Date of Accident: October 3, 2019

Location: Capital Region International Airport (KLAN)
Lansing, MI

NTSB File No.: CEN20FA001

Aircraft: TBM700C2

Registration No.: N700AQ

Serial No.: 252 (Year of Manufacture 2003)

Owner/Operator: N700AQ LLC
965 Airport Access Dr.
Greenwood, IN 46143-1083

Written by: Les Doud
Air Safety Investigator

Report Date: October 5, 2019

Contents:

ACCIDENT SYNOPSIS

The following are excerpts from the NTSB Preliminary Report:

"On October 3, 2019, about 0858 eastern daylight time, a Socata TBM 700 airplane, N700AQ, collided with terrain while on an instrument approach to Capital Region International Airport (LAN), Lansing, Michigan. The commercial pilot, pilot-rated passenger, and 3 passengers were fatally injured. The remaining passenger sustained serious injuries. The airplane was substantially damaged. The airplane was owned by N700AQ LLC and operated under Title 14 *Code of Federal Regulations* (CFR) Part 91 on an instrument flight rules (IFR) flight plan. Day instrument meteorological conditions prevailed at the accident site. The cross-country business flight departed Indy South Greenwood Airport (HFY), Greenwood, Indiana, at 0800.

According to ATC communications, the pilot was provided radar vectors to join the localizer for the instrument landing system (ILS) runway 10R approach at LAN. At 0853:03, the approach controller stated, "TBM zero alpha quebec, five miles from FAMLI, turn right, ah, right heading zero seven zero, maintain three thousand until established on the localizer, cleared the ILS one zero right." The pilot responded, "Zero seven zero, ah, we're cleared for the ILS ten right into, ah, Lansing." The ADS-B data indicated the airplane entered a right turn and joined the localizer inbound.

The ADS-B data indicated that at 0857:06 the airplane was about 1.3 miles from the runway threshold at 1,250 ft msl (about 400 ft above the runway elevation) and established on the localizer inbound to the runway. At 0857:37, the airplane was 0.5 mile from the runway threshold at 1,041 ft msl (about 180 ft above the runway elevation) when it entered a shallow climb and a left turn away from the runway heading. When the left turn began, the airplane had decelerated to 72 knots. Between 0857:37 and 0857:45, the airplane continued to decelerate to 64 knots while it climbed to 1,059 ft. At 0857:45, the final ADS-B datapoint was located about 300 ft north of the localizer centerline and 0.36 miles from the runway 10R threshold. The final ADS-B datapoint was about 480 ft southwest of the initial impact point with terrain.

According to the current weight-and-balance record, dated May 24, 2017, the airplane had an empty weight of 4,674.28 lbs and a useful load of 2,719.92 lbs. The empty weight center-of-gravity (CG) was 187.17 inches aft of the datum. At maximum takeoff weight, 7,394 lbs, the forward and aft CG limits were 187 inches and 193.65 inches, respectively.
The airplane's weight and balance at takeoff were calculated using the reported weights and seat positions for the pilot and the 5 passengers, fueling receipts/invoices, and recent flight tracking data. Based on the available data, the takeoff weight and CG location were estimated to be 7,626.28 lbs and 196.18 inches, respectively. At takeoff, the airplane was about 232 lbs over the maximum allowable takeoff weight and about 2.53 inches past the aft CG limit. The engine burned about 70 gallons (476 lbs) of fuel during the flight. The estimated airplane weight and CG location at the time of impact were 7,150.28 lbs and 196.60 inches, respectively. At impact, the airplane was about 126 lbs over the maximum allowable landing weight and 2.95 inches past the aft CG limit."

The propeller in-situ at the crash scene is shown in Photo #1.

