NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Western Pacific Region

AIRFRAME AND ENGINE EXAMINATION

NTSB Accident: WPR12GA106
Accident Date: February 15, 2012

Exam Date: March 1-2, 2012

This document contains 27 embedded images

A. ACCIDENT

Location:	Moran Junction, WY
Date:	February 15, 2012
Aircraft:	Bell 407, N407HL, Serial # 53869
NTSB IIC:	Michael Huhn

B. EXAMINATION PARTICIPANTS:

Michael Huhn Air Safety Investigator National Transportation Safety Board Gardena, CA	Tom Weisner Inspector, Helicopter Operations FAA FSDO Denver, CO
Bill Sarles Air Safety Investigator Bell Helicopter Fort Worth, Texas	Jack Johnson Air Safety Investigator Rolls Royce Indianapolis, IN

C. SUMMARY

The location and conditions (remote, significant snow, heavily forested) at the accident site precluded on-scene investigation by NTSB, FAA, or other technical personnel. Those same parameters also precluded complete recovery of all aircraft components, but all major components were present for examination at the recovery facility. Known missing components are identified in this report.

Examination of the recovered airframe and engine was conducted on March 1-2, 2012 at the facilities of Beegles Aircraft in Greeley, CO. No evidence of any preimpact mechanical malfunction was noted during the examination of the recovered airframe and engine.

D. DETAILS OF THE INVESTIGATION

1.0 Airframe General

The as-examined wreckage was fracture-separated or disassembled (for recovery purposes) into the following major elements

- Fuselage, including engine, transmission, controls, and rotor mast
- Undercarriage skid (separated for recovery)
- Tail boom
- Tail rotor (TR), gearbox and fairing
- Left vertical stabilizer
- Right horizontal and vertical stabilizer (separated for recovery)

- 4 main rotor blades (MRB)
- External litter basket (separated for recovery)
- Multiple fragments of main rotor blade afterbodies, aerodynamic fairings and cabin transparencies

2.0 Components Not Located

The following components or component elements could not be located by investigators during/for this examination:

- Most afterbody portions of 4 MRBs
- Approximate 13 inch tip section of the red/triangle MRB
- 1 MRB damper
- Approximate 30 inch segment of tail boom (just forward of tail rotor assembly)
- Approximate 30 inch segment of tail rotor directional control rod (just forward of tail rotor assembly)
- One TR flapping stop
- Approximate 34 inch span of left horizontal stabilizer
- Plastic cover for the left-seat collective control stub
- Forward toe/stub segment of left undercarriage skid

3.0 Airframe

3.1 Fuselage/Cockpit/Cabin

- The fuselage was primarily intact

Figure 1 - Aft Right View of Fuselage

Figure 2 - Front View

Figure 3 - Front Left View

Figure 4 - Front Right View

- The skid assembly was essentially intact, except
  - The left section was twisted a few degrees nose up
  - The forward stub end of the left skid was fracture separated from the rest of the assembly

Figure 5 - Front View of Skid Assembly (removed for recovery)

- The quick-release litter was crushed aft and up at its forward section

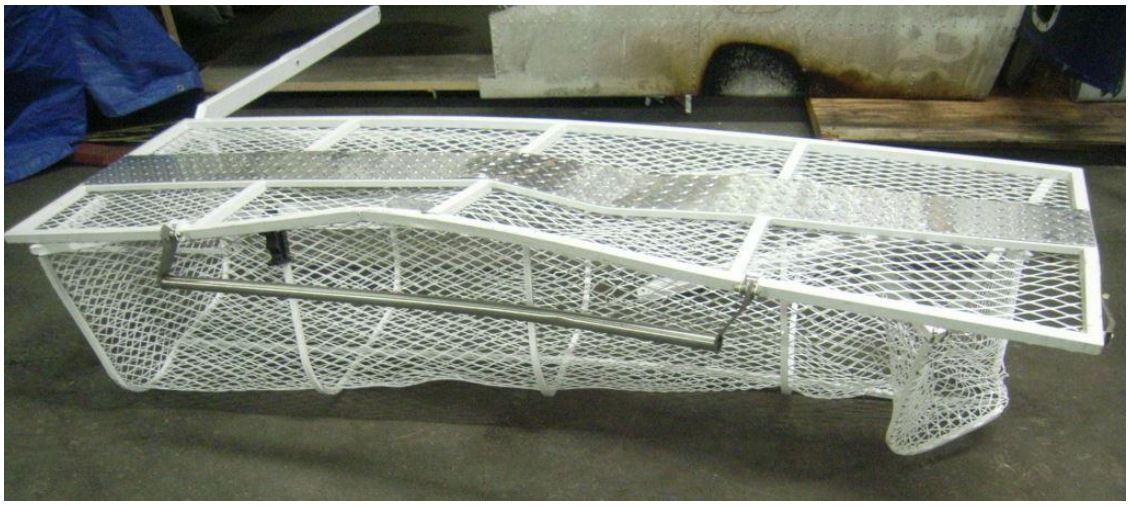


Figure 6 - Front Right View of Litter

- All cabin doors were attached and operable, but not necessarily undamaged
- Of the ten cabin transparencies, only the one for the aft left door was intact; all others were fracture-separated from their frames
- The nose section which enclosed the two sets of anti-torque pedals was partly crushed or torn/displaced, but remained attached
- Aside from the footwell area for the pedals, the cabin volume was not compromised

