NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Western Pacific Region

AIRFRAME AND ENGINE EXAMINATION

NTSB Accident: WPR11GA115
Accident Date: January 31, 2011

Examination Dates
On-Scene: February 1, 2011
Salvage Facility: February 3-4, 2011

This document contains 18 embedded photographs

A. ACCIDENT

Location: Marana, AZ
Date: January 31, 2011
Aircraft: McDonnell Douglas 369FF, N530RL, Serial # 0602FF
NTSB IIC: Michael Huhn

B. EXAMINATION PARTICIPANTS:

AGENCY	PARTICIPANT	ON-SCENE	SALVAGE FACILITY
NTSB Gardena, CA	Michael Huhn	Yes	Yes
FAA Scottsdale, AZ	Ken Fenning	Yes	Yes
PCSD Tucson, AZ	Ted Hartenstein	Yes	Yes
	Mike Grider	Yes	No
	Ryan Roher	Yes	No
PCSD SAR Tucson, AZ	George Economidis	Yes	No
	Steve West	Yes	No
	J.M. Ramirez	Yes	No
MDHI Mesa, AZ	John Hobby MDHI	Yes	Yes
Rolls Royce Indianapolis, IN	David Riser	No	Yes
Boeing Helicopter Mesa, AZ	John Daum	No	Yes

C. SUMMARY

The wreckage was examined in-situ on the mountain on February 1, the day after the accident. The helicopter was removed from the mountain in the afternoon of February 1. No significant changes to the wreckage (such as cutting/separating) were made to enable the recovery and transport to the salvage facility in Phoenix. The wreckage was examined in Phoenix on February 3 and 4. The engine was successfully run in a test fixture on February 7. A follow-up trip to the accident site was conducted on March 8, 2011 to further document the site and recover additional components. No evidence of any pre-existing mechanical defects or malfunctions was noted during the examinations of the recovered airframe and engine.

D. IN-SITU EXAMINATION

1.0 General

- The flight mission was to scout terrain for situating a Pima County communications radio tower
- Time of accident approximately 1120 MST January 31, 2011
- Wreckage secured by military personnel to prevent downhill movement
- 2 PCSD Swat team members remained overnight with wreckage
- According to 1 passenger, landing was attempted on top of hill
- According to PCSD personnel, this helicopter was flown from L seat
- LZ and initial impact location: 32º 21' 06.27" N 111º 28' 20.41" W
- Wreckage approximately 115 feet down 100 ft wide canyon from LZ at top of hill
- Accident site elevation 3595'
- Damage patterns consistent with low speed impact (in horizontal and vertical planes)
- No obvious damage to vegetation or ground scarring from accident aircraft noted
- Aircraft debris field fairly contained (except for MR and TR blade fragments)
- Steel wire noted above crash site, no fresh cuts or other helicopter-related damage noted
- Some debris & ground scars on top of hill
  - Main rotor blade fragments
  - 1 red woven weighted bag with clip
  - 2 MRB fragments ~400' ~S from LZ/canyon top
    - 32º 21.027' N 111º 28.328' W (small)
    - 32º 21.025' N 111º 28.303' W (bigger, station ~124 - ~150)
  - Uprooted bush near south end (left rear quarter) of LZ
  - 2-3 bushes w separated branches
  - Disturbed rock blocks (~2 ft in diameter)
    - These were at top/edge of canyon
    - Large MRB section wedged in these rocks
- Main wreckage consisted of 2 primary segments
  - Cabin/engine/portion of tail boom
    - Lying on L side
    - Hub/nose pointing up-canyon (longitudinal axis ~45 degs to canyon axis, approximately NW heading)
    - Most canopy transparencies fragmented/absent
    - 2 forward doors separated from fuselage (possibly due to rescue)
  - Remainder of tail boom
    - H stab & V stab
    - TR gearbox
    - TR (inboard ~12" only, each blade - 2 total)
    - Tail boom upright and on bottom side (downhill) of cabin
- Wreckage on slope
  - Landing skids mostly fracture-separated from fuselage
  - 3' segment of TR drive shaft
  - Various cockpit/cabin items

2.0 Cabin/Fuselage

2.1 General

The main wreckage was located on Waterman Peak, in a canyon below a pinnacle. Debris was found on top of the pinnacle, and also distributed in the canyon both above and below the main wreckage. The fuselage was on its left side, oriented approximately transversely across the canyon. The front canopy and frame was fracture-separated from the fuselage. Fuel was in the tank, with no evidence of fuel spillage. The quantity of fuel was not determined.