Aircraft Damage:	Destroyed
Injuries:	Six persons on board, Five fatal, one critical

Photo #1 – Propeller in-situ with main wreckage (Photo provided by NTSB)

SUMMARY AND ANALYSIS OF FINDINGS

The accident propeller was recovered from the main wreckage site to the Airport Operations Facility of the Capital Region International Airport for examination. The propeller was disassembled on October 5, 2019 to evaluate the condition of components and assess damage in an effort to determine functionality, and estimate engine power at time of impact.

All blade damage indicated propeller impact forces with terrain were in the lead-to-trail direction with blade angle in the normal range of operation. Chordwise/rotational scoring and abrasion on the camber and face side, leading edge gouges, blade-to-hub impact marks in the lead-to-trail direction and compound bending and twisting all indicated rotation under power. Rotational scoring on the spinner dome also suggested rotation at impact. Blade bending in the forward direction, leading edge gouge deformation toward high pitch, and face side scoring all suggest zero-to-positive blade section impact angles and therefore rotation under power and generating some amount of thrust.

A counterweight impression in the spinner dome adjacent to the #3 blade at 44° is equivalent to a blade angle of approximately 31°. A pitch change knob mark on preload plate #3 at 8° is also equivalent to a blade angle of approximately 31.5°. A fork bumper impact mark on preload plate #1 at 27° is equivalent to a blade angle of approximately 16-17.5° which is approximately near the running flight idle blade angle hydraulic stop.

There were pitch change knob impact marks on preload plates #1, #3 and #4 at 50-51° which are equivalent to a blade angle of approximately -8°, or approximately near the mechanical reverse stop. Blade damage suggested these marks were post-impact/impact sequence marks after forceful rotation/twisting towards low pitch.

Basic estimates of propeller thrust required (F_n) during the aircraft's final approach were calculated using the available ADS-B data and the following equation:

