



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

**October 29, 2014**

**Airworthiness Group Chairman's Factual Report**

**NTSB No: CEN13FA192**

**A. ACCIDENT**

Operator: Era Helicopters LLC  
Aircraft: Sikorsky S-76A++, Registration N574EH  
Location: Grand Lake, Louisiana  
Date: March 15, 2013  
Time: 1147 central daylight time

**B. AIRWORTHINESS GROUP**

Group Chairman:	Chihoon Shin National Transportation Safety Board Washington, District of Columbia
Member:	Ronald Price National Transportation Safety Board Washington, District of Columbia
Member:	Jason Adame Federal Aviation Administration Baton Rouge, Louisiana
Member:	Kirk Gustafson Federal Aviation Administration Boston, Massachusetts
Member:	Nicholas Faust Federal Aviation Administration Boston, Massachusetts
Member:	Val Marshall Era Helicopters LLC Lake Charles, Louisiana
Member:	Chris Lowenstein Sikorsky Aircraft Corporation Stratford, Connecticut

Member: Mike Binder  
Sikorsky Aircraft Corporation  
Coatesville, Pennsylvania

Member: Harold Barrentine  
Bell Helicopter Textron, Inc.  
Fort Worth, Texas

Member: Bryan Larimore  
Turbomeca  
Grand Prairie, Texas

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**LIST OF ACRONYMS**

AAIP	approved airworthiness inspection program
AGL	above ground level
ASB	alert service bulletin
BHTI	Bell Helicopter Textron, Incorporated
CDT	central daylight time
CFR	Code of Federal Regulations
CT	Connecticut
DC	District of Columbia
FAA	Federal Aviation Administration
FCD	Fleet Campaign Directive
FCU	fuel control unit
FOD	foreign object debris
HEMS	helicopter emergency medical services
HSI	Helicopter Support, Inc.
IGB	intermediate gearbox
IPS	inches-per-second
LA	Louisiana
LCH	Lake Charles Regional Airport
LOW	light-on-wheels
NTSB	National Transportation Safety Board
PCL	pitch change link
P/N	part number
RBI	Rotor Blades Incorporated
S/N	serial number
SAC	Sikorsky Aircraft Corporation
SEM	scanning electron microscope
TGB	tail gearbox
TRDS	tail rotor drive shaft
USDA	United States Department of Agriculture

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## C. SUMMARY

On March 15, 2013, about 1147 Central Daylight Time (CDT), a Sikorsky S-76A++ helicopter, registration N574EH, operated by Era Helicopters LLC, was destroyed after ground impact near Grand Lake, Louisiana (LA). All three occupants onboard, consisting of the pilot and two maintenance personnel, were fatally injured. The helicopter was operating under the provisions of 14 *Code of Federal Regulations* Part 91 as a post-maintenance check flight after avionics maintenance was performed on the helicopter. Visual meteorological conditions prevailed. The flight departed Lake Charles Regional Airport (LCH) at 1119 CDT. While returning to LCH in cruise flight about 1,000 feet above ground level (AGL), the pilot radioed to the LCH control tower that they had an emergency and would be immediately landing off the airport. Radar data provided by the Federal Aviation Administration (FAA) showed the helicopter in a descent prior to contact being lost. The wreckage of the helicopter was found about 5 miles southeast of the threshold for Runway 33 at LCH. The majority of the helicopter was consumed by a post-crash fire. A ground witness observed the accident helicopter in a shallow descent as it passed at about 600 feet AGL and stated the helicopter was producing an unusual grinding noise.

Representatives from the National Transportation Safety Board (NTSB), FAA, Sikorsky Aircraft Corporation (SAC), and Era Helicopters were present for the documentation and investigation of the helicopter accident site. Of the four tail rotor blades<sup>1</sup>, two of the tail rotor blades ('yellow' and 'red') were fractured adjacent to the tail rotor hub; at the time of this report, these two tail rotor blades have not been located and recovered. The tail rotor head, two recovered ('blue' and 'black') tail rotor blades, tail gearbox (TGB), intermediate gearbox (IGB), and the No. 3, 4, and 5 tail rotor drive shafts (TRDS) were retained for further examination and transported from the accident site to Helicopter Services, Incorporated (HSI) in Trumbull, Connecticut (CT).

From April 9-11, 2013, the Airworthiness Group, consisting of participants from the NTSB, FAA, SAC, and Era Helicopters, convened at HSI to further examine the retained components. The examination revealed signatures consistent with the 'red' tail rotor blade initially separating from the tail rotor assembly, followed by the 'yellow' tail rotor blade separating from the tail rotor assembly consistent with forces caused by the shift in the center of mass along the span of the 'red'/'yellow' tail rotor blade spar.

On September 5, 2013, the 'blue' and 'black' tail rotor blades were brought to the Feather Identification Lab in Washington, District of Columbia (DC), part of the Smithsonian Institution's National Museum of Natural History, to determine if there was evidence of bird remains (snarge<sup>2</sup>) on the blades. Additionally, on September 24, 2013, a specialist from the United States Department of Agriculture (USDA) Wildlife Services in LA examined the tail rotor area of the helicopter wreckage for evidence of bird remains. No evidence of bird remains consistent with a bird strike were found on the components.

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<sup>1</sup> The S-76 tail rotor consists of two tail rotor blade assemblies that are orthogonally offset. Each tail rotor blade assembly consists of two blades that share a common spar and are diametrically opposed. The tail rotor blades are color-coded 'blue', 'red', 'black', and 'yellow', the sequence of which is also their sequence of rotation. One tail rotor blade assembly consists of the 'red' and 'yellow' tail rotor blades and the second tail rotor blade assembly consists of the 'blue' and 'black' tail rotor blades.

<sup>2</sup> Snarge is a term used for the remains of birds that are sent to identification centers where forensic techniques are used to identify the species of bird.

Due to the low number of flight hours accumulated on the ‘red’/‘yellow’ tail rotor blade assembly since its last S-76 tail rotor 1,500-hour inspection, the Airworthiness Group looked for deficiencies and plausible maintenance errors when performing a 1,500-hour inspection. On July 23, 2014, the Airworthiness Group, consisting of representatives from the NTSB, FAA, SAC, BHTI, and Era Helicopters, convened at Bell Helicopter Broussard to perform testing on a scrap tail rotor blade set to simulate a S-76 tail rotor 1,500-hour inspection. A focus of this testing was whether a tail rotor blade could be assembled with a pivot bearing compression screw still installed in the pivot bearing and the likelihood of detecting the compression screw. The Airworthiness Group determined that a tail rotor blade could be assembled with the compression screw installed. Additionally, a tail rotor blade assembled with a compression screw installed in the pivot bearing was visually no different than one without a compression screw installed in the pivot bearing. However, a tactile inspection of the tail rotor blade revealed a noticeable increase in the force required to pitch and flap a blade with a compression screw still installed in the pivot bearing versus a blade without the compression screw installed. The Airworthiness Group also performed a tail rotor blade spar “flex check” on a known cracked blade spar and determined that the audible sound made by a cracked spar was relatively quiet.

## **D. DETAILS OF THE INVESTIGATION**

### **1.0 HELICOPTER INFORMATION**

#### **1.1 HELICOPTER GENERAL DESCRIPTION**

The Sikorsky S-76A++ helicopter has a four-bladed, fully articulated main rotor that provides helicopter lift and thrust, and a four-bladed flexible beam tail rotor that provides main rotor anti-torque and directional control. The helicopter is equipped with two Turbomeca Arriel 1S1 turboshaft engines that are positioned side-by-side behind the main transmission assembly.

#### **1.2 TAIL ROTOR DETAILED DESCRIPTION**

The S-76A++ TGB is mounted near the top of the vertical stabilizer with the tail rotor on the left side of the helicopter.<sup>3</sup> The tail rotor consists of two blade assemblies that are secured between two retention plates that provides a compressive clamp-up of the tail rotor spars (**Figure 1**). The retention plates contain two channels, orthogonally offset from each other, which accommodate the spar of the blade assembly.