- RFF personnel reportedly used main battery quick disconnect to de-power helicopter
- RFF personnel cut at least 1 wire bundle

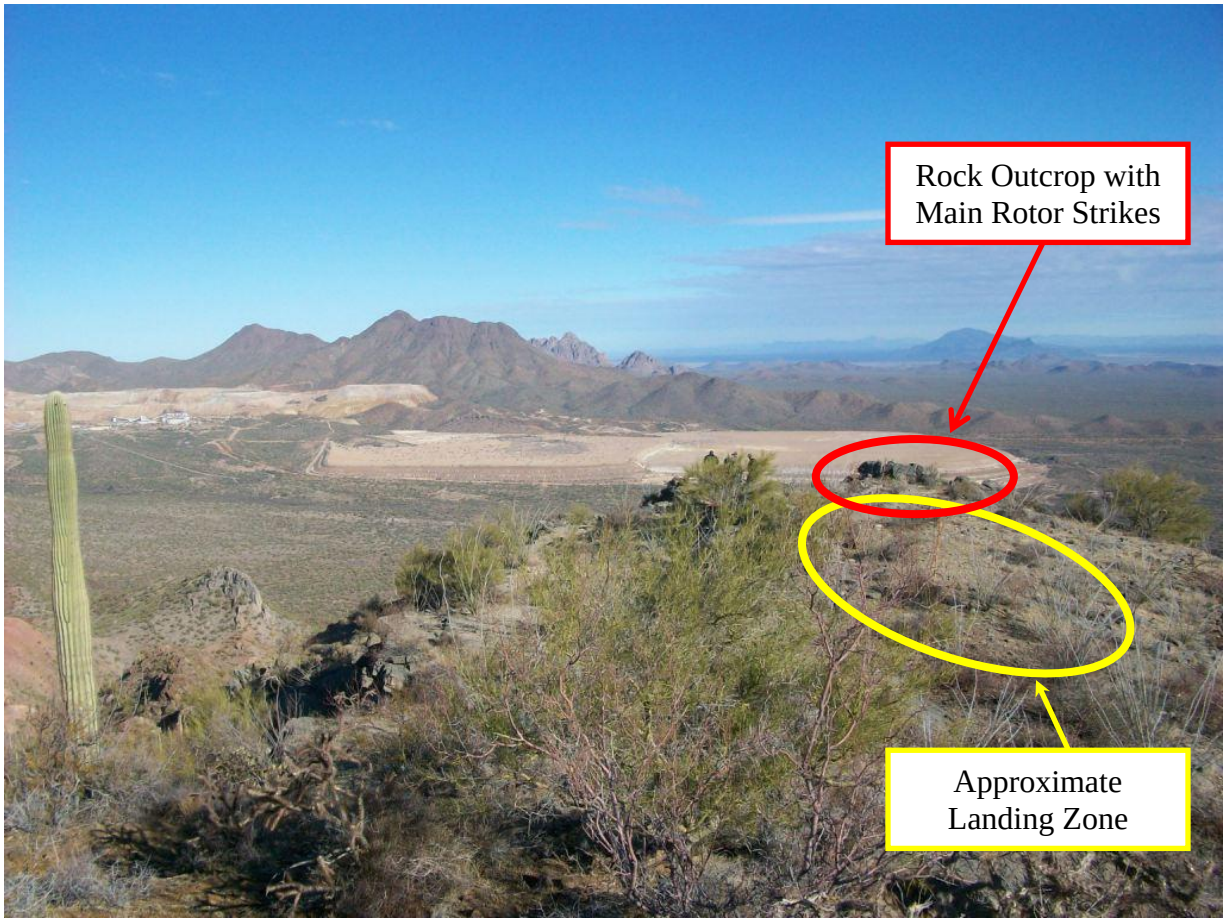

Figure 1- View of Landing Zone Looking Northwest (FAA photo)