$$F_n - D - W \sin \gamma = \frac{W}{g}\frac{dV}{dt}$$

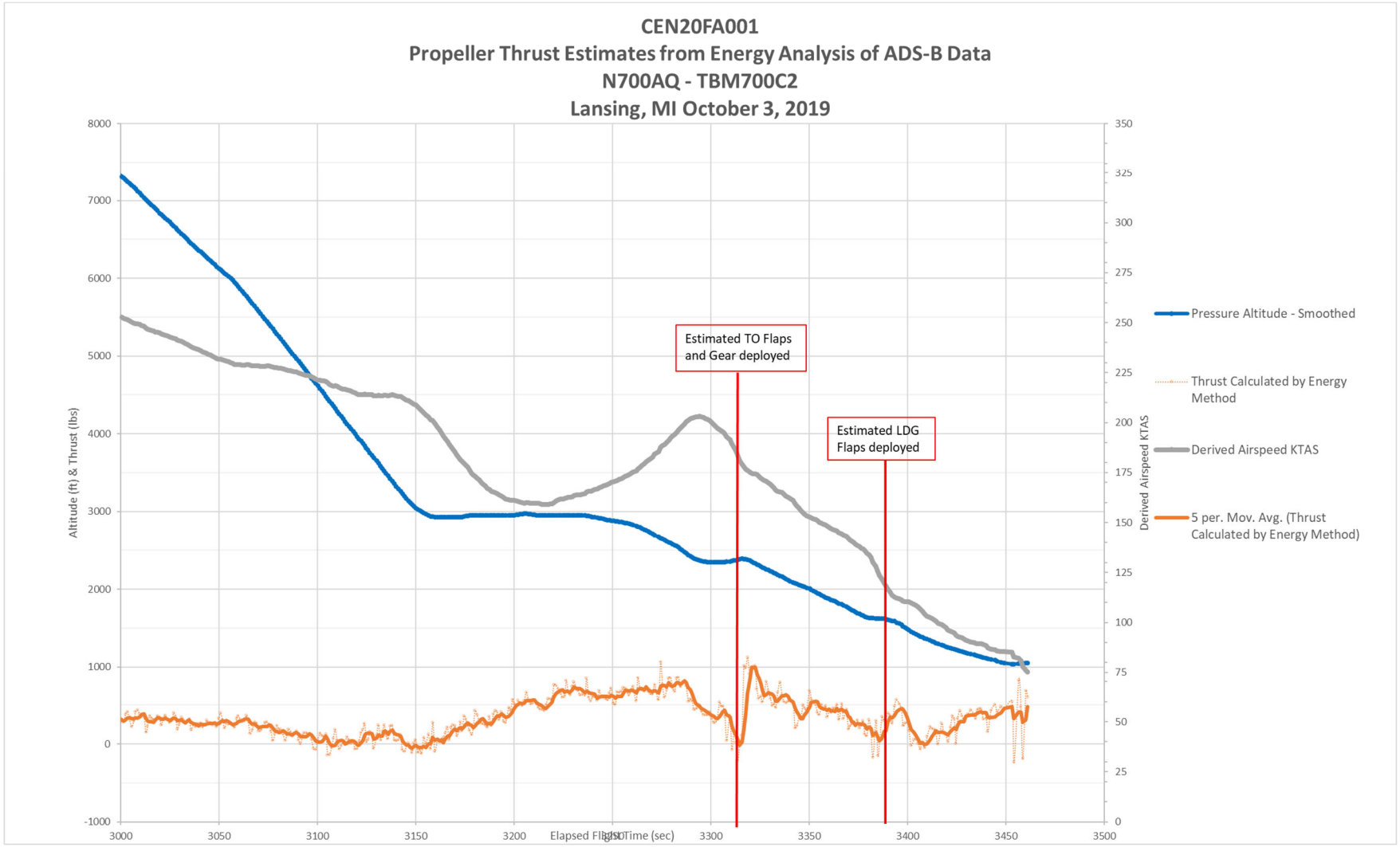
Aircraft weight (W) determined from aircraft records, passenger weights provided by NTSB and estimated fuel load at the time of impact was estimated to be 7150 lbs. Flight path angle (γ), and acceleration (dV/dt) was calculated using ADS-B data provided by NTSB. Airframe drag (D) was calculated using airframe drag coefficient estimates obtained during unrelated TBM700 flight tests at Hartzell Propeller.

The estimated propeller thrust required during the final approach is shown in Figure 1. The estimates suggest the powerplant was running, capable of generating thrust, responding to airframe configuration changes/power lever inputs necessary to maintain the approach path until the accident sequence began. The average estimated propeller thrust over the final 11 recorded ADS-B data points was 412 lbs. The average flight condition during those final recorded data points was approximately 1050 ft. Pressure Altitude and 82 KTAS. Assuming a propeller RPM of 2000, the power required to generate 412 lbs. of thrust at that flight condition is approximately 170 Hp (24% torque) at approximately a 15.6° blade angle.

CONCLUSIONS

There were no discrepancies noted that would prevent or degrade normal propeller operation prior to impact with terrain. All damage was consistent with high impact forces. Damage indicated blade angle at time of impact was in the normal range of operation with power ON.

Figure 1 – Estimate of Propeller Thrust Required



Date of Inspection: October 5, 2019

Location: Airport Operations Facility - Capital Region International Airport
4100 Capital City Blvd.
Lansing, MI 48906

Representatives:

