail gearbox, horizontal stabilizer, tail rotor drive shafts, and the vertical fin.

Airframe Examination

The fuselage had undergone extreme fragmentation followed by a post-crash fire. The composite engine cowling with inlet (doghouse) had separated intact from airframe and had damage to the forward attach points evident. The right-side baggage hold door with the air conditioning (AC) inlet, exhibited thermal damage along its edges, and separation damage. The engine inlet bell mouth had been liberated from its attachment points and exhibited thermal and impact damage. Segments and pieces of miscellaneous airframe panels had thermal damaged.

The landing gear was high skid type landing gear with steps. Landing gear skid assembly had fractured in multiple locations. The forward steel cross tube was separated from the skid attachment fixture at both sides and fractured on the left, at the mid span arch, and fractured at the top right before the arch (arch missing). The rear steel cross tube fractured approximately midspan and at the right-side skid attach point. The right oleo strut was present but detached. The entire assembly of right skid and step with steel full length skid shoe was present. The right forward skid section was fractured at the forward cross tube junctions. The left skid was fractured in four locations, and the steel spring extension was broken off. The middle section of the skid had separated, the forward section was fragmented and exhibited extreme thermal damage. The full-length skid shoe and step had separated. The left oleo strut was present but detached.

Fractured portions of the door and door frames were present, but not enough sections were located to assemble a complete door or frame. The cabin interior plastic ceiling was present but separated from the airframe structure. No roof structure was recovered. Structure forward of the aft baggage bulkhead was not present.

The tail boom had fractured into 3 sections. The mid-length fracture exhibited twisting and buckling. The vertical tail section had separated aft of the tail rotor gear box (TRGB), exhibited twisting and bucking in the clockwise direction when looking forward. The dorsal fin was bent up, left, and aft. The vertical fin appeared undamaged.

Photo 7 - Tail section.

2.2 COCKPIT/CABIN

The instrument panel remained relatively intact but had separated from the cockpit cabin structure. All readings recorded below are approximate values as found after recovery.

Photo 8 - Cockpit instrument panel.

Cockpit Instruments:

Hobbs	01635.8 [hours]
Emergency locator transmitter switch	Undetermined
Caution Warning panel	Intact, switch in BRIGHT

Fuel Quantity	0
Clock	4:57
Oil Temperature	0
Oil Pressure	0
Ammeter (Amps)	0
NR (rotor speed)	410
Airspeed Indicator [knots]	180
Attitude Gyro	10 deg nose up and level
Altimeter [inches of mercury/feet]	29.99 / 3,400
Vertical Speed Indicator (VSI)	2500 climb
GPS	Garmin GNS430
Comm	King 196A
Transponder	Alt / 1200
Comm	Garmin GMA350C
TQ [torque]	15%
T4 [exhaust gas temperature]	0
Directional Gyro	Electronic (unreadable)

Table 1- Cockpit instrument readings recorded during the wreckage examination.

The cover of the 30A switch panel and circuit breaker pedestal in the cockpit had separated from the circuit switch board. Thermal damage was evident on the pedestal. The Caution Warning Panel was removed for further examination by investigators.

The fuel flow control lever (FFCL) control cable was separated from airframe. The rotor brake cable remained attached to the rotor brake system but had separated from the cockpit rotor brake handle.
A portion of the pilot's composite seat base and seat back had thermal damage and had fractured from its seat mounts, no floor structure was observed, and no seat cushions were present. Partial seat belt sections of the pilot's harness were observed partially melted into the pilot's seat back. The pilots 4-point seat buckle was observed latched with no webbing attached. A portion of the front side-by-side bench seat had heavy thermal damage. Only three of four aft seat backs and base cushions were present (six cushions total). The base structure of the aft seats were missing. The rear steel seat belt actor bar was thermally damage with no seat belt anchors attached. A passenger briefing card was found in seat pocket.