Figure 7 - Cockpit Looking Forward

- The left front seat cushions had been removed from their normal positions, but were available for examination; the right ones remained installed
- The restraint systems for the two front seats were buckled but had been cut, consistent with victim extraction
- The right cyclic control was partially fracture separated from its attach point at its base
- The right collective was attached but difficult to move due to linkage deformation elsewhere in the helicopter
- The right anti-torque pedals and cockpit linkage were attached but deformed and nearly immobile
- The left anti-torque pedals and cockpit linkage were undamaged but locked out from the flight control system, consistent with system isolation for non-pilots
- The handle for the center-console-mounted "Emergency Pedal Stop Release" was positioned about 1/2 inch out (extended from) its housing
- The center upper instrument console/pedestal was attached but displace right and partially crushed
- A mounting arm assembly for portable GPS units was attached to each side of the center upper instrument console/pedestal; the right arm contained a Garmin GPSMap 296
- The Garmin GPSMap 296 was removed and retained by NTSB for data download by the NTSB recorders laboratory
- The center radio mount appeared undamaged; all radios had been removed and were available for inspection
- The overhead circuit breaker panel appeared undamaged
- The hour meter on the instrument panel registered 788.7 hours
- The hour meter mounted external to the cockpit (not visible during flight operations) was damaged and unreadable
- The Artex ME406HM ELT had been removed from its mount on a shelf aft of the cabin; the switch had two positions (ARM and OFF), and was found in the ARM position
- Attempts to trace the ELT antenna wiring from the ELT mount to the antenna were unsuccessful; the location and condition of the ELT antenna was not determined


ARTEX
FORWARD
ME406HM
EMERGENCY LOCATOR TRANSMITTER
TSO C91a / TSO C126 / ETSO-2C126
CANADA IC :1215B-ME406AF
TYPE ELT (AF) DO-160D ENV. CAT: D1XBC
[204][204]XRXXFXXZAZA[204]H[XXXX]XXA
FREQ.: 121.5 & 406.028 MHz
PERP/EIRP: 5W FOR 24 HOURS (406.028 MHz)
PERP: 50mW FOR 50 HRS / EIRP: 100mW FOR 48 HRS (121.5 MHz)
SOFTWARE V138A
ARTEX AIRCRAFT SUPPLIES, INC.
14405 KEIL ROAD N.E. AURORA, OR 97002
PHONE: 1-503-678-7929
www.artex.net
WARNING
FOR AVIATION EMERGENCY USE ONLY. UNAUTHORIZED OPERATION PROHIBITED
PART NO: 453-6604
REV. D
SERIAL # 11250
MFG. DATE (WW/YY): 17/08
ARTEX QA7
INSTRUCTIONS
ARM: Switch in "ARM" Position.
MANUAL ON: Switch in "ON" position.
RESET: Switch to "ON" postion and back to "ARM".
THIS ELT IS PROGRAMMED FOR AND MUST BE REGISTERED IN COUNTRY: UNITED STATES
THREE DIGIT COUNTRY CODE: 366
15-DIGIT HEX ID: ADCC4 0AFC8 00261
REPLACE BATTERY WITH LITHIUM BATTERY
PART NUMBER 455-0012

Figure 8 - ELT

Figure 9 - ELT Tray in Aft Fuselage

3.2 Tail Boom/Empennage

- The tail boom was fracture separated into 4 main sections
  - Approximate 2 foot stub from fuselage ('Section C')
  - Section aft of Section C to about 2 feet forward of empennage juncture ('Section B')
  - Empennage/TR section ('Section A')
  - Approximate 2 foot section between Sections A and B was not recovered
- The empennage (Section A) was fracture-separated from the tail boom at the empennage junction, but the TR drive shaft had fractured about 2 feet forward of that break