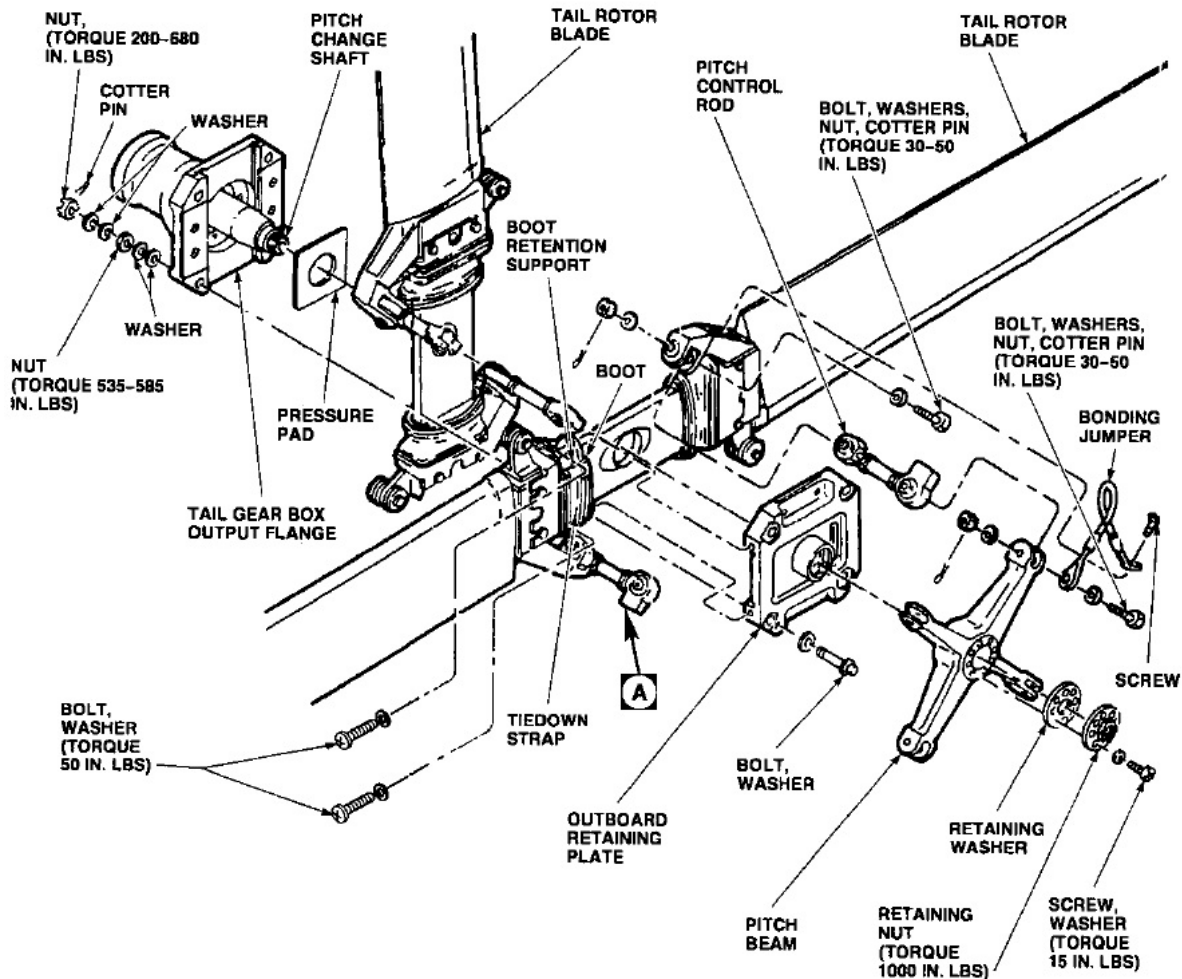
Each tail rotor blade assembly consists of a composite spar with two blades. Each blade is attached at 1) the outboard end of the spar via four bolts and 2) near the center of the spar at the elastomeric pivot bearing, also known as a “snubber” bearing. One end of the pivot bearing contains a retaining plate that slides into a retainer that is bonded to the spar. The other end of the pivot bearing contains two bolt holes which secure the pivot bearing to the body of the blade pitch horn.

Pitch control links (PCL), also referred to as the pitch control rod, are connected from the clevis-end of each blade pitch horn (inboard side) to a central pitch beam (outboard side). The pitch beam is connected to the pitch change shaft, which actuates the pitch beam along the tail rotor rotational axis to change the collective pitch of the tail rotor blades.

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<sup>3</sup> In this report, unless otherwise noted, the terms “left” and “right” are used when in the frame of reference of looking forward from the aft end of the helicopter, i.e. aft looking forward.

Pilot pedal inputs are transmitted to a pedal damper/trim actuator and subsequently the control mixing unit on the upper deck flight controls compartment above the cockpit. The control output from the mixing unit rotates a pair of quadrants that are attached to control cables. The control cables are routed via pulleys through the tailboom and empennage up to a second quadrant, whose output controls the tail rotor servo which actuates the pitch change shaft.



**Figure 1. Sikorsky S-76A++ tail rotor assembly.** [image courtesy of SAC]

### 1.3 HELICOPTER HISTORY

The accident helicopter, serial number (S/N) 760369, was manufactured in 1990. Records showed the helicopter had accumulated an aircraft total time (ATT) of 6,765.7 hours as of March 15, 2013. The No. 1 engine<sup>4</sup>, S/N 3016, had a time since new (TSN) of 8361.10 hours and a time since overhaul (TSO) of 1475.11 hours as of March 15, 2013. The No. 2 engine, S/N 3508TEC, had a TSN of 6696.80 hours and a TSO of 1287.50 hours as of March 15, 2013.

### 2.0 WRECKAGE DOCUMENTATION AT THE ACCIDENT SITE AND LAKE CHARLES, LA

The NTSB investigator-in-charge convened with Airworthiness Group members from the FAA, SAC, and Era Helicopters at the accident site in Grand Lake, LA on March 16, 2013 to perform

<sup>4</sup> The No. 1 engine is installed in the left position and the No. 2 engine is installed in the right position.

documentation of the helicopter and the accident site. Subsequently, portions of the wreckage were recovered and transported to a hangar in Lake Charles, LA for additional examination.

## 2.1 MAIN WRECKAGE

The helicopter came to rest upright on a southerly heading. The main wreckage exhibited damage consistent with exposure to a post-crash fire. The majority of the airframe, including the cockpit, main cabin, and forward portion of the tailboom, was either consumed or heavily heat distressed by the post-crash fire (**Photo 1**). The aft-right and forward wheeled landing gears were partially consumed by the post-crash fire. The aft-left landing gear was found buried about 1 foot into the ground underneath the main wreckage.



**Photo 1. N574EH at the accident site exhibiting heavy damage from the post-crash fire.**

The main gearbox housing was consumed by the post-crash fire, exposing its internal gears. The gears did not exhibit evidence of heavy operational wear or missing gear teeth.

Three of the four main rotor blades remained connected to the main rotor hub and the main rotor blade spindles were oriented at about 11 o'clock, 2 o'clock, 5 o'clock, and 8 o'clock positions when viewed from above (**Photo 2**). The 11 o'clock blade had fractured chordwise outboard of its pitch horn but was found adjacent to the main wreckage about 6 feet away. All four main rotor blades exhibited evidence consistent with low rotational energy at ground impact. The 5 o'clock and 11 o'clock blades exhibited severe chordwise deformation of the spar consistent with exposure to extreme heat. The tip cap for the 5 o'clock blade was found separated from the blade and was found about 12 feet to the east of the main wreckage.



**Photo 2. Main rotor blades.** [photo courtesy of Turbomeca]

The main rotor blade damper for the 2 o'clock blade had fractured at the piston end normally connected to the eyelet attached to the inboard trailing edge of the blade. The fracture surface exhibited signatures consistent with overload. All components associated with the 2 o'clock blade damper were accounted for. The main rotor blade damper for the 5 o'clock blade exhibited fractures on the rod end attached to the main rotor hub and the end of the piston normally threaded to the eyelet attached to the inboard trailing edge of the blade. The fracture surface of the hub-side of the 5 o'clock blade damper exhibited signatures consistent with overload. The 5 o'clock blade damper body, containing the piston, was neither observed nor recovered from the wreckage. The remaining two main rotor blade dampers were found intact and attached on both hub and blade ends.

The bifilar vibration absorber remained attached to the main rotor hub but was partially consumed by the post-crash fire, with three of the four bifilar arms and associated weights fractured from the bifilar. The fracture surfaces exhibited evidence consistent with exposure to extreme heat. The separated bifilar weights were recovered in the wreckage. The bifilar arm and associated weight between the 11 o'clock and 2 o'clock blade remained attached to the bifilar but exhibited heavy sooting on its surfaces.

The majority of the main transmission case was consumed by post-crash fire, exposing its internal gears which exhibited evidence of exposure to extreme heat. The main rotor controls were continuous from the three main rotor hydraulic actuators' lower attachment fittings through the swashplate and up to the pitch control rods' connection to the pitch horns. The main rotor



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controls forward of the hydraulic actuators were consumed by post-crash fire, thus their continuity could not be confirmed.

### 2.3 POWERPLANTS

The two engines were found behind the main transmission and were still covered by the engine cowling. Both engines exhibited evidence of exposure to the post-crash fire.