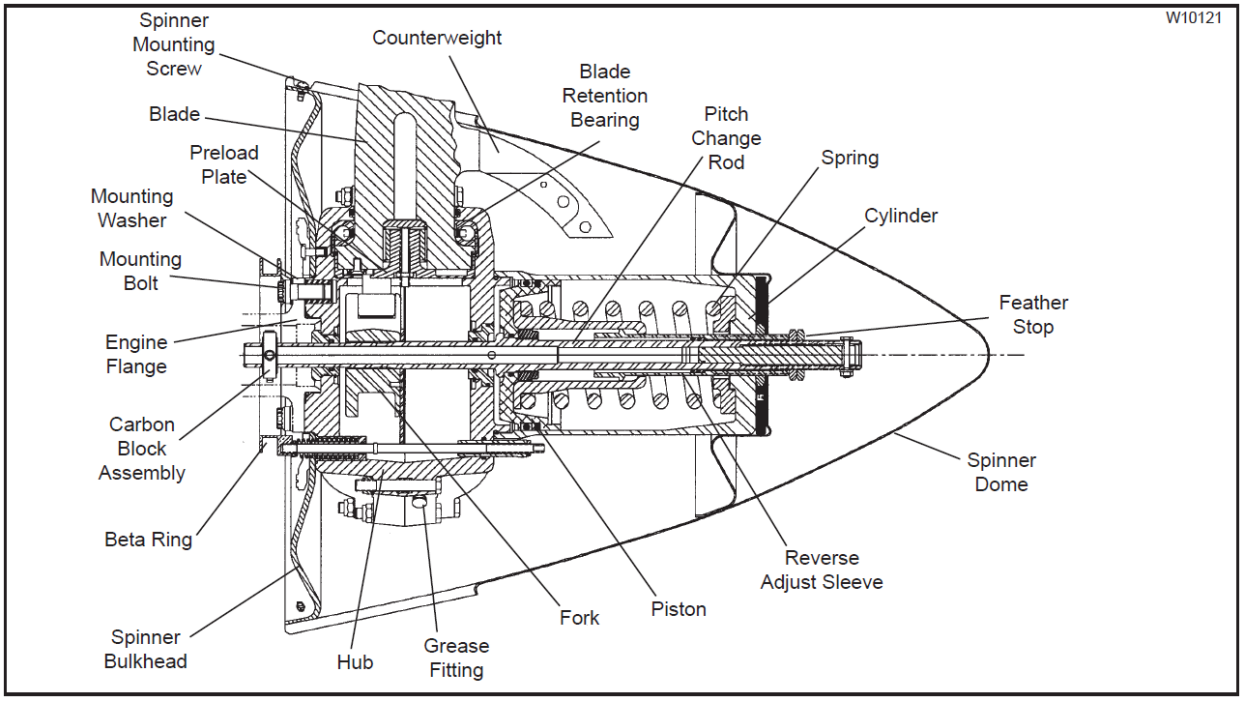
Les Doud	Hartzell Propeller Inc.
Todd Fox	NTSB Investigator in Charge
Phil Santoro	Daher Air Safety Investigator
Marc Gratton	PWC Air Safety Investigator

General Comments: The propeller on the accident airplane is a 91.0" diameter, 4-blade, single-acting, hydraulically operated constant speed model with feathering and reverse pitch capability. Oil pressure from the propeller governor is used to move the blades to the low pitch (blade angle) direction. Force from a feathering spring and twisting moments from the blade counterweights are used to move the blades to the high pitch/feather direction in the absence of governor oil pressure. The propeller incorporates a Beta mechanism that actuates when blade angles are lower than the flight idle position. The propeller utilizes an aluminum hub with aluminum blades. Rotation is clockwise as viewed from the rear. A cross section sketch of the propeller is shown in Figure 2.

Installation Data: See Installation Data Sheet No. 79 for additional installation data. (Blade angles referenced at the 30-inch station)

Reverse:	-11 ± 0.5 degrees
Low Pitch:	21.0 ± 0.1 degrees
Feather:	86.0 ± 0.5 degrees

Figure 2



Propeller Model: HC-E4N-3 with E9083SK blades

Propeller Assembly Serial Number: HH1456

Service History: Excerpts of the propeller logbook were reviewed and indicated the propeller was overhauled on May 28, 2009 by Santa Monica Propeller. The last overhaul was also performed by Santa Monica Propeller on June 4, 2014. The last propeller service was an annual/100-hour inspection performed by BMG Jet Center on June 1, 2019.