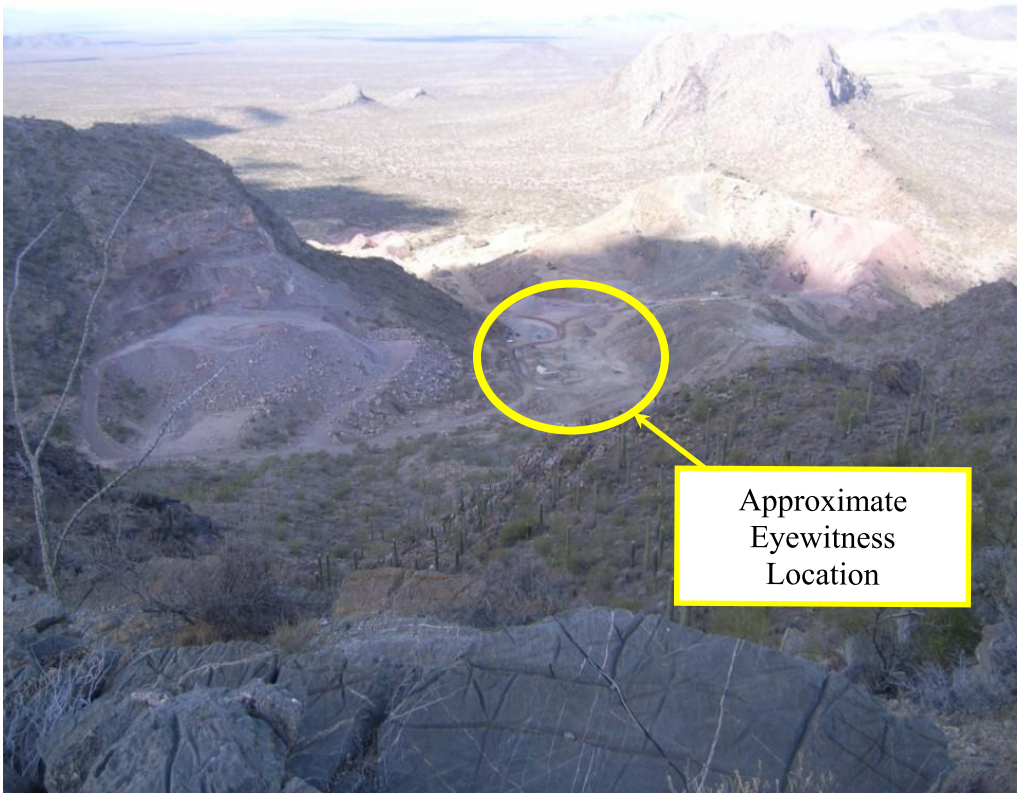

Figure 2 - View of Eyewitness' Location from Landing Zone

Figure 3 - Uprooted Bush Near South End of Landing Zone

Figure 4 - Rock Outcrop and Main Rotor Blade Fragment

Figure 5 - View from Landing Zone Down to Wreckage (with Main Rotor Blade Fragment in Rock)

Figure 6 – Downslope View of Main Wreckage (note line securing wreckage)

Figure 7 - Bottom View of Wreckage In Situ

Figure 8 - Looking Upslope at Main Wreckage

2.2 Avionics, etc

- The instrument panel was fracture-separated from its fuselage mounts.
- ELT (Ameriking AK-450, TSO-91a, 121.5Mhz) installed, connected, armed, red light blinking - NTSB shut off & disconnected antenna
- Hobbs 519.0
- GPS, Garmin 530
- No flight follow/tracking system installed
- No TAWS system installed
- Passenger video camera in use during flight