The accessory and reduction gearbox casings for the No. 1 engine were consumed by the post-crash fire, leaving its gears exposed. The fuel, oil, and air lines, the oil filter base and oil filter, the body of the fuel control unit (FCU), the FCU filter and main fuel filter were all consumed by the post-crash fire. The FCU throttle block remained attached to the cable and the pointer was consistent with the shutdown position, but the throttle scale had been consumed by post-crash fire. The magnetic plugs and chip detectors were heavily damaged and could not be checked for evidence of chips. The gas generator was seized and could not be manually rotated. The axial compressor showed no evidence of foreign object debris (FOD) ingestion. The free turbine was seized and could not be manually rotated. The free turbine exhibited no evidence of blade shedding. The reduction gearbox input pinion alignment marks exhibited no evidence of slippage. A borescope inspection of the engine did not reveal evidence of anomalous damage.

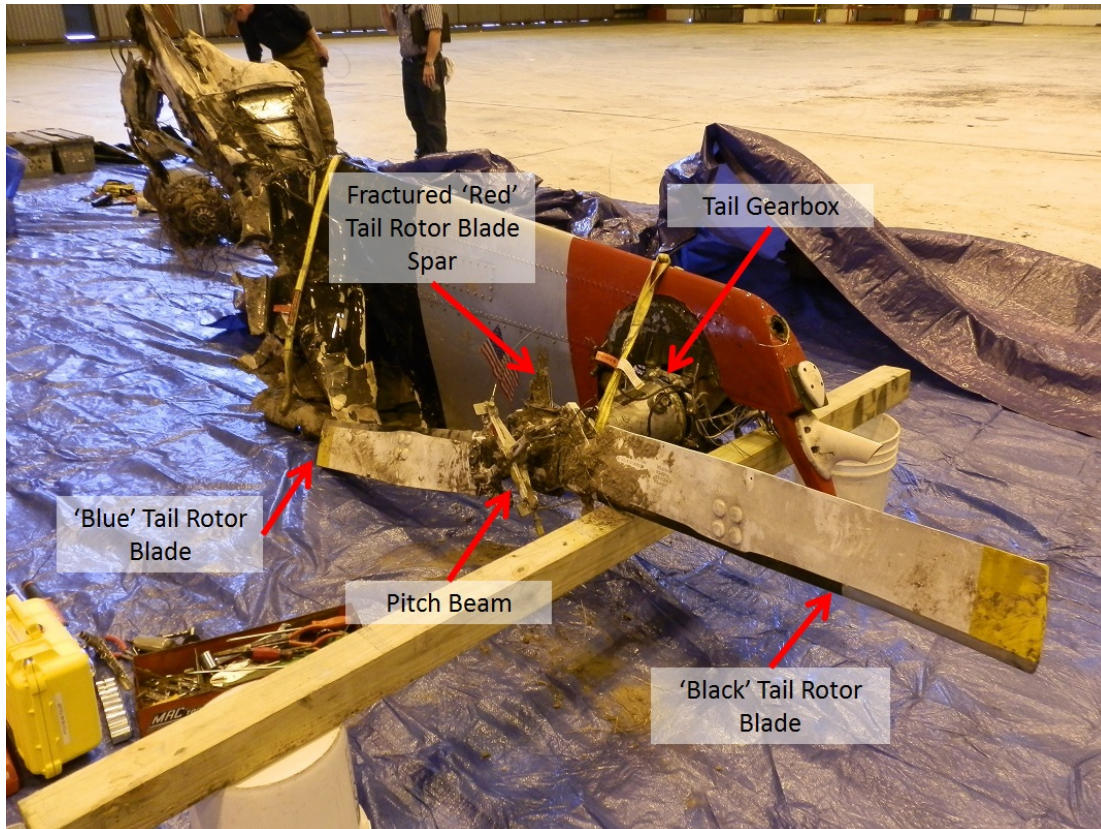
The accessory and reduction gearbox casings for the No. 2 engine were partially consumed by the post-crash fire, leaving its gears exposed. The fuel, oil, and air lines, the oil filter base and oil filter, the body of the FCU, the FCU filter and main fuel filter were all consumed by the post-crash fire. The magnetic plugs and chip detectors were heavily damaged and could not be checked for evidence of chips. The gas generator was seized and could not be manually rotated. The axial compressor showed no evidence of FOD ingestion. The free turbine was seized and could not be manually rotated. The free turbine exhibited no evidence of blade shedding. The reduction gearbox input pinion alignment marks exhibited no evidence of slippage. A borescope inspection of the engine did not reveal evidence of anomalous damage.

### 2.3 EMPENNAGE AND TAIL ROTOR

The empennage, consisting of the vertical stabilizer and the left and right horizontal stabilizers, was found immediately aft of the main wreckage and generally aligned with longitudinal axis of the main wreckage. The empennage was found resting on its left side (i.e. the right horizontal stabilizer was pointed almost vertically upward) with the left horizontal stabilizer fractured chordwise adjacent to the vertical stabilizer. The empennage did not exhibit evidence of heat damage apart from the forward end which connected it to the heat-distressed tailboom. The surfaces of the empennage which were not heat damaged did not exhibit evidence of soot deposits. The empennage contained the IGB and the TGB, both of which remained attached and secured to the empennage structure; the No. 5 TRDS, which remained attached and secured on both ends to the IGB and TGB; and the aft portion of the No. 4 TRDS, which remained attached and secured to the IGB. The TGB exhibited a circumferential crack adjacent to the mating surfaces between the output housing and center housing.

Only two of the four tail rotor blades (the 'black' and 'blue' blades) were recovered at the accident site. The 'black' blade had fractured from the 'black'/'blue' tail rotor spar while the 'blue' blade remained attached to the spar. The 'blue' and 'black' blade surfaces were mostly intact and did not exhibit damage associated with high rotational energy. The 'black' and 'blue'

PCLs remained attached on both ends to the pitch beam and their respective blade pitch horns. The 'red' PCL had fractured at the pitch beam-side threads and the remainder of the 'red' PCL was not recovered. The remnant 'red' PCL remained attached to the pitch beam. The 'yellow' PCL remained whole and attached on its outboard end to the pitch beam, but the inboard rod end was observed to be free. The bolt and nut connecting the 'yellow' PCL to its respective blade pitch horn were not recovered. Disassembly of the pitch beam and outboard retention plate revealed the 'red'/'yellow' tail rotor spar had shifted toward the 'yellow' blade side by evidence of the shifted spar nylon wraps. The elliptical plug of the 'red'/'yellow' spar exhibited crushing damage on the 'red' blade side, with the direction of crushing going toward the 'yellow' blade side.



**Photo 3. The recovered empennage with the installed TGB and remaining tail rotor blades.**  
[photo courtesy of SAC]

The IGB, TGB, tail rotor head components, tail rotor blades, rotor brake, and the Nos. 3, 4, and 5 TRDS were retained for further examination.