2.3 MAIN ROTOR DRIVE SYSTEM

Main Rotor and Drive System Description

Power from the engine reduction gearbox is transferred to a power transmission shaft, the forward end of which is connected to a freewheel shaft. The freewheel shaft is connected to the engine-to-transmission drive shaft via a splined adapter. Flexible couplings on both ends of the engine-to-transmission shaft allow for minor misalignment. The engine-to-transmission shaft is connected to the main transmission input pinion pulley flange, which drives the main transmission input pinion, the aft hydraulic pump, and air conditioning unit, the latter two of which are belt driven via the pulley flange. The main transmission contains a single-stage sun and planetary gear system that turns the main rotor shaft. The main rotor shaft is attached to the Starflex via 12 bolts. The main transmission is attached to the airframe via four rigid suspension bars and an anti-torque bi-directional crossbeam with laminated pads installed between the lower transmission housing and the airframe.

The main transmission transmits rotation and flight controls motion to the rotor head and main rotor blades. As viewed from the top, the main rotor turns clockwise. The STARFLEX type semi-rigid main rotor head is made from new materials (resin glass fiber, laminated thrust bearings, self-lubricating bearings) allowing all conventional bearings and lubrication systems to be eliminated. The three main rotor blades are of glass-resin laminate flexible construction and are attached to the rotor hub through flanges and STARFLEX. Pitch variation is achieved through distortion of elastomer bearings. The vibration dampening device mounted in center of the rotor head consists of a weight oscillating between three springs fitted 120º apart.

Main Rotor and Drive Examination

The MGB-engine coupling shaft (transmission shaft) was torsionally twisted in the engine driven direction (Figure 3). One of the bolt holes was deformed opposite the direction of drive rotation. The engine side splined adapter had smeared splines as did the splines on the freewheel shaft drive. All these signatures are consistent with power at the time of rotor impact.