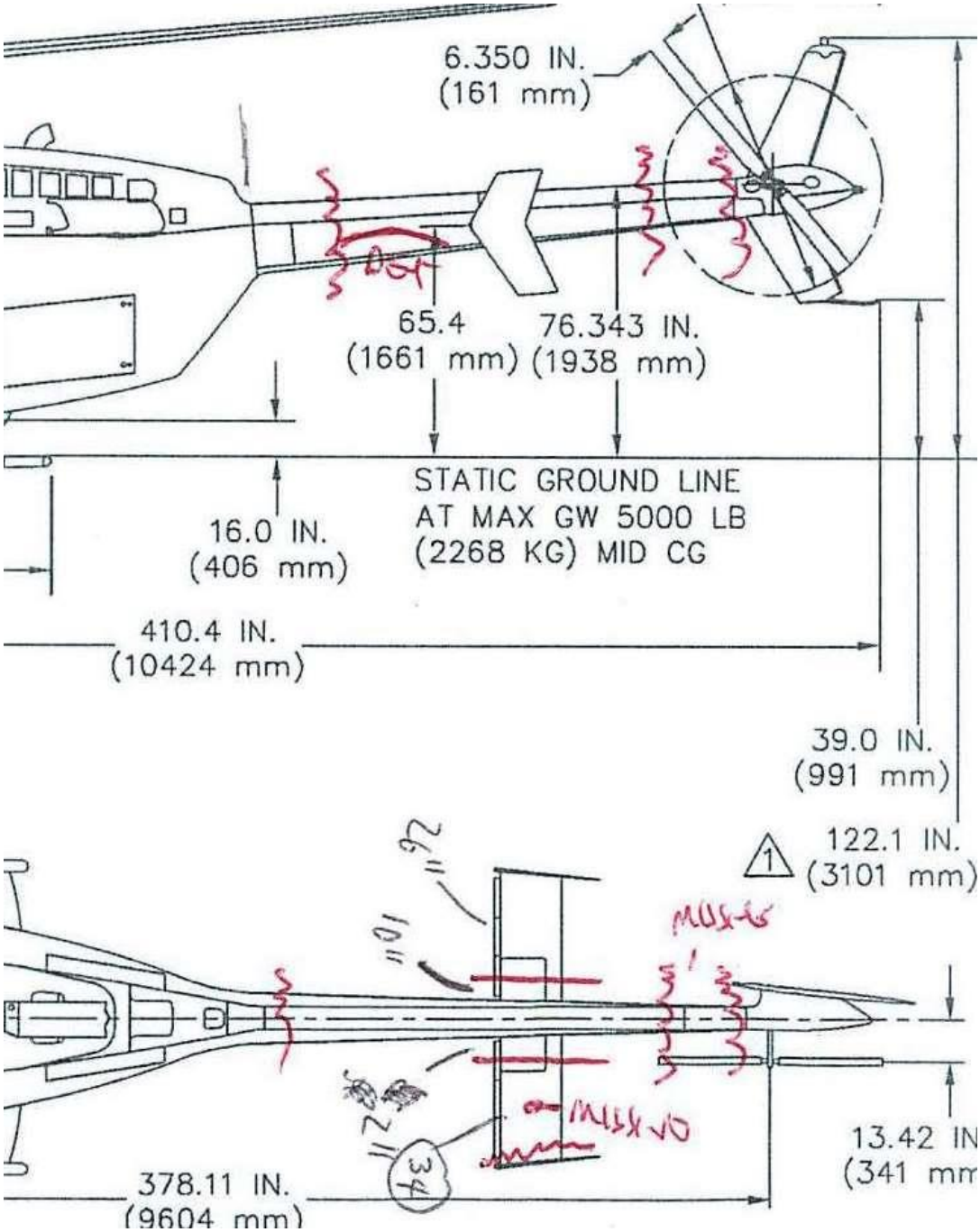


Figure 10 - Annotated Line Drawing Showing Fractures (jagged) and Cuts (straight)