	S/N	Date of Manufacture	TTSN	TSO
Hub/Factory	A58602	1/13/2002	3550.6	1089.4
Blade 1	J69907	1/4/2002	3550.6	1089.4
Blade 2	J69915	1/4/2002	3550.6	1089.4
Blade 3	J69914	1/4/2002	3550.6	1089.4
Blade 4	J69906	1/4/2002	3550.6	1089.4

Blade Orientation: The blades were arbitrarily identified 1-2-3-4 counterclockwise as viewed from the rear of the propeller (in sequence of rotation). The hub serial number was between the #1 and #2 blades.

As Received: The propeller was presented for examination as shown in Photo #2. The propeller assembly remained attached to the engine propeller shaft that fractured from the engine RGB during the impact sequence. One blade was bent in the forward/thrust direction. Three blades were bent in the aft direction. All four blades exhibited chordwise/rotational scoring on the camber side with paint discoloration from the tip to the outboard end of the de-ice boot. Three blades exhibited chordwise/rotational scoring on the face side. The spinner dome was dented adjacent to one blade with a counterweight impression area with the center/average angle of approximately 44^0. The pitch change rod was in the feathered position. Three blades could be partially rotated by hand force indicating fractured pitch change mechanisms. One blade had been forcefully rotated beyond the reverse stop position, two blades were in an approximate low pitch position and one blade was in an approximate feathered position. The beta ring appeared intact and undamaged with the carbon block and beta arm in position. The beta arm and valve moved freely.

Spinner Dome: The spinner dome remained attached to the propeller assembly by all spinner mounting screws. The dome was dented adjacent to blade #3 with a counterweight impression area at approximately 44^0 (Photo #3). The dome had rotational scoring near the apex and longitudinal scoring in the dented area.

Spinner Bulkhead: The rear/main spinner bulkhead appeared intact and undamaged. The forward bulkhead was dented in the area where the dome was dented.

Propeller Cycling: Propeller cycling was not attempted due to the apparent pitch change mechanisms damage.

Engine/Propeller Mounting: The propeller mounting flange appeared intact and undamaged. All propeller mounting bolts were present and safety-wired. No attempt was made to remove the propeller from the propeller shaft flange.

Photo #2 – Propeller as-presented

Photo #3 - Counterweight impression average angle

Hydraulic Unit/Pitch Change Components:

Cylinder: D-488 Rev. N S/N 4704. The cylinder appeared intact and undamaged.
Piston: C-492 Rev. H S/N 5824. The piston appeared intact and undamaged with some normal wear scuffing on one side of the piston covering approximately one third of the circumference.
Pitch Change Rod: D-6071-1 Rev. E S/N B1683. The pitch change rod appeared intact and undamaged.
Fork: The fork forward tangs at #1 and #4 were fractured and the fragments were found loose in the hub cavity. The #3 forward tang was cracked. There were pitch change knob/cam follower impact marks in the fork slots.
Feathering Spring/Guides: The feathering spring, spring seats and spring retaining/guide cup appeared intact and undamaged.

Pitch Stops:

Reverse Stop: The reverse pitch stop appeared intact and undamaged.
Feather Stop: The feather stop appeared intact and undamaged.
Beta/Low Pitch System: The beta ring, beta rods and low pitch stop sleeves appeared intact and undamaged. The beta ring could be actuated with normal force and returned to position freely.