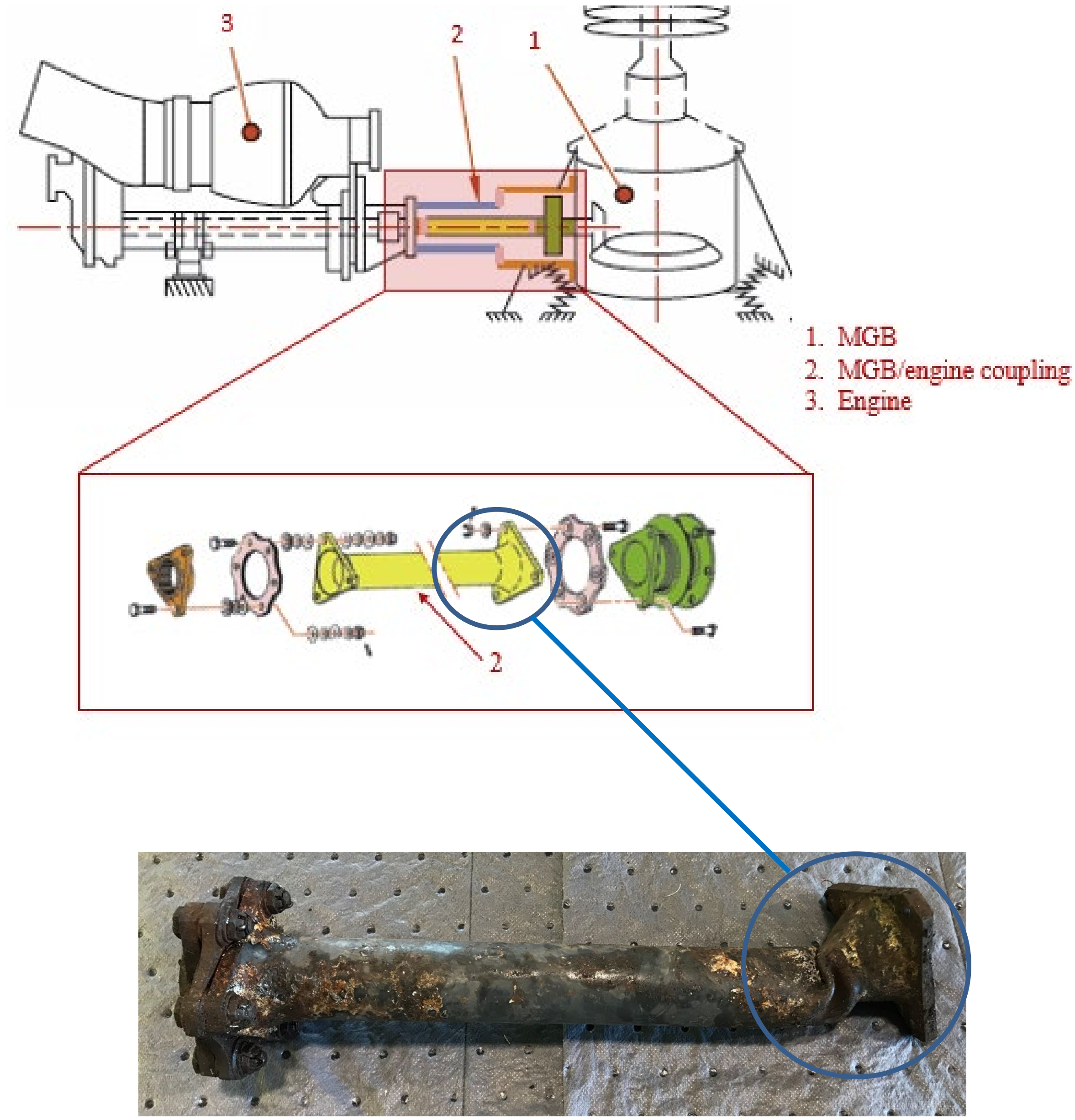

Figure 3 - MGB-engine coupling shaft exhibiting torsional deformation.

The transmission and rotor head remained connected as a single unit but had separated from the aircraft structure and exhibited extreme thermal damage (Photo 5).