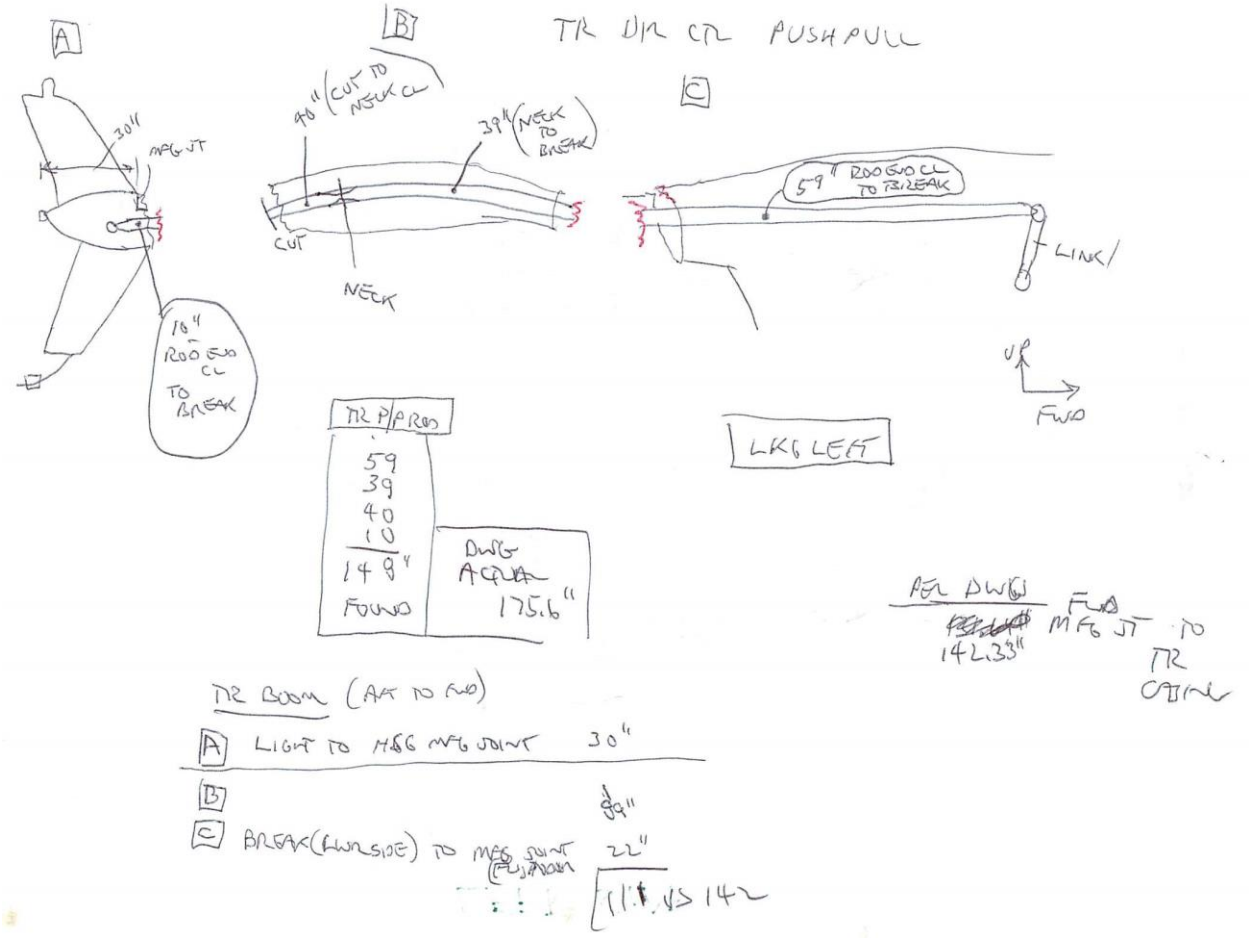


Figure 11 - Hand Sketch of Tailboom Fractures and Dimensions

Figure 12 - Tailboom/Fuselage Fracture (Note TR drive shaft)

Figure 13 - Longest Tailboom Section (Horizontal cut for recovery)

Figure 14 - Empennage with TR

- The empennage (aft) vertical stabilizers exhibited minor damage
- The horizontal stabilizers had been cut from the tail boom for recovery
- The lower RH vertical stabilizer exhibited LE damage
- The upper RH vertical stabilizer exhibited minor LE damage
- The LH vertical stabilizer had fracture separated from the LH horizontal stabilizer, and its upper section exhibited impact damage

No mechanical deficiencies, damage, or failures that could be associated with the pre-impact condition of the airframe were identified.

4.0 Main Rotor System

- The helicopter was equipped with 4 main rotor blades
- The MRB system rotates counterclockwise when viewed from above
- Normal operational rotation speed is constant, at 413 rpm
- All four blades had been fracture-separated from the hub
- The hub remained attached to the transmission & airframe
- Undamaged blade length from centerline of blade attach bolt to tip was 187"
- Undamaged blade length from blade root to tip was ~188.5"
- Control continuity for the cyclic and collective systems was established from the cockpit controls to the MRBs

Blade	**As-Found Length**	**Observations** (measurements from root end of blade fitting, not CL of blade bolt)
Blue Diamond	Spar 188" Leading edge 174"	41" - downward bend in blade 122" - LE crack
Orange Square	Full	48" – LE crack 71" - LE crack 104" - LE full fracture Root fitting cracked
Red Triangle	175"	105" - Crease
Green Circle	Full	110" – Crease 125" - LE fracture LE twisted up Significant vegetation scars/witness marks

Figure 15 - Main Rotor Blades (L to R: Green/circle, Red/triangle, Orange/square, Blue/diamond)

Figure 16 - MRB Hub

Figure 17 – Collective and Cyclic Servo Assembly

5.0 Tail Rotor System

- The helicopter was equipped with 2 tail rotor (TR) blades
- The TR is mounted on the left (port) side of the tail boom, and rotates clockwise when viewed from the left (port) side of the helicopter
- Normal operational rotation speed is constant, approximately 2,500 rpm
- The aft end of the boom (which contained the TR blades) was fracture-separated from the helicopter
- Both blades remained attached to the hub, which remained installed in the boom
- TR part number of installed blades (406-016-100-119) matched Bell specification
- One of the TR 'flapper stops' was missing; its absence was consistent with impact damage
- TR blade damage signatures were consistent with impact, and not consistent with in-flight failure during normal operation

Blade	**As-Found Length**	**Observations** (measurements spanwise from root end of blade)
Green Circle 'A'	Full	18" – LE bend Outboard 9" impact damaged
Orange Square 'B'	Full	11" - LE fracture 18" – Large LE dent Afterbody delaminated along full span

Figure 18 - TR Blade 'A'