Hub Assembly: The hub unit had no visually detectable fractures or cracks. There was preload plate shelf damage in all four blade retention pockets. There were knob and/or fork impact marks on the forward hub half internal surface in all four blade retention pockets and the pitch change rod bushing was fractured. The preload plate web in the aft hub half for #2 and #3 blades was fractured inward. There was damage in the bearing race area of the #3 blade retention pocket due to a bearing race fracture. There were blade impact marks in the #2 and #3 blade apertures in the aft/trailing edge quadrant. All except #4 hub-side blade bearing race assemblies had ball impact marks to varying degrees. The #3 blade race was fractured and fragmented (Photo #4)

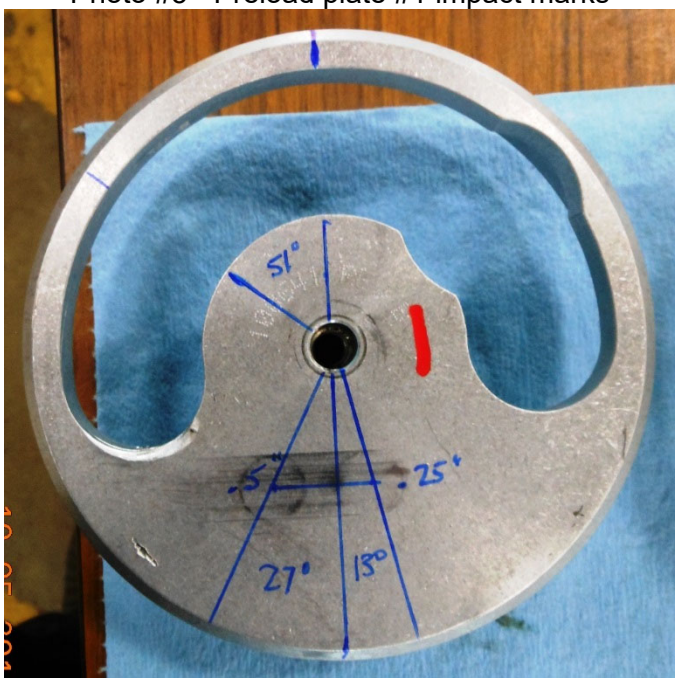
Photo #4 - Blade #3 bearing race fractured with ball imprints

Preload Plates: All four preload plates had sheared, smashed or fractured lips.

NOTE: For this propeller model, when the blade knob is aligned with the hub parting line, the blade angle at the reference station is approximately 42° (knob 6° + 36° offset = 42°).

Preload Plate	Condition
1	There was a knob impact mark at 51° forward of split line in the knob slot. There were fork bumper marks at 27° forward and 13° aft of the split line. (see Photo #5)
2	There was a knob impact mark at 40° forward of split line in the knob slot.
3	There was a knob impact marks at 50° and 8° forward of split line in the knob slot.
4	There was a knob impact mark at 51° forward of split line in the knob slot.

Photo #5 - Preload plate #1 impact marks



Propeller Blade Properties: There was visible paint discoloration on all four blades camber side from the tip down to the outboard end of the de-ice boot. See Photos #6 through #8 for blade damage.

Photo #6 - Blades camber side showing discoloration

Photo #7 - Blades face side

Photo #8 - Blade bend and twist comparison

Blade # 1

Camber side	Chordwise/rotational scoring
Face side	Chordwise/rotational scorning near leading edge from tip extending 3” toward shank
Bend	Forward/thrust direction
Twist	Not remarkable, no visually discernable twist due to impact
Lead edge damage	Nicks and gouges
Trail edge damage	Not remarkable
Knob condition	Fractured from blade butt, dowel hole deformation opposite low pitch direction
Counterweight	Appears intact and undamaged
Blade bearings	Intact, ball imprints in races
Butt/shank impact marks	Not remarkable
De-Ice boot	Not remarkable

Blade # 2

Camber side	Chordwise/rotational scoring, circular spanwise scoring in mid-blade area
Face side	Chordwise/rotational scorning near leading edge from tip extending 6” toward shank
Bend	Aft and opposite rotation
Twist	Leading edge down/toward low pitch
Lead edge damage	Not remarkable
Trail edge damage	Nicks and tear near tip
Knob condition	Cam follower fractured from knob bracket that remained attached to blade butt
Counterweight	Appears intact and undamaged
Blade bearings	Intact, ball imprints in races
Butt/shank impact marks	Not remarkable
De-Ice boot	Not remarkable