### 3.0 DETAILED EXAMINATION OF THE TAIL ROTOR SYSTEM WRECKAGE SENT TO HSI

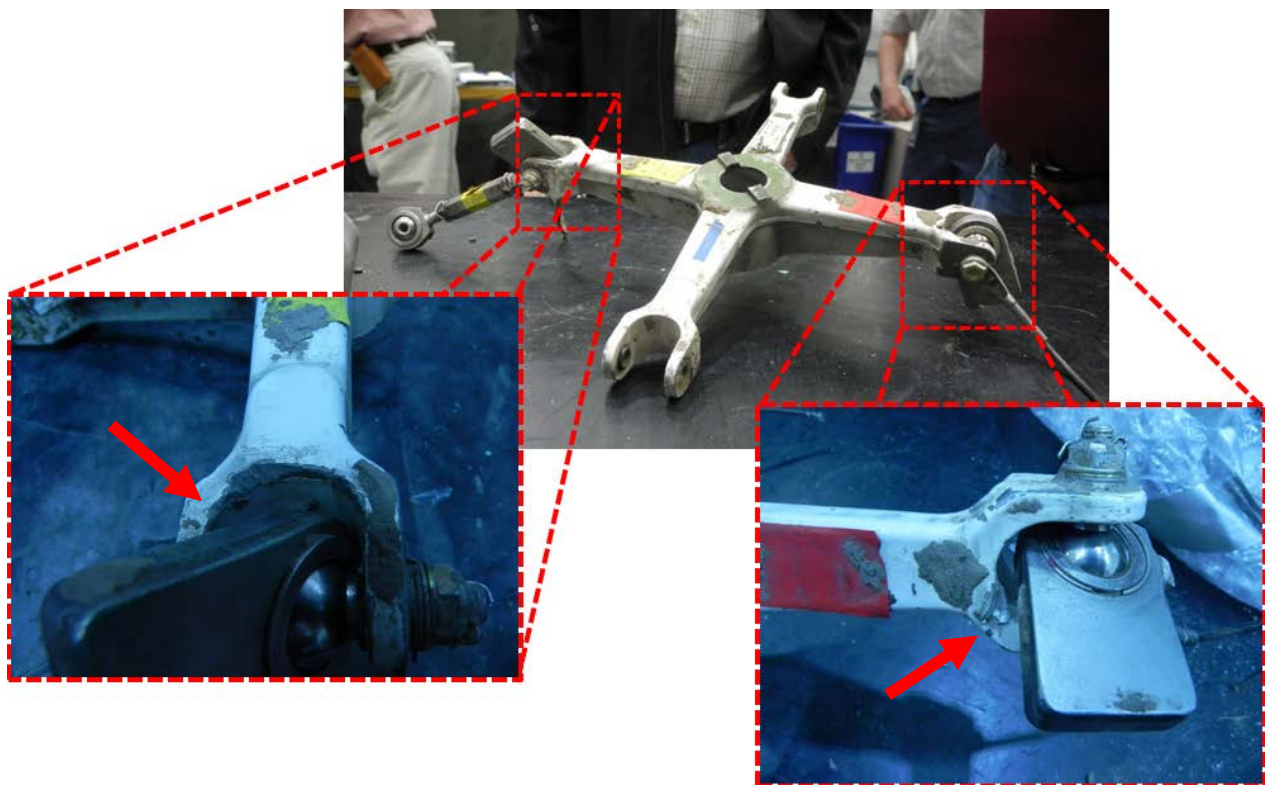
From April 9-11, 2013, participants from the NTSB, the FAA, SAC, and Era Helicopters convened at HSI to examine the components retained from the accident site for further examination.

#### 3.1 TAIL ROTOR HEAD AND TAIL ROTOR BLADES

The tail rotor head and tail rotor blades were received partially disassembled. The pitch beam had been removed from the pitch change shaft and the outboard retention plate and the recovered tail rotor blades were removed from the inboard retention plate.

### 3.1.1 TAIL ROTOR HEAD

The pitch beam was received separate from the tail rotor head assembly. The PCL for the ‘yellow’ tail rotor blade and the remnant upper end of the PCL for the ‘red’ tail rotor blade remained attached to the pitch beam (**Photo 4**). The attaching hardware between the pitch beam and both the ‘red’ and ‘yellow’ PCLs remained installed with their cotter pins intact. The inboard edge of the pitch beam fork connected to the ‘red’ PCL exhibited a large impact mark matched to that of the remnant ‘red’ PCL that was still installed. The inboard edge of the pitch beam fork connected to the ‘yellow’ PCL exhibited multiple impact marks matched to that of the ‘yellow’ PCL. The PCLs from the ‘black’ and ‘blue’ tail rotor blades had been previously disconnected from the pitch beam by investigators after the wreckage was salvaged from the accident site. No evidence of cracks or fractures was observed on the pitch beam.

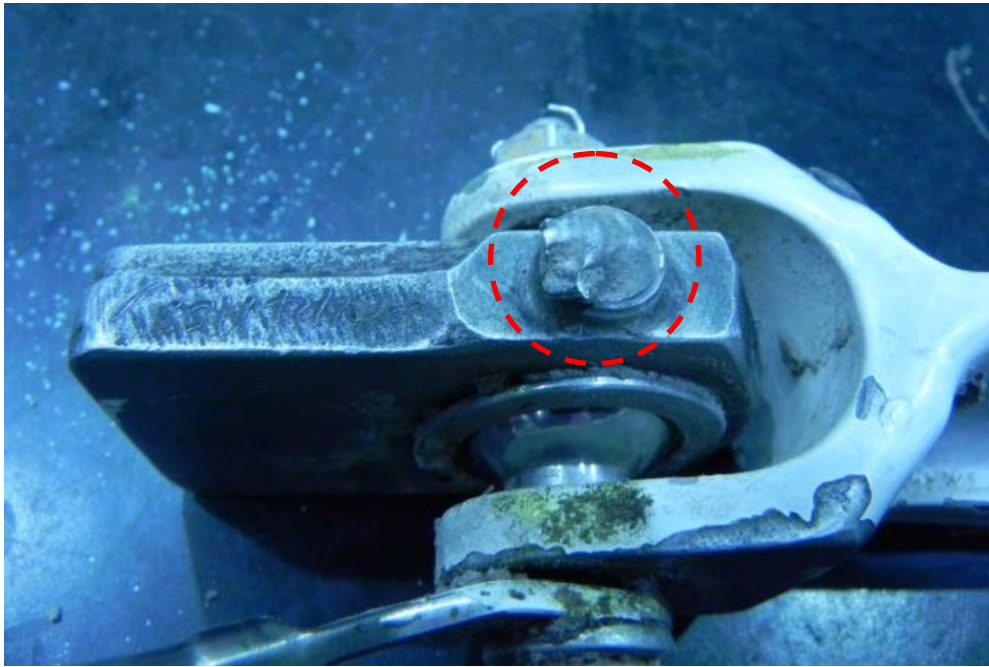


**Photo 4. Tail rotor pitch beam with the ‘yellow’ and remnant ‘red’ PCLs attached. The unlabeled arrows point to the impact marks observed on the pitch beam fork of the ‘yellow’ and ‘red’ PCL.**

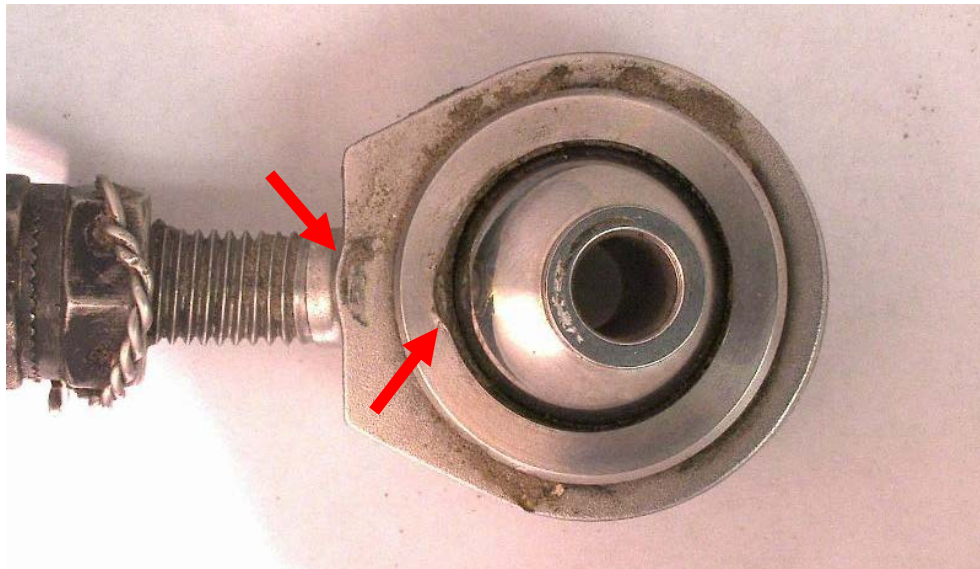
The ‘red’ PCL had fractured at the start of the threaded shank adjacent to the PCL tab (**Photos 5**). The fracture surfaces exhibited signatures consistent with overload. A run-on torque check of the ‘red’ PCL measured 107 inch-pounds.<sup>5</sup> The ‘yellow’ PCL exhibited a slight bend deformation at the blade-side rod end. A run-on torque check of the ‘yellow’ PCL was performed but an error made during the measurement process resulted in an inaccurate torque reading. The bolt connecting the ‘yellow’ PCL to the

<sup>5</sup> According to Sikorsky S-76 Maintenance Manual No. SA 4047-76-2, the attaching hardware for the tail rotor PCL rod ends are required to have 30 – 50 inch-pounds of torque.

pitch beam had to be tapped out with a mallet during removal of the bolt; a slight bend in the bolt was observed after removal. The blade-side rod end ball joint contained two impact marks, one on each side of the ball joint and 180° apart, consistent with ball trunnion impact (**Photos 6 and 7**). Another impact mark, aligned with one of the trunnion impact marks, was found on the ball housing adjacent to the threaded shank (**Photo 6**).