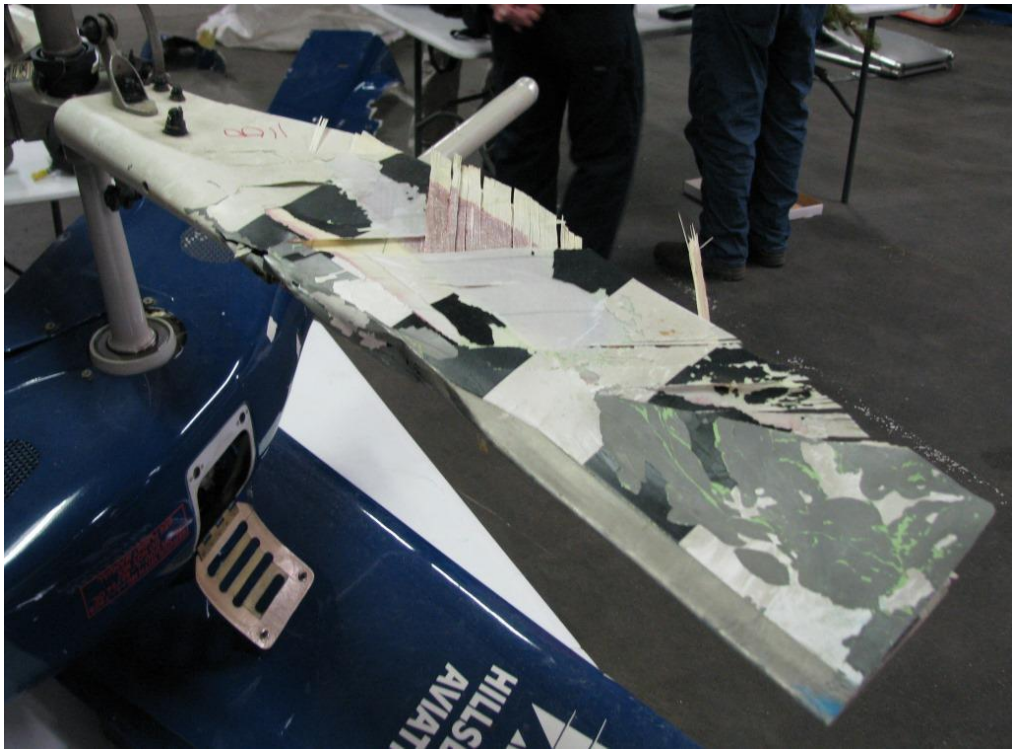


Figure 19 - TR Blade 'B'

- Recovery personnel noted that the TR gearbox had leaked some fluid while on site
- When examined a few weeks after the accident, the gearbox still contained fluid, and there were no indications of fluid leakage while operating
- The magnetic chip detector in the TR gearbox was free of particles
- Aside from damage ascribed to impact, TR drive system integrity was established
    - No indications consistent with a non-impact failure during normal operation (such as shaft flailing or bearing/support deformation) were observed
- The TR assembly was free to rotate in the hub, and corresponding rotation of the driveshaft was observed.
- Control continuity for the TR system was established from the cockpit pedals to the forward break in the tail boom
- Aside from damage ascribed to impact, control continuity for TR system was established from the forward break in the tail boom to the TR
- The TR blade pitch change (control) mechanism was present and continuous from the empennage separation point to the blade assembly
- Both blade links of the pitch change mechanism were bent by impact, but no other abnormalities were observed
- Blade pitch angle range was measured by two different devices, with slightly different results.
    - Electronic protractor yielded 40.6 degrees
    - Mechanical protractor method yielded 41.5 degrees
- Rotation of the driveshaft also rotated the TR assembly

6.0 TR Directional Control Actuator (DCA)

- The TR directional control actuator (DCA) remained installed and appeared undamaged
- Pre-removal visual inspection did not reveal any indications of leakage or other pre-existing anomalies
- The DCA was removed for shipment to the Bell helicopter facility for functional testing and detailed examination
- The DCA tested satisfactorily, and no conditions which could have contributed to a loss of directional control of the helicopter were detected.
- The test details are documented in a separate report

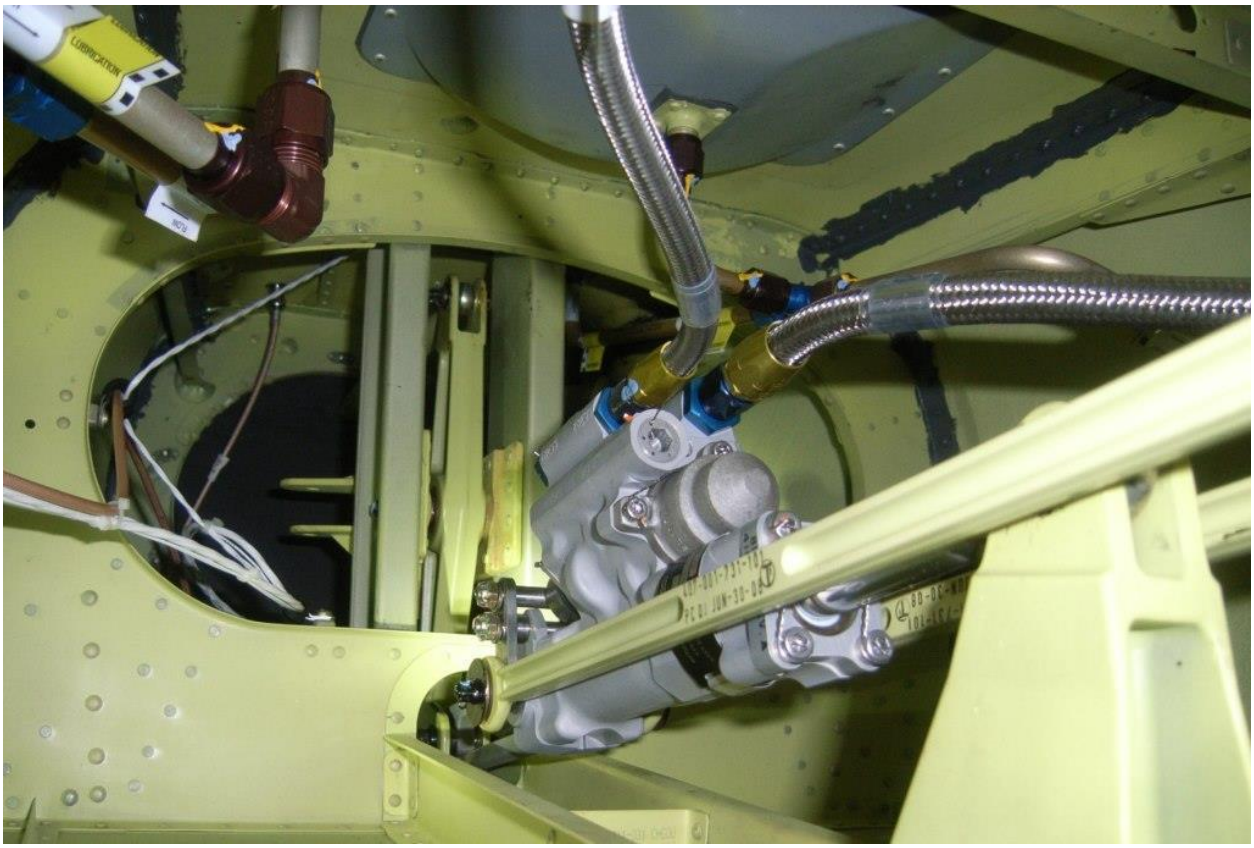


Figure 20 - DCA (installed/as found)