Figure 9 - Two-Segment Instrument Panel Outside Helicopter

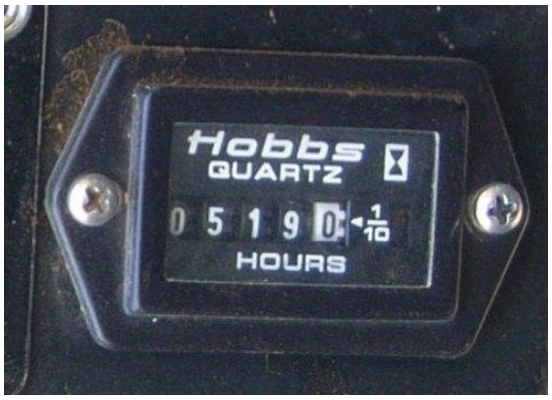

Figure 10 - Hobbs Hour Meter

2.3 Landing Gear

- Both landing gear struts were separated or fractured at the fuselage

2.4 Tail Boom

The tail boom was separated from the fuselage approximately 5 feet forward of the aft end of the boom, and was situated along the right side of the fuselage. The vertical and horizontal stabilizers remained attached to the tail boom. The tail stinger was not bent,

- Engine/transmission mast in normal location/position
    - Relatively intact
- Rotation of MR hub resulted in rotation of TR drive shaft
- Movement of pilots cyclic in 2 perpendicular axes (lateral and longitudinal) resulted in corresponding motion of swash plate
- Movement of passengers anti-torque pedals produced movement in pushrod at tail boom fracture
- There was no evidence of main rotor blade contact with the tail boom or the upper surface of the dog house.

Figure 11 - Tail Boom and Tail Rotor In-Situ

3.0 Flight Controls

3.1 Main Rotor

- All 5 MRBs fracture-separated from hub
    - 4 actuator/dampers separated from hub
    - 1 remained partially attached to hub
- Cyclic controls, continuity good

- Collective controls, continuity validated, throttle in ground idle as observed, collective pulled up as observed
- Swash plate assemblies appear intact as far as continuity and hardware attachment, move with collective and cyclic inputs
- M/R gearbox free to rotate, N2 appeared OK; must verify

The helicopter was left-hand command with dual controls, except that the right pedal foot rests were not installed. The collective was found in the full up position and the left cyclic was fractured at the cyclic socket base. Flight control continuity was verified for the collective and cyclic controls. The control rods and links up to the stationary swash plate appeared undamaged. The main rotor hub had extensive damage, with all 5 pitch housings and blade retention straps fractured at the hub base. Except for one pitch housing, all were separated from the hub. The main rotor blades were attached to the separated pitch housings, and were highly fragmented. Blade tip sections, pieces of the blade tip skin, and tip weights were found on top of the pinnacle with contact scars on the rock outcrop. A long section of one main rotor blade section was stuck into the rock outcrop. The other blades sections were scattered on top of the pinnacle and in the canyon above the wreckage. The blade tip sections that were recovered showed deep abrasion marks to the lower blade surfaces. The two rock outcrops that were on either side of the pinnacle bore metal and other contact scars.

Figure 12 - Main Rotor Hub

Figure 13 - Segment of Main Rotor Blade with Chordwise Scoring

Figure 14 - Additional Main Rotor Blade Fragment

3.2 Tail Rotor

- T/R pedal, right side continuity validated, left side interconnect tube severed
- T/R gearbox free to rotate
- T/R drive shaft- no torsional failure noted
- Movement of plate/linkage at TR hub produced movement of pushrod at forward end of tailboom section
- Rotation of TR produced rotation of TR drive shaft in boom

- TR drive shaft fractures did not appear to be torsional
- Outboard segments of 2 TR blades not yet located

Both tail rotor blades were damaged. Several inches of each blade were fracture-separated, and the remaining blade segment ends had rotational abrasion damage. The tail rotor drive shaft was fractured into three sections. The tail rotor drive shaft and control rod fracture locations coincided with the tail boom fracture locations. The tail rotor gearbox, swash plate, pitch links, fork, and hub rotated freely, and had no visible damage. The pilot's tail rotor pedal bracket was fractured, consistent with the damage to the lower fuselage, instrument panel and front canopy damage. Pedal control continuity was verified from the right tail rotor pedals aft to the tail boom separation, and from that separation point to the tail rotor blades.