**Photo 5. Fracture surface of the threaded shank of the 'red' PCL.** [photo courtesy of SAC]

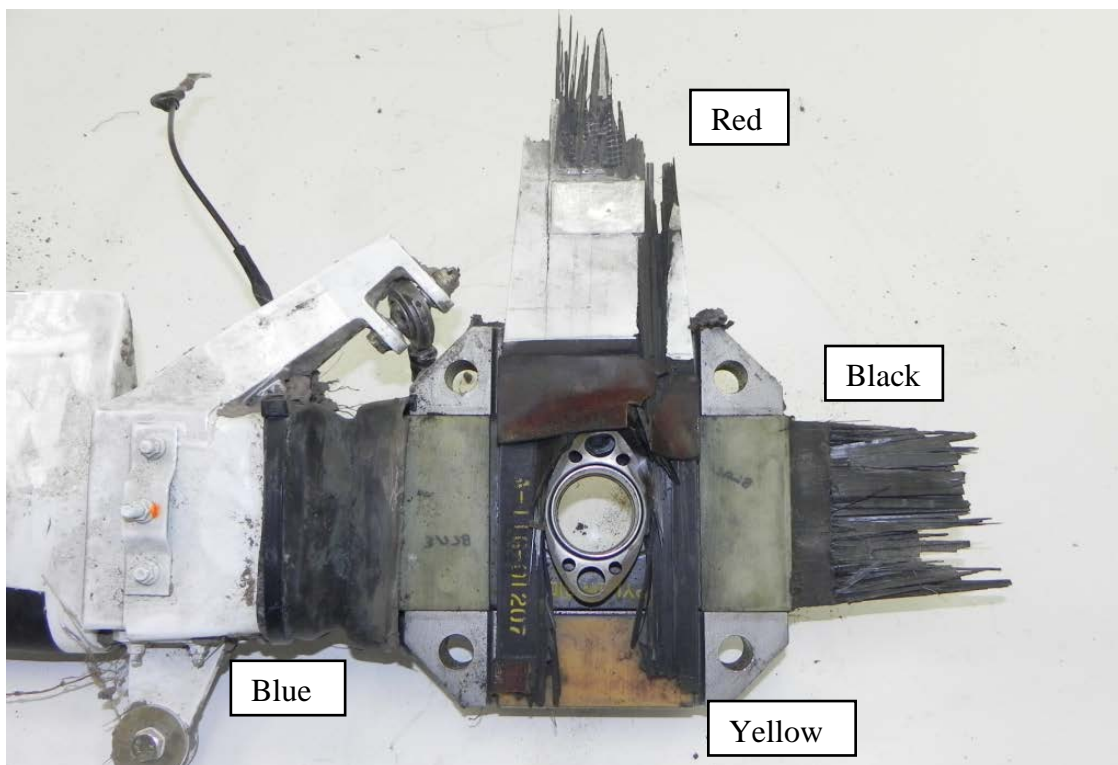


**Photo 6. The trunnion impact mark and the second impact mark adjacent to the threaded shank of the 'yellow' PCL blade-side rod end.** [photo courtesy of SAC]



**Photo 7. Trunnion impact mark 180° opposite of the trunnion impact mark seen on opposing side of the ‘yellow’ PCL blade-side rod end. [photo courtesy of SAC]**

The outboard retention plate was received separated from the inboard retention plate. Sections of spar for the ‘red’/‘yellow’ tail rotor blade and the ‘black’/‘blue’ tail rotor blade remained attached to the outboard retention plate (**Photo 8**). No cracks or fractures were observed on the outboard retention plate. There was no evidence of fretting or galling on the surfaces which mates the outboard retention plate to the inboard retention plate. The nylon shims on both spar channels remained installed with no evidence of major discoloration. The center bushing for the pitch change shaft did not exhibit any abnormal contact between the bushing and the shaft.

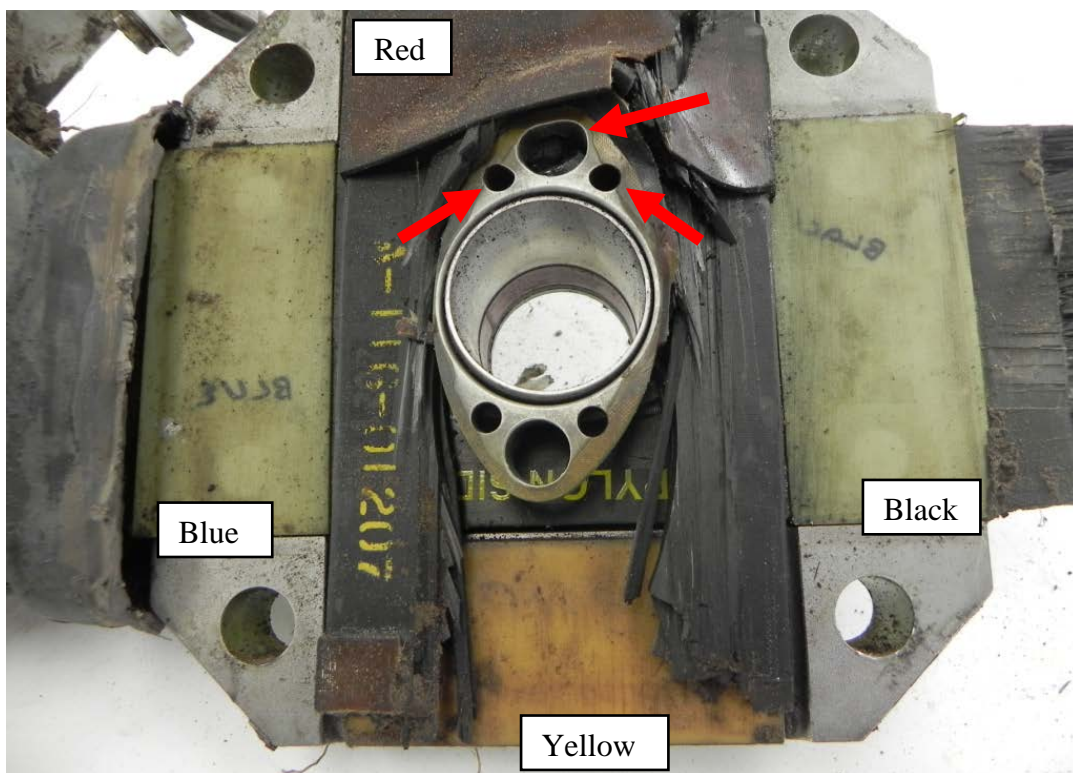


**Photo 8. Outboard retention plate containing the ‘red’/‘yellow’ spar and the ‘black’/‘blue’ spar. [photo courtesy of SAC]**

The inboard retention plate was received attached to the TGB output bevel gear. The inboard retention plate exhibited no evidence of cracks or fractures. The nylon shims on both spar channels remained installed with no evidence of major discoloration. The 12 bolts, lock washer, and large nut securing the inboard retention plate to the TGB output bevel gear remained installed with all safety wiring intact.

### 3.1.2 'RED' AND 'YELLOW' TAIL ROTOR BLADE SPAR

The center section of the 'red'/'yellow' tail rotor spar<sup>6</sup> remained attached to the outboard retention plate. The spar was fractured in two locations and had shifted in the direction of the 'yellow' tail rotor blade, while the elliptical centering plug remained in its normally installed location. Crush deformation of the three holes of the elliptical centering plug on the 'red' side of the spar was observed, consistent with the spar being pulled by force in the direction of the 'yellow' side of the spar (**Photo 9**). A small section of the spar was observed to have punctured the center hole (of the three deformed holes). Severe splintering of the spar was observed adjacent to the crushed side of the elliptical plug. The remnant spar was also fractured in the spanwise direction, about 0.5 inches inboard from the trailing edge side when measured at the nylon wrap.



**Photo 9. The three deformed holes of the elliptical centering plug.** [photo courtesy of SAC]

One of the spar fractures was located near the root end of the 'red' tail rotor spar, adjacent to the 'red' blade's bumper plate (**Photo 10**). The area of the 'red' side bumper plate exhibited a slight bowing in the outboard direction (when looking outboard from the pylon-side of the spar). The remnant adhesive layout for the 'red' blade's pivot bearing retainer was observed on the spar fracture. Examination of the remnant adhesive layout

<sup>6</sup> According to maintenance records, the 'red'/'yellow' tail rotor blade assembly was S/N A137-00708X and the spar was S/N A116-01207.

under a scanning electron microscope (SEM) revealed no definitive direction that the layout fibers were pulled. The fracture had a broomstraw appearance, with the broomstraw appearance more prevalent near the central width of the spar. Examination of the fracture under a SEM revealed no evidence consistent with composite matrix rubbing. The spar's nylon wrapping on the 'red' side had a dark maroon discoloration.