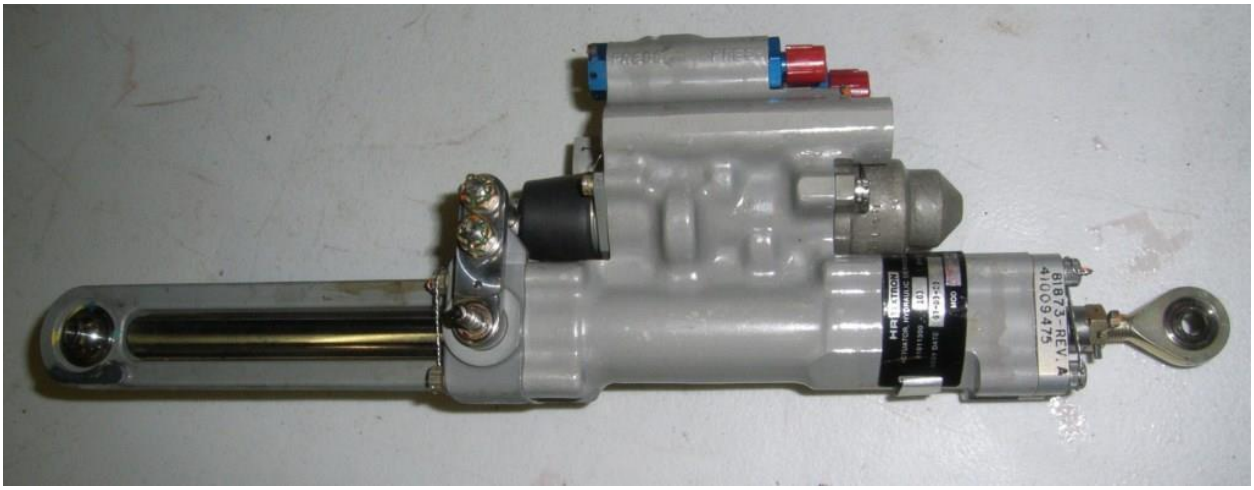


Figure 21 - DCA (Removed for testing)

6.1 Damaged Treetop

- As detailed in a separate report ("Flight and Site Information'), during the recovery process, personnel observed a small tree whose top was damaged. Since the tree was near a trail sign that the helicopter had hovered near in order to read it for orientation, there appeared to be the possibility that the tree had been unknowingly struck by the TR, which could have prompted a subsequent failure of the TR.
- As detailed in the other report, GPS track data confirmed that the helicopter had transited and loitered near the tree and trail sign
- The GPS data showed that the helicopter passed southwest of the tree before proceeding slightly northeast to the sign. The data did not indicate that the helicopter hovered in the immediate vicinity of the tree
- Information from site data and TCSO SAR personnel indicated that the tree was a few hundred feet southwest of the sign, and that the sign was oriented so that its information faced approximately northeast, in a direction away from the tree. In other words, when reading the sign, the sign would be positioned between the reader and the tree.
- The upper 3-4 feet of the tree was sectioned from the tree by recovery personnel and returned with the helicopter wreckage
- The tree (a softwood evergreen) was examined concurrent with the helicopter examination
- The broken branch on the tree was about 3/4 inch in diameter, and the material was soft and flexible
- The break appeared to be either partial, or partially recovered/healed; it was not clean and did not sever/penetrate the majority of the branch
- No other branches were observed to be broken or missing from the recovered sample
- The aggregate evidence was consistent with the branch not being broken by a direct strike by the helicopter or the TR. The evidence was also not consistent with the possibility that the TR was damaged by the subject tree/branch.

Figure 22 - Tree with Broken Branch (6 inch scale on table)

Figure 23 - Closeup of Branch Fracture

7.0 Engine

- The helicopter was equipped with a Rolls Royce (Allison) 250-C47B turboshaft engine
- The engine serial number was CAE 848151
- The engine was removed for examination
- No pre-impact mechanical anomalies or deficiencies that would have precluded normal operation and continued flight were observed
- Extraction of the ECU IR (Incident Recorder) data revealed a total of 15 datapoints, recorded at 1.2 second intervals.
- Examination of ECU IR data recorded during the accident sequence revealed that the engine was responding normally to control inputs
- In addition to IR data, 8 additional "Snapshot" data lines were recorded in a separate file
    - Snapshot data is recorded immediately following an engine exceedance.
    - All snapshot data lines were recorded within the final 3 seconds of the accident flight.
- The ECU data is published under separate cover
- All evidence was consistent with a rapid and catastrophic interruption of power
- Exclusive of impact damage, there was no physical evidence of engine failure or disruption
- All evidence was consistent with normal engine operation until an external event induced the overspeed and shutdown
- Based on the pilot's statement, the ECU data, and the physical evidence of the engine, it was decided that no additional engine examination or testing was warranted, and therefore none was conducted

Figure 24 - Engine Subsequent to Removal

Figure 25 - Engine Control Unit (ECU) Before Removal

E. PERFORMANCE CHART

An Allowable Payload chart was found in the helicopter, in a binder identified as a Teton County SAR (TCSAR) group item. The chart contained two tables, one for "HIGE" (hover in ground effect), and one for "HOGE" (hover out of ground effect). The tables presented the maximum allowable payload (in pounds) as a function of pressure altitude (PA) and ambient temperature. Each table was annotated with the statement "Pilot (180lbs) and Standard Fuel (500lbs) already included in calculation."