Blade # 3

Camber side	Chordwise/rotational scoring
Face side	Chordwise/rotational scorning near leading edge from tip extending 8” toward shank
Bend	Aft and in direction of rotation
Twist	Leading edge down/toward low pitch
Lead edge damage	Nicks and gouge near tip with material deformation towards high pitch
Trail edge damage	Nicks and tears
Knob condition	Fractured from butt, hole deformation opposite high pitch
Counterweight	Appears intact and undamaged
Blade bearings	Intact, ball imprints in races
Butt/shank impact marks	Not remarkable
De-Ice boot	Not remarkable

Blade # 4

Camber side	Chordwise/rotational scoring
Face side	Not remarkable
Bend	Aft
Twist	Not remarkable
Lead edge damage	Nicks and gouges on outboard half, square gouge in mid-blade area
Trail edge damage	Not remarkable
Knob condition	Appears intact with some impact marks on the end of the cam follower were it contacted fork slot
Counterweight	Appeared intact and undamaged, was removed to facilitate propeller disassembly
Blade bearings	Not remarkable
Butt/shank impact marks	Not remarkable
De-Ice boot	Not remarkable

PHOTOGRAPHIC SUMMARY

NOTE: The following is a list of the original and unedited digital photographs. The photographs are available in digital format (CD, memory stick/card, FTP). The numbering sequence may not be chronological as some may have been deleted if out-of-focus, too dark, redundant, etc. Photos used in the text of this report are taken from photos on this list but may have been adjusted from the original. Modifications to images used in the report are limited to cropping, magnification, file compression, or enhancement of color, brightness, or contrast for the sole purpose to improve clarity of the report. No other alterations are permitted.

Picture File Name	Description
DSCN0118.JPG	Propeller as-presented A
DSCN0119.JPG	Propeller as-presented B
DSCN0120.JPG	Propeller as-presented C
DSCN0121.JPG	Propeller as-presented D
DSCN0122.JPG	Propeller as-presented, propeller mounting flange area, governor & beta arm A
DSCN0123.JPG	Propeller as-presented, propeller mounting flange area, governor & beta arm B
DSCN0124.JPG	Propeller as-presented, propeller mounting flange area, governor & beta arm C
DSCN0125.JPG	RGB gearbox and propeller shaft fracture
DSCN0126.JPG	Blade #4 camber side before removal
DSCN0127.JPG	Blade #1 position as-received A
DSCN0128.JPG	Blade #2 position as-received A
DSCN0129.JPG	Blade #3 position as-received A
DSCN0130.JPG	Blade #4 position as-received A
DSCN0131.JPG	Blade #1 position as-received B
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DSCN0136.JPG	Pitch change rod position as-presented B
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DSCN0145.JPG	Blade #4 aft pocket
DSCN0146.JPG	Aft hub half internal surfaces and spinner bulkhead A
DSCN0147.JPG	Aft hub half internal surfaces and spinner bulkhead B
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DSCN0189.JPG	#3 preload plate
DSCN0190.JPG	#4 preload plate
DSCN0191.JPG	#1 preload plate slot impact marks
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DSCN0203.JPG	Blades trailing edge view
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DSCN0227.JPG	Components bagged for storage B
DSCN0228.JPG	Hub secured for storage
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DSCN0567.JPG	Aircraft in-situ at ground scar toward direction of flight B
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DSCN0573.JPG	Left wing
DSCN0574.JPG	Aircraft in-situ 315° close-in view/pilot door open
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DSCN0580.JPG	From main wreckage viewing back toward runway approach path
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TH000016.JPG	Counterweight impact angle after removal of dome A
TH000017.JPG	Counterweight impact angle after removal of dome B
TH000018.JPG	Counterweight impact angle after removal of dome C