**Photo 10. The spar fracture for the 'red' tail rotor blade. The left arrow points to the bumper plate and the right arrow points to the remnant adhesive layout for the pivot bearing retainer.**

The opposing spar fracture, located on the 'yellow' side of the spar, occurred near the edge of the retention plate (**Photo 11**); the remnant nylon wrapping also exhibited a dark maroon discoloration. The 'red'/'yellow' spar had S/N "A-116-01207" stenciled on the surface of the spar. The spar fracture had an overall blunt and flat appearance.

X-ray examination of the remnant 'red'/'yellow' spar, in accordance with Sikorsky Alert Service Bulletin (ASB) No. 76-65-40<sup>7</sup>, showed no evidence of "waviness" of the composite filaments in the undamaged areas.

Attachment 1 contains Sikorsky Materials Engineering Report No. MAR-OA1308141, detailing the materials laboratory examination of the tail rotor components.

<sup>7</sup> Sikorsky ASB No. 76-65-40, dated July 17, 1987 (Revision A dated March 18, 1988) required radiographical inspection of the tail rotor blade spar for evidence of discrepancies of the composite filament layout (plies) that may have occurred during manufacturing of the spar. According to component maintenance records, spar S/N A116-01207 complied with Sikorsky ASB No. 76-65-40 on October 9, 1987 when it underwent a computed tomographic (CT) inspection with no discrepancies found. Refer to Section 6.0 of this report for more information of the accident investigation which resulted in the release of ASB No. 76-65-40.



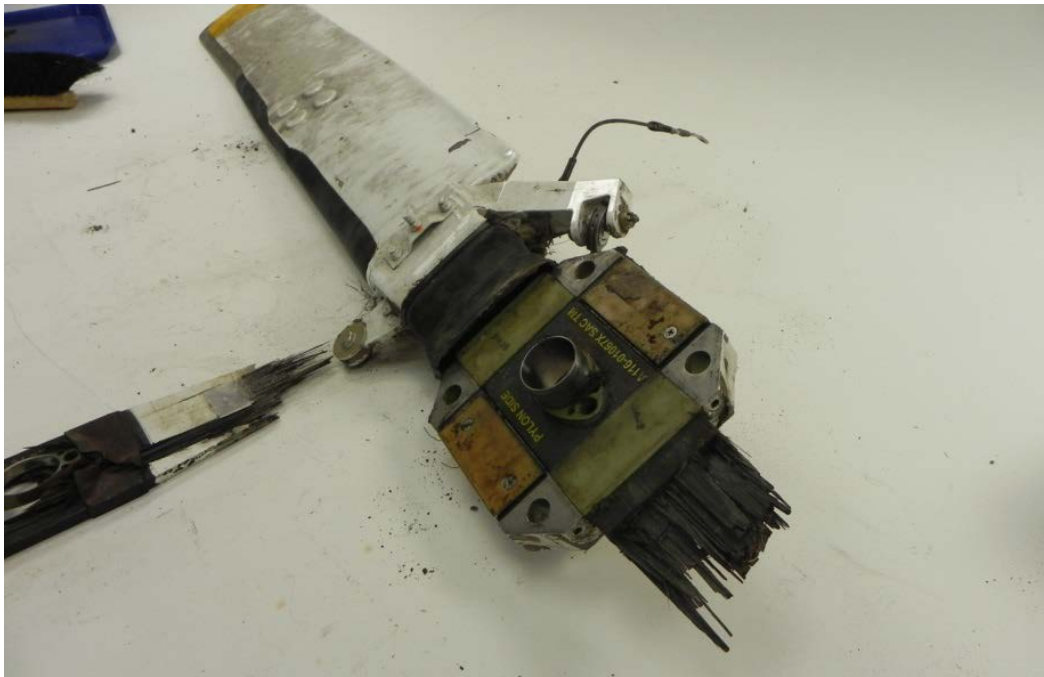
**Photo 11. The fracture observed at the ‘yellow’ tail rotor blade spar.**

### 3.1.3 ‘BLACK’ AND ‘BLUE’ TAIL ROTOR BLADES AND SPAR

The spar for the ‘black’/‘blue’ tail rotor blade<sup>8</sup> was fractured adjacent to the ‘black’ tail rotor blade rubber boot, but remained continuous through outboard retention plate and the ‘blue’ tail rotor blade (**Photo 12**). The ‘black’ blade spar fracture had a broom straw appearance across the entire width of the spar, the length of the broom straws relatively uniform across the fracture. The ‘black’/‘blue’ spar had S/N “A116-01067X” stenciled on the surface of the spar. The spar was removed from the outboard retention plate and the ‘blue’ blade was disassembled from the spar. Minor cracks and fractures were seen in several areas on the leading and trailing edge surfaces of both ‘black’ and ‘blue’ blades. There was no evidence of heat damage on the blade surfaces. The pitch horns remained attached to both blades with their respective PCLs and associated attaching hardware and cotter pins still installed. A run-on torque check of the attaching hardware for the PCL measured 26 inch-pounds for the ‘black’ PCL and 34 inch-pounds for the ‘blue’ PCL.

<sup>8</sup> According to maintenance records, the ‘black’/‘blue’ tail rotor blade assembly was S/N A137-00607X and the spar was S/N A116-01067X.





**Photo 12. The 'black'/'blue' spar attached to the outboard retention plate. The fracture of the 'black' tail rotor spar is seen on the lower-right.** [photo courtesy of SAC]

X-ray examination of the 'black'/'blue' spar, in accordance with Sikorsky Quality Assurance Technical Instruction No. 3210 Revision D showed no evidence of "waviness" of the composite filaments in the undamaged areas.<sup>9</sup> Both the 'black' and the 'blue' tail rotor blades exhibited no evidence of damage consistent with high rotational energy (**Photo 13**).



**Photo 13. Overall view of the 'black' (left) and 'blue' (right) tail rotor blade. The outboard retention plate and the remnant 'red'/'yellow' spar is seen in the center.** [photo courtesy of SAC]

<sup>9</sup> According to component maintenance records, spar S/N A116-01067 complied with Sikorsky ASB No. 76-65-40 on July 12, 1988 when it underwent a CT inspection with no discrepancies found.

### 3.2 TAIL GEARBOX AND TAIL ROTOR SERVO

The TGB was received as a complete assembly with tail rotor servo and associated pulleys and spring capsules; the tail rotor quadrant; the pitch change shaft; and the inboard retention plate installed (**Photo 14**). The TGB contained only traces of oil and no oil sample was submitted with the TGB; the TGB was not drained of oil when it was recovered at the accident site.



**Photo 14. The TGB assembly as received.**

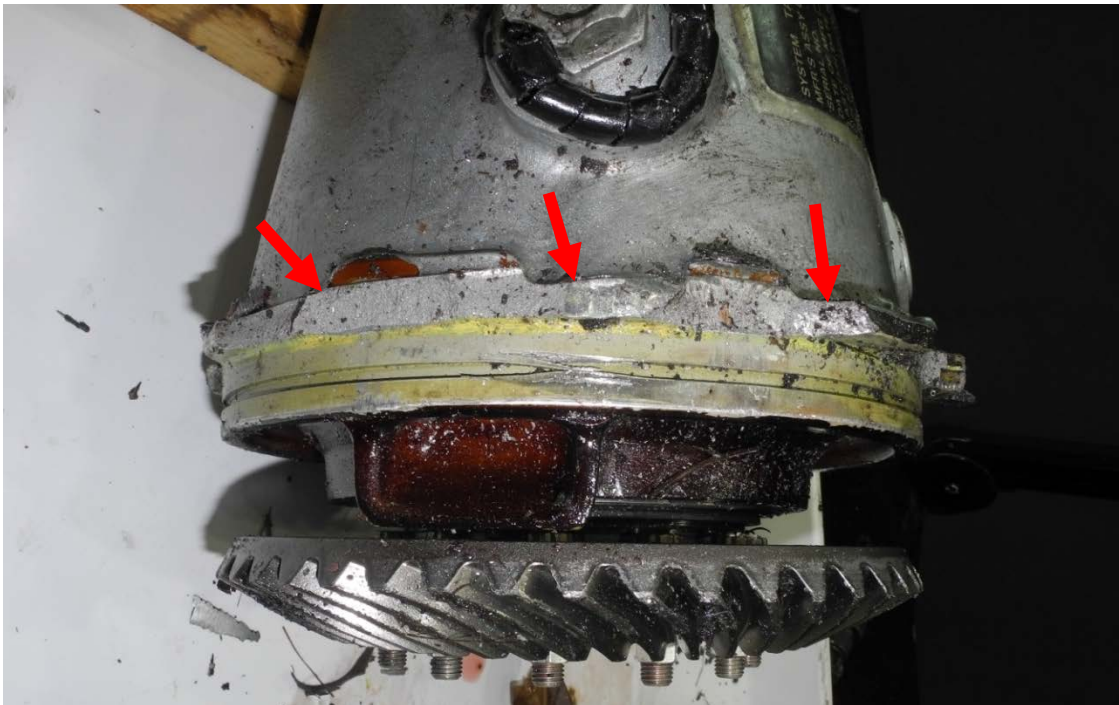
#### 3.2.1 TAIL GEARBOX

The output housing, containing the output bevel gear, was separated from the center housing; the mounting hardware for the tail rotor quadrant, spring capsules, and pulleys were holding the output housing to the center housing. Rotation of the input pinion by hand did not engage the output bevel gear. There was no evidence of binding when the input pinion was rotated. Rotation of the output bevel gear by hand revealed no evidence of binding. The pitch change shaft rotated in unison with the output bevel gear. The TGB exhibited no damage to its internal bearings and no discoloration of its external paint or internal coatings. Discoloration of paint and coatings are consistent with heat distress.