The data from this chart was compared to the data from the Bell Flight Manual; the two datasets were consistent. Neither TCSAR nor Hillsboro Aviation personnel knew why the chart was in the binder, and the pilot stated that he used the performance charts in the Flight Manual.

Additional performance information is documented separately.

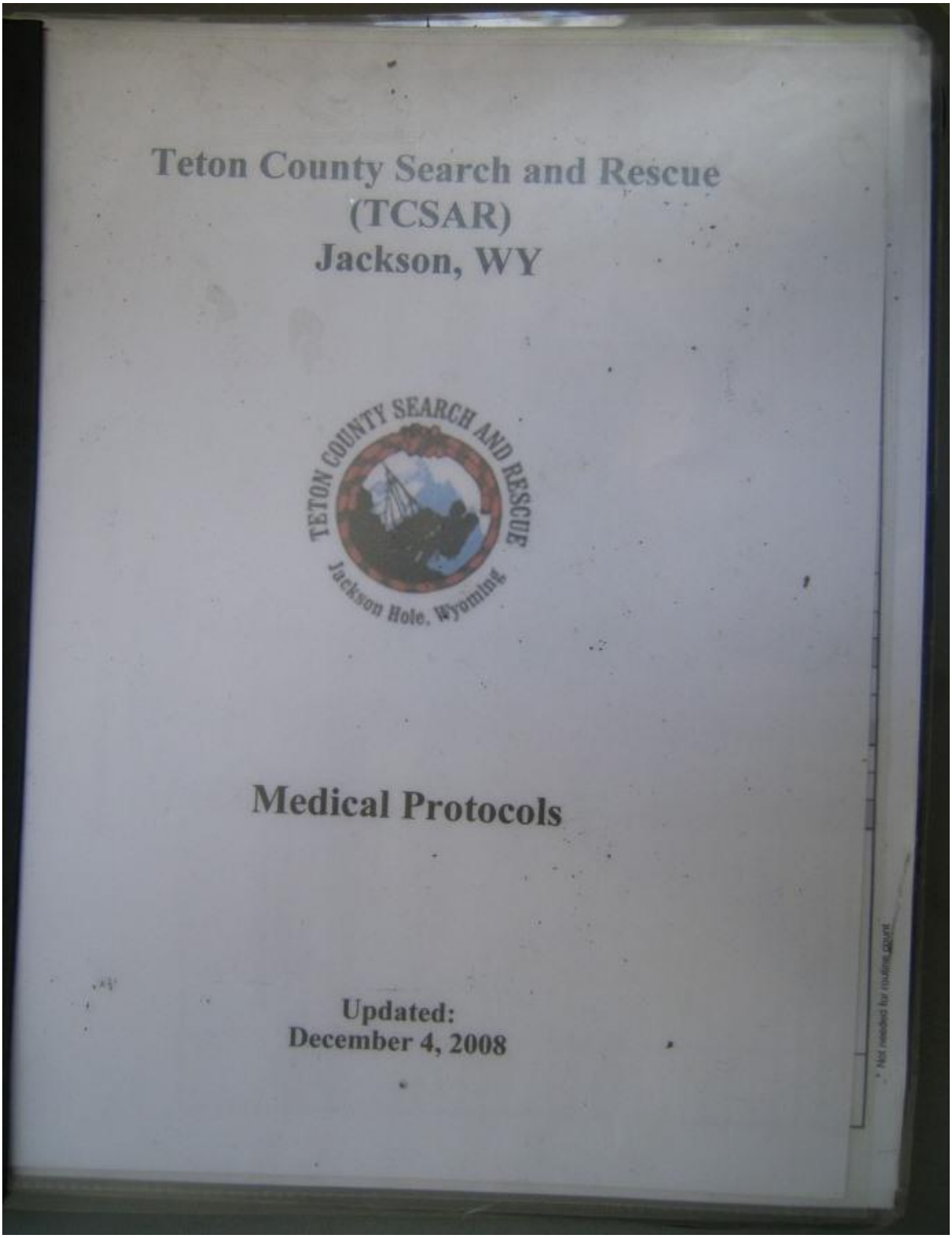
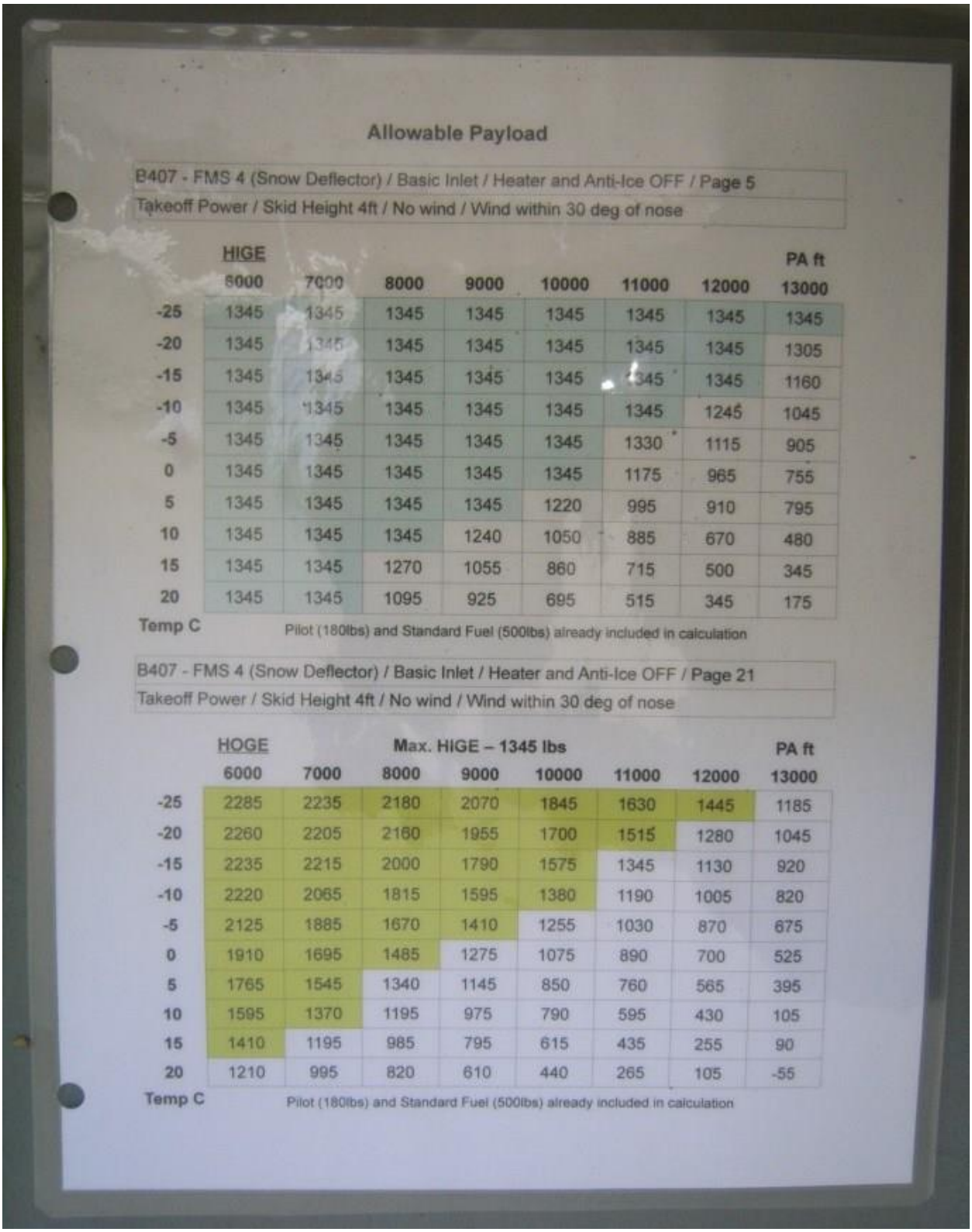