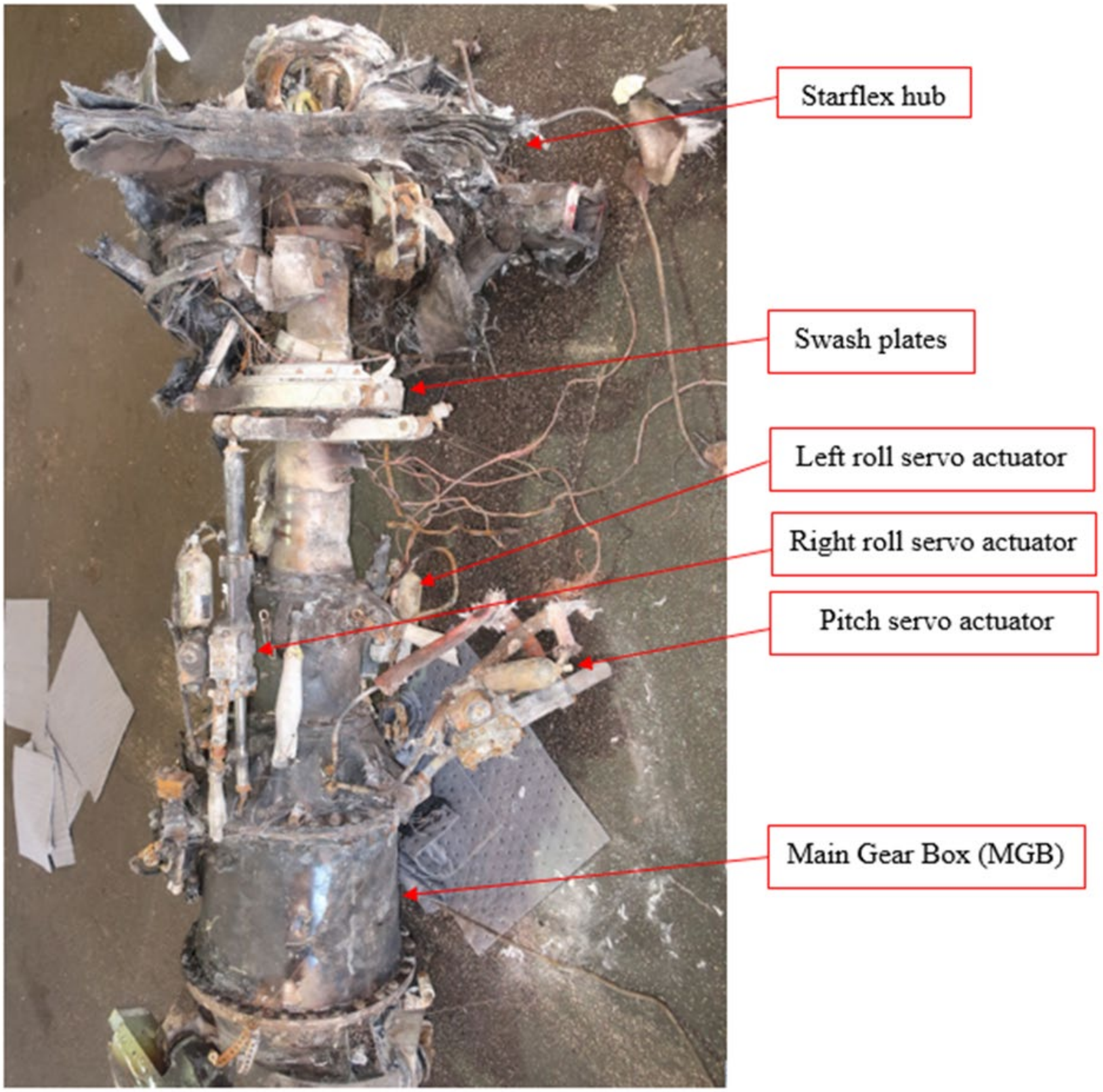

Photo 9 - Main rotor head, rotor mast, servo actuators, and main gearbox (transmission).

All three pitch change links connecting the rotating swash plate to the blade control horns were thermally separated. The rod ends for each link remained attached to their respective connecting points. The composite Starflex hub exhibited heavy thermal damage. Each star arm was fractured at an angle, indicative of power. The blade attachment sleeves were located in the vicinity of the rotor head. The main rotor drive scissor was connected. Two of the vibration dampening springs were separated from rotor head and exhibited thermal damage. The third spring remained in the rotor head.

Rotor Blades

The majority of all three rotor blades were located with the wreckage. All three blades were cut off at the root by recovery personnel. Miscellaneous fragments of blade skins were recovered. Blades were arbitrarily identified by the investigators as 1, 2, and 3 (Photo 6).

Photo 10 - Main rotor blades laid out and labeled.

Blade 1
Thermal separation was evident approximately 3 feet from the root. The mid-section was separated and 3 inches of blade tip was missing. The trailing edge, upper and lower blade skins were missing or separated. The composite structure was frayed at the tip and mid span.

Blade 2
Fractured at mid span with extensive damage to the outboard 2/3^{rds} of the blade. The trailing edge and blade skin was not present. The core composite structure exhibited extensive fraying damage. The blade tip remained attached.

Blade 3
Thermal damage and separation along the first 1/3rd of the blade outboard of root. There were leading edge divots. The blade had been cut mid span by recovery personnel. The trailing edge was not present. Blade tip was present on the blade.

Transmission Examination

The transmission was externally thermally damage and had separated from the aircraft structure. The transmission drive shaft drive splines were smeared on the engine driven side. Torsional twisting on shaft close to the transmission side was evident with the twist corresponding to the driven direction. All four transmission lift strut rod ends had remained attached to the transmission. The lift strut tubes had been separated by thermal damage. The MGB chip detector plug was removed with no chips observed on the plug. The transmission was seized and could not rotated by hand.

2.4 TAIL ROTOR SYSTEM

Tail Rotor System Description

Engine power is transferred to the tail rotor via two tail rotor drive shafts and a tail rotor gearbox (TRGB). The forward tail rotor drive shaft, made of steel, is connected to a flange connected to the aft end of the freewheel shaft. The aft tail rotor drive shaft, made of aluminum, connects to the forward tail rotor drive shaft via a splined, steel flange adapter. Flexible couplings are located between each drive shaft attachment point to allow for minor misalignment. Five ball bearings (also known as "hanger bearings"), mounted within support brackets along the tailboom, support the tail rotor drive shafts. The TRGB provides gear reduction and changes the direction of drive. The tail rotor hub, connected to the TRGB output shaft, provides final drive to the tail rotor.