The output bevel gear and output housing were removed from the TGB center housing as a single assembly. The splines and threads on the outboard end of the bevel gear exhibited no damage. The lock washer, large nut, and tapered split cone exhibited no damage. The top land of the output bevel gear teeth exhibited damage from the tooth heel to about 1/3 of the length of the top land (**Photo 15**). One of the twelve bolts securing the output bevel gear to the output gear shaft was fractured; the fracture surface exhibited signatures of overload. Small metallic flakes were found throughout the output bevel gear surfaces and the inner diameter of the output gear shaft. The flanges of the output housing that attaches to the center housing were fractured (**Photo 16**). The flanges remained attached to the center housing with their respective attaching nuts. All observed fracture surfaces of the output housing exhibited signatures consistent with overload.



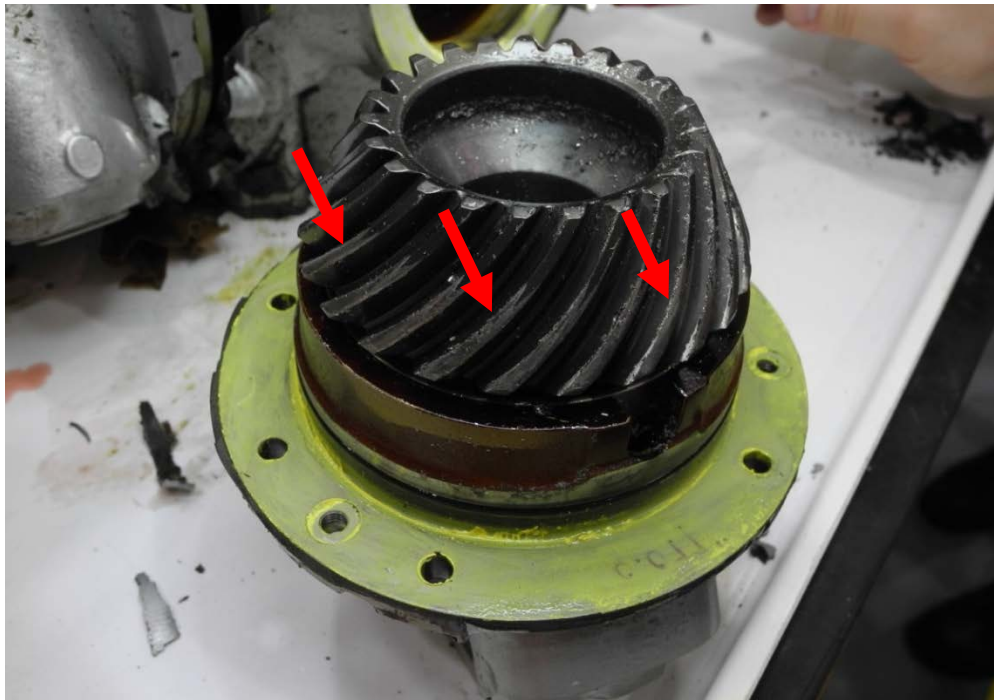
**Photo 15. Damage seen on the top lands of the output bevel gear teeth.**



**Photo 16. Fractures of the output housing flanges that attach to the center housing.**

The nuts securing the input pinion and housing assembly to the center housing remained installed and intact. The input pinion and input housing were removed from the TGB center housing as a single assembly. The top land surface of the input pinion gear

teeth exhibited damage from the tooth heel to about ½ of the length of the top land (**Photo 17**). The driving and coasting surfaces of the input pinion gear teeth did not exhibit signatures of abnormal operation or of FOD ingestion through the gear mesh. Small metallic flakes were found throughout the surfaces of the input pinion.

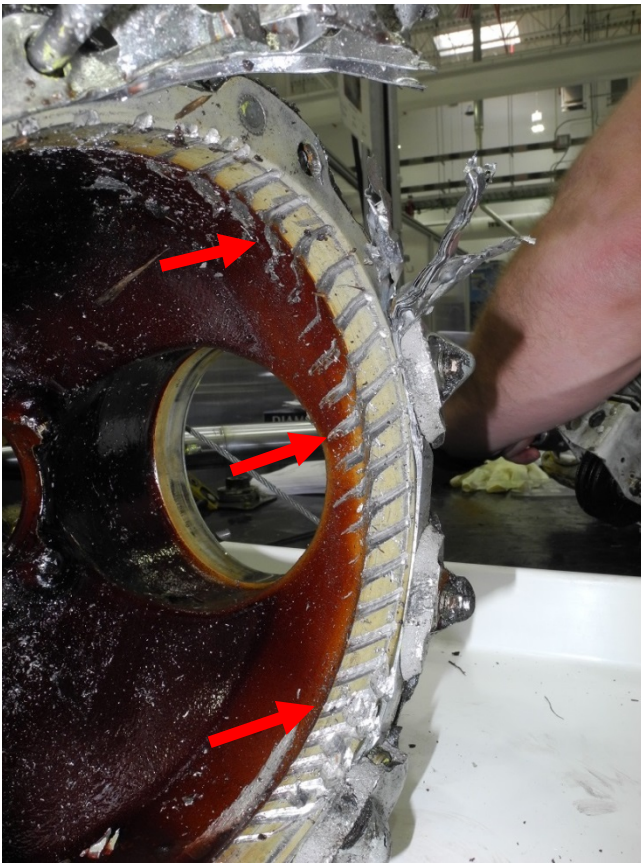


**Photo 17. Damage seen on the top lands of the input pinion gear teeth.**

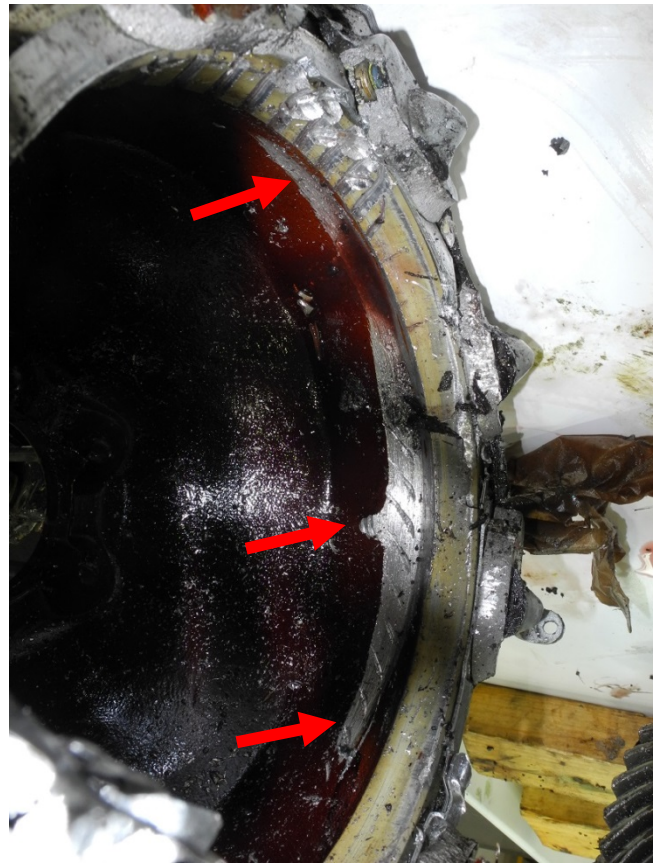
The exterior of the center housing exhibited no signatures of cracks or fractures aside from those associated with the fracture of the output housing. Small metallic flakes were found throughout the interior surfaces of the center housing and a trace amount of oil was found inside the housing. On the center housing, static impressions of output bevel gear teeth impacting the sealing surface (the inner diameter mating surface) to the output housing were seen from about the 3 o'clock to the 8 o'clock position<sup>10</sup> (**Photo 18**); the impressions were consistent with impact from a non-rotating output bevel gear. Damage to the center housing with a shiny, machined appearance was found adjacent to the sealing surface from about the 7 o'clock to the 12 o'clock position (**Photo 19**); this damage was consistent with impact from a rotating output bevel gear. Additional static gear tooth impressions were found in the damaged area with the machined appearance.