Figure 15 - Tail Rotor (Note missing ends)

4.0 Engine and Drive System

The engine remained attached and secure in its mounts in the aft section of the fuselage. Terrain, damage, and personnel considerations precluded detailed examination of the engine until the wreckage was transported to Phoenix. The engine appeared undamaged except for the exhaust stack, the right side of the burner can, and the right air tube. The fuel control arm was near the full open position. The N2 section could be rotated freely and the

overrunning clutch engaged properly when the main rotor hub was rotated backwards. The main and tail rotor transmissions rotated freely.

E. SALVAGE FACILITY EXAMINATION

1.0 Cabin/Fuselage

1.1 General

The front canopy frame and transparencies were extensively fractured. The instrument panel was fracture-separated from its pedestal mounts. The forward fuselage structure, cockpit floor, fuselage station (FS) 44.65 bulkhead and lower skins were severely crushed and deformed. The external fuselage skins and door frames were dented, crushed and deformed. The rear cabin A-frame structure and interior cabin appeared relatively undamaged.

- No significant changes were made to the wreckage for/during transport off mountain
- Forward fuselage above floor level (which was very light structure) was almost completely separated from body- due to impact and also rescue/recovery
- Aft passenger cabin volume remained uncompromised
- All 4 cabin doors either fracture-separated or detached for transport
- All 4 doors were located and recovered
- All 3 hard points for external mounting of mission equipment were installed, but external mission equipment was not installed for accident flight
    - Associated FLIR/Nightsun equipment was not installed in place of aft seats (due to passenger carriage)

Figure 16 - Fuselage Immediately After Recovery from Mountain (MDHI photo)

1.2 Seats

The crew and passenger seats were mesh-type seats. The front bottom mesh seat frames were bent and distorted. There was no noted deformation of the left or right seat box structure. The rear bench seat appeared undamaged. All seat belts and inertia reels were checked and functioned normally.

- Front seat had 4 point harnesses- still operational, not cut for rescue
- Aft seats had 3 point harnesses- still operational, not cut for rescue
- Front seat bottom forward legs were deformed/fractured (no aft legs; affix directly to structure)
- Aft seats intact

1.3 Landing Gear

The right landing gear was torn from the front and aft damper attachment points, and the drag braces were fractured near their fuselage attach points. The right skid tube was fractured just aft of the forward landing gear foot. The left aft landing gear was torn from the aft damper attachment points and the drag brace was fractured near the fuselage attach. The left forward strut and brace were fractured but not separated from the fuselage. The forward struts were separated at the foot attach points, and the skid tube was fractured at the forward foot attachment area. Landing gear skids/struts did not show damage consistent with high-G vertical impact; all damage was consistent with impact loads from other directions

1.4 Tail Boom

- The vertical stabilizer, horizontal stabilizer, tail rotor assembly and gearbox were attached to the aft section of the tail boom.
- Tail Boom fracture- separated at approximately FS 218, 5 feet forward of end of boom (add 11" to TR axis; i.e.5'11" from TR axis to fracture plane)
- TR drive shaft and TR control rod also fractured at same location
- Horizontal and vertical stab, plus two HS endplates attached; moderate impact damage & fractures to all components
- TB fracture not consistent with MRB strike
- TB had 20 deg twist at approximately station 257
    - Twist direction: aft segment CCW wrt forward section when looking forward
    - Twist direction: Bottom of Vstab moved to right/starboard
- Longitudinal dent (approximately 1" x 2") on L side of stinger