The two tail rotor blades share a common composite spar that is flexible in both the flapping and pitch change (torsional) directions. Two metal half-shells are clamped to the center of the spar. The inboard half-shell connects to the tail rotor hub and allows for the tail rotor to teeter. Blade pitch is changed via pitch change links mounted between a pitch horn and a pitch change assembly. The pitch horns rotate about a set of elastomeric bearings at the root end of each blade. The spider slides along the tail gearbox output shaft and is controlled by a pitch change bellcrank. Each set of tail rotor blades and pitch change links are assigned a color for identification purposes; the assigned colors are 'red' and 'yellow'.

Photo 11 – Tail rotor blades remained attached to the hub and gearbox.

Tail Rotor Examination

Tail Rotor assembly remained attached to the TRGB (Photo 7). One tail rotor blade exhibited trailing edge separation at midspan and was bent inboard. The other tail rotor blade was relatively intact, no damage was evident. Both pitch links were connected, pitch change movement was achieved by hand manipulation, with free and easy movement. The pitch change push-pull rod had separated from its actuation lever to the midspan break of the tail boom. TRGB moved freely with no binding. The tail rotor drive shaft was connected to the TRGB via the forward splined shaft. A torsional twist was observed along the drive shaft. The tail rotor short shaft had separated from the tail rotor drive shaft at the splined connector and had separated from the engine drive at the flex coupling. The aft flex coupling was intact. The forward flex coupling exhibited bending, and shear force overload signatures. Control continuity from the forward flex cable input to the yaw load compensator was confirmed. The tail rotor control push-pull tube had separated mid span on the tail boom. The push-pull tube from the TRGB to mid span on the tail boom was not present. The TRGB chip detector plug was removed, no chips or debris fragments were observed on plug. The horizontal stabilizer was intact with the right side having some inboard leading-edge damage. The entire tail rotor drive shaft cover was present. The fuel shut off lever (FSOL) was separated from airframe.

2.5 FLIGHT CONTROLS

Flight Control System Description

The cyclic and collective control inputs are transmitted to the stationary swashplate through a series of push-pull tubes and bellcranks. The main rotor cyclic and collective controls are hydraulically assisted via three dual-cylinder main rotor servo controls: fore/aft, right-roll, and left-roll. Each main rotor servo control comprises two cylinders that are stacked in tandem. The main rotor servo controls are mounted to the transmission upper housing and the stationary swashplate. The pedal control inputs are transmitted to the single-cylinder tail rotor servo control through a series of control linkages, bellcranks, and a flexible ball control cable. A yaw load compensator, with an associated accumulator, is connected to the tail rotor servo control output piston via the compensator connecting link, which actuates a push-pull tube connected to the pitch change bellcrank mounted to the tail rotor gearbox.

Flight Control System Examination

Portions of the flight controls were found separated from their linking tubes. Primary cockpit flight controls (cyclic, collective, pedals) had been thermally damaged, had separated from their linking push-pull tubes and cables under the cockpit deck. No cockpit floor structure was observed with the wreckage. Flight control continuity could not be established because control push-pull tubes were presumed destroyed in the post-crash fire. The helicopter was configured with the left seat pilot’s flight control configuration. The fuel shut off control lever (FFCL) and rotor brake steel levers were found completely separated from their linkages, with extreme thermal damage evident. The three main rotor control servos remained attached to the transmission. The input control rods were thermally separated on all three servos. The right roll servo remained attached to the transmission base and the stationary swash plate. The fore/aft servo remained attached to the transmission but thermally separated from the stationary swash plate. The left lateral servo remained attached to the transmission but thermally separated from the stationary swash plate.

2.6 ENGINE[1]

Engine Description

The Safran HE (Turbomeca) Arriel 1D1 turboshaft engine features a single-stage axial flow compressor and a single-stage centrifugal flow compressor, an annular combustor, a two-stage turbine rotor that drives the compressor, and a free turbine rotor (power turbine) (Figure 4). The reduction gearbox is

[1] Safran HE onsite examination report

driven via a splined coupling (known as a "muff coupling") connected to the free turbine rotor. The reduction gearbox provides final drive to the power transmission shaft. An accessory gearbox is driven from a gear coaxial to the shaft between the axial and centrifugal flow compressors.