Figure 26 - Binder Cover



Allowable Payload

B407 - FMS 4 (Snow Deflector) / Basic Inlet / Heater and Anti-Ice OFF / Page 5

Takeoff Power / Skid Height 4ft / No wind / Wind within 30 deg of nose

	HIGE							PA ft
	6000	7000	8000	9000	10000	11000	12000	13000
-25	1345	1345	1345	1345	1345	1345	1345	1345
-20	1345	1345	1345	1345	1345	1345	1345	1305
-15	1345	1345	1345	1345	1345	1345	1345	1160
-10	1345	1345	1345	1345	1345	1345	1245	1045
-5	1345	1345	1345	1345	1345	1330	1115	905
0	1345	1345	1345	1345	1345	1175	965	755
5	1345	1345	1345	1345	1220	995	910	795
10	1345	1345	1345	1240	1050	885	670	480
15	1345	1345	1270	1055	860	715	500	345
20	1345	1345	1095	925	695	515	345	175

Temp C

Pilot (180lbs) and Standard Fuel (500lbs) already included in calculation

B407 - FMS 4 (Snow Deflector) / Basic Inlet / Heater and Anti-Ice OFF / Page 21

Takeoff Power / Skid Height 4ft / No wind / Wind within 30 deg of nose

	HOGE		Max. HIGE – 1345 lbs					PA ft
	6000	7000	8000	9000	10000	11000	12000	13000
-25	2285	2235	2180	2070	1845	1630	1445	1185
-20	2260	2205	2160	1955	1700	1515	1280	1045
-15	2235	2215	2000	1790	1575	1345	1130	920
-10	2220	2065	1815	1595	1380	1190	1005	820
-5	2125	1885	1670	1410	1255	1030	870	675
0	1910	1695	1485	1275	1075	890	700	525
5	1765	1545	1340	1145	850	760	565	395
10	1595	1370	1195	975	790	595	430	105
15	1410	1195	985	795	615	435	255	90
20	1210	995	820	610	440	265	105	-55

Temp C

Pilot (180lbs) and Standard Fuel (500lbs) already included in calculation

Figure 27 - Payload Chart from Binder