2.0 Flight Controls

The helicopter was configured with dual controls and left hand command. Dual controls were installed except that the foot rests for the right tail rotor controls were not installed. Flight control continuity was verified for the cyclic and collective control system. The cyclic longitudinal and lateral trim actuators appeared to be near the neutral position. Breaks in the

tail rotor control rod coincided with damage locations in the tailboom. All fractures of the flight control system were consistent with damage during the accident sequence

- Pilot's collective and cyclic sticks were fracture-separated at their respective bases
- Passengers collective and cyclic installed but undamaged
- Collective and cyclic continuity (stop to stop) re-verified (originally verified on mountain)
- Collective and cyclic trims intact/functional
- Instrument panel/pedestal removed at accident site (likely for rescue but also partially impact-damaged)
- Lateral and longitudinal cyclic trim actuators evenly extended

2.1 Main Rotor Blades

The five main rotor blades were separated from main rotor hub. The strap packs, main rotor dampers and main rotor blades exhibited multiple fractures consistent with impact while being rotationally driven. Two of the main rotor static mast legs were found fractured. The outboard sections of the main rotor blades were highly fragmented, with deep chordwise scratches. There were contact marks on the rock outcrop at the top of the canyon, and one main rotor blade remained lodged in the rock outcrop. Sections of the main rotor blades were found in the canyon, and above the canyon on the pinnacle.

- 5-blade main rotor (highly fragmented)
- MRB hub and mast remained affixed to body of helicopter
- Two (Aft right and forward left) of 4 legs of mast base "star" fitting were fractured completely through
- Rotor blade components gathered and laid out for exam
- Arrangement as laid out on flatbed when viewed from forward end of trailer, from left to right:
    - Green, White, Blue, Red, Yellow

Blade	SN	Remarks	Near-Root Fracture+	Outboard Fracture+	Probable Outboard Segment
White*	6084T600	Root sept'd from hub	LE: 18 TE: 18	LE: 92 TE: 84 (station 101)	
Blue	6084T598	Root sept'd from hub	LE: 13 TE: 13	LE: 102 TE: 102 (station 119)	Probably Segment 'A' (below)
Yellow	6084T599	Root sept'd from hub	None	LE: 99 TE: 83 (station 100)	Probably Segment 'B' (below)
Green	6084T597	Root remained attached to hub by 'TT' straps	LE: 11 TE: 11	LE: 29 OB of station 130 TE: 20 OB of station 130	
Red	6084T601	Root sept'd from hub	LE: 13 TE: 13	LE: 110 TE: 97 (station 114) This component retrieved by PCSD SAR 2/3/11	

*In sequence clockwise looking down on hub
+ As measured from center of main bolt through blade and hub, in inches

Rotor rotates CCW looking down
All blades PN 369D21121-503
Station 99 is 81" OB of Blade Bolt

Free segments, NOT positively associated with any specific blades

Item	Blade Association	Inboard Fracture	Outboard Fracture
A	Probably NOT: Green, White Red Yellow	LE: 2" OB of station 124 TE: 1" IB of station 124	LE: 12"OB of station 148 TE: 5" OB of station 148
B	Probably NOT Red, Probably Yellow	LE:12" IB of station 124 TE: 5" IB of station 124	LE: 11"OB of station 130 TE: 11"OB of station 130

- Only 2 tips located but 3 total tip weights recovered
- Heaviest blade scoring (consistent with rock impact) observed on Green and White blades at outboard fracture ends
- Also scoring on two small, free segments
- Dampers;
    - Partially attached to blade: Yellow, Blue
    - Completely fracture-separated from blade: Red, White, Green

Figure 17 – 2-D Layout of Main Rotor Blades (Green, White, Blue, Red, Yellow)

Figure 18 – 2-D Layout of Main Rotor Blades (Yellow, Red, Blue, White, Green)