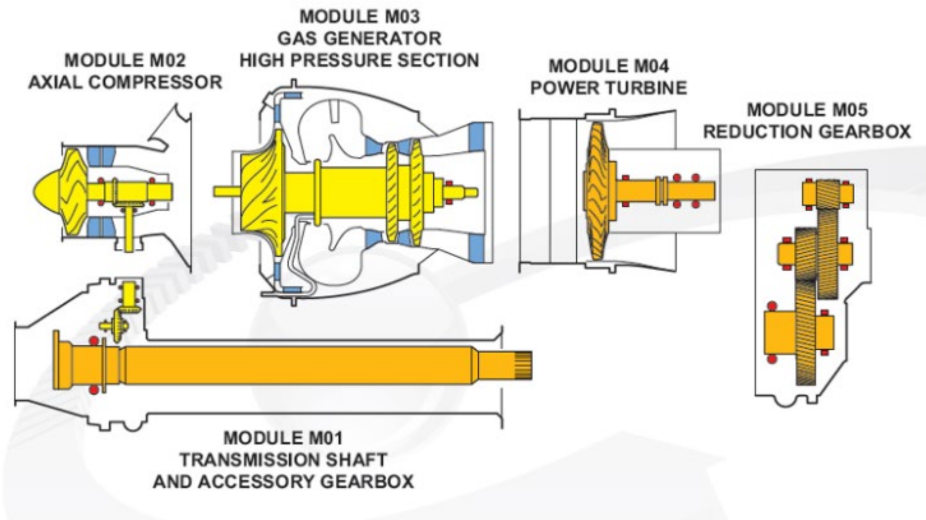

Figure 4 - Cut away of an Arriel 1D1

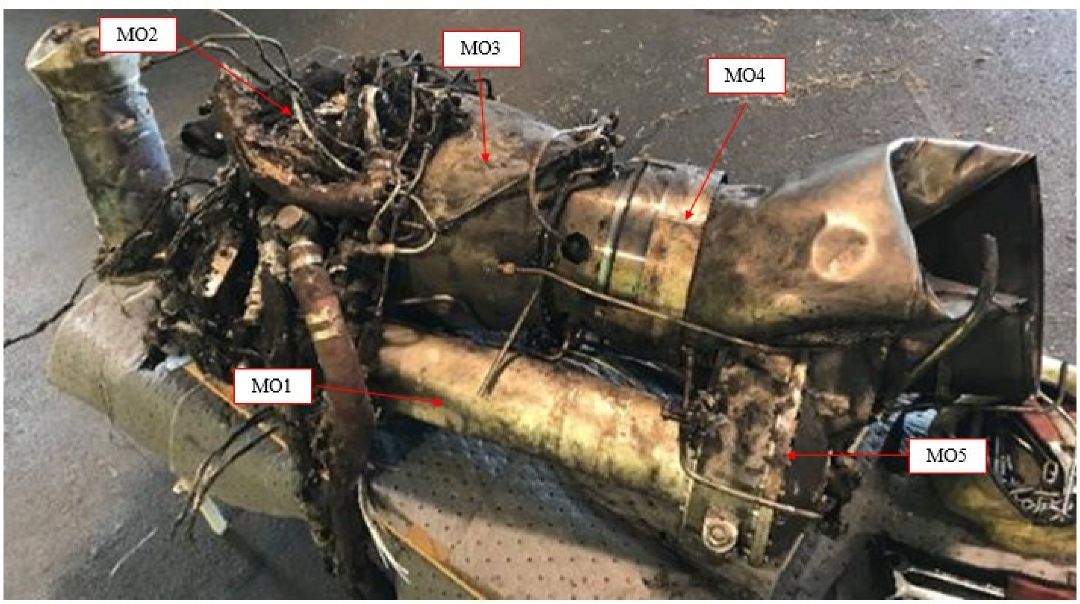

Photo 12 - External view of the engine.

Engine Examination

The engine was examined after being recovered from the accident site. It had been thermally damaged by the post-crash fire (Photo 8). Several of the accessories and attaching fuel and oil lines were thermally damaged or consumed. The fuel control unit (FCU) had broken off at its mount to the accessory gearbox but remained attached by the fuel and air lines. Neither the FCU throttle nor anticipator Teleflex cables were still attached.

The engine, engine deck, rear fuselage section, transmission, and rotor head were all entangled when recovered. The engine and FCU were separated from the rest of the wreckage debris for examination. The attachments for the fuel, oil, and air lines appeared to be correctly installed and safety-wired. The freewheel shaft clutch could be rotated in the freewheeling direction only and was difficult to turn due to the damage sustained. The gas generator could not be rotated by hand and the intake was packed with debris. The axial compressor exhibited severe foreign object damage (FOD) damage on all 13 blades. The free turbine could not be rotated by hand until removed at which time it rotated freely. The module 1 and module 5 magnetic plugs were removed and found clean however the module 1 had burnt oil on it as a result of the post-crash fire.

The rear bearing oil return (TU208) and main electric chip detectors were free of metal debris but were thermally damaged. The engine oil filter was clean but thermally damaged. The FCU sustained impact and thermal damage and was broken away from its mount on the accessory gearbox. Both the N1 and N2 input shafts were present but could not be rotated by hand. The throttle arm was still present, but the anticipator arm was broken off. The FCU fuel filter was clean but thermally damaged.

The module 5 reduction gearbox was removed for examination of the input pinion alignment mark. Misalignment of the mark was negligible.

The second stage high pressure turbine was visible after removal of the free turbine nozzle guide vanes (FTNGV) and did not show any signs of damage. The second stage nozzle guide vane showed metal splatter which is consistent with the engine operating at the time of impact. The gas generator rear bearing was examined, and no anomalies were noted. The oil supply scavenge and vent tubes were all clean.

Nothing was noted during the engine examination that would preclude normal operation though due to the significant thermal and impact damage an exhaustive examination of all systems was not possible.

3.0 MAINTENANCE RECORDS

According to Safari Helicopters, N985SA, was maintained in accordance with the Airbus Helicopters maintenance program. The following maintenance history was documented from the maintenance records maintained by the operator.

Maintenance Action	Inspection Type	Date	Airframe Hours
Most recent scheduled inspection	30 hour	Dec 22, 2019	21,847.5 hours
Check flight for main rotor sleeves	N/A	Dec 16, 2019	21,830.6 hours
Main rotor sleeves inspection due.	Component	Dec, 14,c2019	21,829.8 hours

Aircraft will not start. Replaced starter-generator.	N/A	Dec 12, 2019	21,824.7 hours
Check flight for 100-hour inspection	N/A	Dec 1, 2019	21,797.0 hours
Inspection	100 hour	Nov 30, 2019	21,792.7 hours
Engine inspection	300 hour	Nov 15, 2019	21,749.4 hours
Inspection	150 hour	Nov 14, 2019	21,794.3 hours
Transponder check due. Replaced transponder.	Component	Oct 30, 2019	21,705.9 hours
Hydraulic reservoir seep at slight glass. Replaced hydraulic tank. Cleaned pump and inlet strainer. Serviced with Royco 782 hydraulic fluid.	N/A	Oct 30, 2019	21,705.9 hours
Inspection	100 hour	23 Oct 2019	21,690.2 hours

Video Camera Installation and Removal

The maintenance record STC (supplemental type certificate) list shows that a video camera/recording system (STC SR00115DE) was installed November 27, 1998. The Safari Helicopters Director of Maintenance stated that there was no maintenance logbook entry for the removal of the video recording system; however, he had knowledge that the system had been removed from the baggage compartment and that the only item that remained installed was a camera located in the nose of the helicopter.

F. LIST OF ATTACHMENTS

Attachment 1 – Summary of conversation with the Director of Maintenance of Safari Helicopters

Van S. McKenny IV
Aerospace Engineer – Helicopters