2.2 Tail Rotor Blades and Gearbox

- 2 blade tail rotor
- Rotor/Gearbox mounted on aft end of boom, extends out L side of boom
- Blades attached to hub/gearbox
- Free to rotate and change pitch; corresponding motion observed in TR drive shaft and control link
- Linkage continuous from pushrod (fractured at tail boom fracture location) to rotors

Blade	Span*	Bend	Twist
A	23 inches	10º aircraft left at 15" (16.5") span	LE slightly twisted aircraft left as move spanwise outboard
B	26 inches	5º aircraft right at 14" (15.5") span	No noticeable twist

*Span measured from blade root shank (colored red) to fracture; a silver-colored hub measured 3" in diameter (Therefore add 1.5 " to get blade span from axis of rotation)

TR drive shaft fracture-separated into 3 pieces

Part	Length	Remarks
A (aft-most)	32"	Slight rotational scoring; possibly from on-site control continuity motions
B	35"	
C (forward-most)	100"	Heavy rotational scoring at 5, 7.5 and 8.5 inches from aft fracture. Two bearings approximately 2" wide at 20 and 80.5 inches from aft fracture

On March 8, 2011, personnel from the FAA and MDHI returned to the accident site to further document and attempt to recover additional components. Those efforts were documented under separate cover, which can be found in the accident docket.

2.3 Anti-Torque Pedal Assemblies

- Passenger's (right) side
  - Pedals not installed; assembly intact
  - Anti-torque continuity from cockpit to tail boom break re-verified (originally verified on mountain)
- Pilot's (left) side
  - Pedal assembly partially fracture-separated from bulkhead
  - Both pedal shafts fracture-separated from assembly
  - Torque tube had some bending and crippling/crumpling
  - Transverse torque tub fracture-separated inside fitting for link (at through-bolt hole)
    - No obvious fatigue fracture
    - Consistent with overload
    - Some smearing observed on fracture face
    - Entire assembly (5 parts total) provided to FAA for exam by Boeing helicopter (to characterize fracture face)
    - Laboratory analysis of the fractures determined the fracture mode to be overload.

2.4 Main Transmission and Drive System

The main rotor transmission assembly rotated freely when the main rotor hub was rotated. The tail rotor transmission rotated freely. The engine to transmission driveshaft and oil cooler blower appeared undamaged, except that the oil cooler blower drive belt was broken. The main rotor driveshaft was removed and the alignment line inspected; it was found to be slightly misaligned. Correct operation of the overrunning clutch was verified. The main and tail rotor transmissions contained appropriate amounts of oil, and the chip detectors did not contain any metallic chips. The tail rotor drive shaft was fractured in two places. None of the fractures were consistent with torsional loading, and the break locations corresponded to the tail boom damage locations.

- Main Rotor Drive Shaft

- Slight twist observed
- Twist direction: Lower end CW when viewed from bottom
- Twist amount: 1/4" along a length of 24"

3.0 Engine Information

3.1 General

The aircraft was equipped with a Rolls-Royce 250-C30 turbo shaft engine, SN: CAE-900098. Except for the outer combustion case and right air tube being dented and crushed, the engine appeared undamaged. The engine was removed from the helicopter for examination and testing. The engine was run in a test cell at AeroMaritime, Mesa, AZ. All functional and power performance requirements were met during the test cell run.

- Right engine cowl door detached during accident sequence
- STC air filter removed /examined- Moderately full of debris but attributed to accident location/conditions/circumstances
- Engine removed by lifting fuselage off engine
- Engine relatively undamaged- some crush damage to the outer combustion case (OCC)

Refer to the Rolls-Royce engine investigation report for detailed information.

3.2 Engine Controls

- Throttle & governor linkage continuity verified

3.3 Fuel Information

There was no evidence of fuel leakage at the accident site. The helicopter was last refueled on 1/28/2011 with 31 gallons. The fuel truck driver reported that this topped of the main tank. No fuel was put in the aux tank. After the accident the fuel sample was taken from the fuel truck and tested. The test results determined the fuel met the specifications for aviation turbine fuels.