Attachment 2 contains Sikorsky Materials Engineering Report No. MER-MI1308142 detailing the materials laboratory examination of the tail gearbox components.

<sup>10</sup> The clock position is in the frame of reference of when looking inboard through the center housing opening which mates to the output housing, and with the center housing opening which mates to the input housing at the 6 o'clock position.



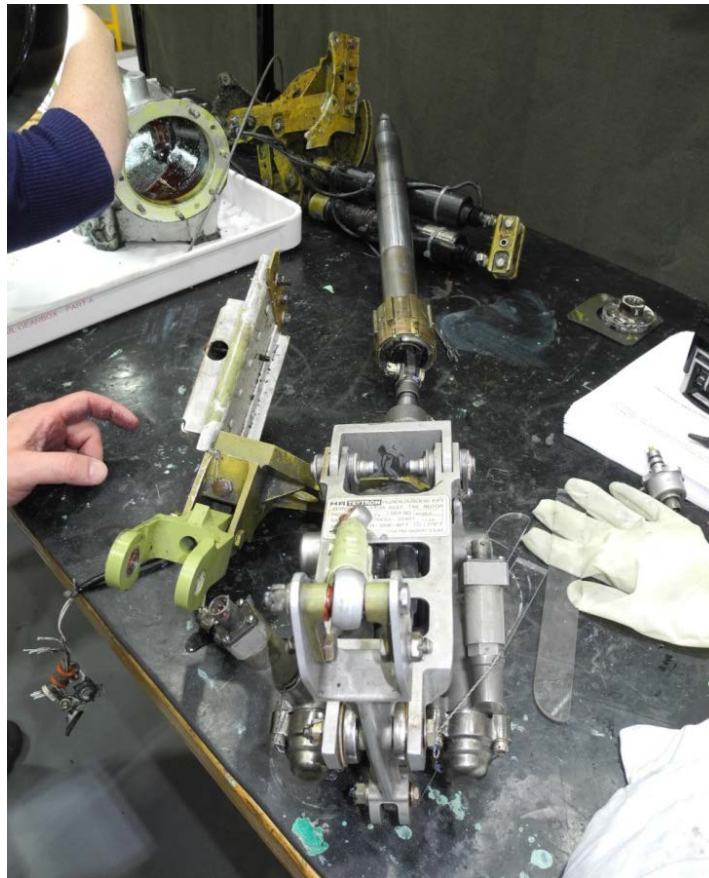
**Photo 18. Gear teeth impressions found on the output housing sealing surface of the TGB center housing.**



**Photo 19. Damage with a machined-like appearance found adjacent to the output housing sealing surface of the TGB center housing.**

### 3.2.2 TAIL ROTOR SERVO

The tail rotor servo remained attached to the TGB center housing. The pitch change shaft remained attached to the tail rotor servo with its attaching hardware installed and intact (**Photo 20**). Impact damage on the inner diameter of the inboard end of the pitch change shaft was observed; the damage was consistent with impact by the link connecting the pitch change shaft to the tail rotor servo.



**Photo 20. The tail rotor servo and pitch change shaft after removal from the TGB.**

### 3.3 TAIL ROTOR DRIVE SHAFTS

The aft section of the No. 3 TRDS, with its hangar bearing sleeve and aft flange, was the only recovered section of the No. 3 TRDS. The aft section of the No. 3 TRDS remained attached to the forward section of the [severed] No. 4 TRDS via flexible coupling. The No. 3 TRDS, the forward section of the No. 4 TRDS, and their mating flexible coupling all exhibited heat distress.

The No. 4 TRDS was received in three sections: the forward section (attached to the No. 3 TRDS), the center section, and the aft section (attached to the IGB). The entirety of the center section exhibited heat distress, with the forward end of the center section exhibiting a flattened appearance with a hole of missing material (**Photo 21**). Heavy soot deposits were observed from the midpoint to the aft end of the center section. The forward end of the aft section of the No. 4 TRDS also exhibited heavy sooting. Rotational smear marks were observed near the fracture of the aft section (**Photo 22**). The aft section of the No. 4 TRDS remained attached to the IGB input flange via flexible coupling.

The No. 5 TRDS was received as a single assembly that was disassembled from the IGB and TGB (**Photo 21**). There were no signatures of cracks or fractures in the No. 5 TRDS.

An unlabeled TRDS airframe mount was also recovered from the accident site (**Photo 21**). The mount contained two flange ends connected to each other via flexible coupling and a hangar bearing sleeve. The entire assembly exhibited significant heat distress.



**Photo 21. The No. 4 TRDS (bottom shaft), No. 5 TRDS (top shaft), and unlabeled TRDS airframe mount (red arrow).**



**Photo 22. The No. 4 TRDS with the rotational smear marks near the fracture. [photo courtesy of SAC]**

### 3.4 INTERMEDIATE GEARBOX

The IGB was received as a single assembly (**Photo 23**). Examination of the exterior of the IGB revealed no evidence of cracks or fractures. Rotation of the input pinion by hand resulted in the corresponding rotation of the output gear, exhibiting continuity of drive. The IGB exhibited no significant signatures of heat distress.



**Photo 23. The recovered IGB as received. The No. 4 TRDS remains attached to the input flange.**

#### 4.0 BIRD REMAINS (SNARGE) EXAMINATION OF THE EMPENNAGE

On September 5, 2013, the ‘blue’ and ‘black’ tail rotor blades were brought to the Smithsonian Institution National Museum of Natural History’s Feather Identification Lab in Washington, DC to sample the blades for evidence of bird remains. No significant evidence of bird remains was found. On September 24, 2013, a specialist from the United States Department of Agriculture (USDA) Wildlife Services in LA, with oversight from representatives from Era Helicopters and the FAA, took 46 samples from the horizontal and vertical stabilizers and tail rotor area of the helicopter wreckage to test for evidence of bird remains. The samples were sent to the Feather Identification Lab in Washington, DC. No bird remains were found in any of the samples. Attachment 3 contains the memo from the Feather Identification Lab regarding the results of the sampling.

#### 5.0 TAIL ROTOR MAINTENANCE

##### 5.1 TAIL ROTOR BLADE AND SPAR INSPECTIONS PRESCRIBED BY SAC

The S-76 25-hour inspection checklist includes an inspection of the tail rotor spar which prescribes the flapwise flexing of the tail rotor blade to audibly inspect for evidence of disbonding by listening for “clicking” or “squishing” sounds; this check has been colloquially called the “flex check” or “wiggle check”. Additionally, a “force-deflection check” follows the flex check and requires the mechanic to “take notice of force required to move blade through a 2- to 3-inch range at tip” in order to detect a significant reduction in stiffness. If a significant reduction in stiffness is noted, a subsequent inspection involving a spring scale is required to determine if a blade will need to be removed for further detailed inspection of the blade spar. These inspection procedures can be found in Table 2-2 of the Sikorsky S-76 Composite Materials Manual No. SA 4047-76-5.

The S-76 50-hour inspection checklist includes an inspection of the tail rotor blade assembly, including the torque tube and airfoil region, spar attachment region, pitch horn, rubber boot, and the leading edge polyurethane patch for disbonding. These inspection procedures can be found in Table 2-2 of the Sikorsky S-76 Composite Materials Manual No. SA 4047-76-5.



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The S-76 tail rotor 500-hour inspection, found in Sikorsky S-76 Maintenance Manual No. SA 4047-76AA-2, requires a borescope inspection of the leading and trailing edges of the tail rotor spar for cracks and delamination, as well as an inspection for flatwise centerline cracks inboard and outboard of the bumper contact pad, adjacent to the pivot bearing retainer.

The S-76 tail rotor 1,500-hour inspection, found in Sikorsky S-76 Maintenance Manual No. SA 4047-76-2, requires a portion of the inspection to be performed with the blades in their installed position and the remainder of the inspection to be performed with the blades removed. The first three steps of the 1,500-hour inspection focuses on inspecting the blade-to-spar bolted joint for looseness and measuring the radial play of the pitch change shaft. The remaining steps (steps 4 thru 14) include inspections for corrosion, removal of the pivot bearings for an elastomeric bearing inspection, and a borescope inspection of the spar for cracks. When a tail rotor blade set is sent to an overhaul and repair facility for a 1,500-hour inspection, steps 1 thru 4 are typically not performed by the overhaul and repair facility because the tail rotor is not in its installed configuration (steps 1 thru 3 of the 1,500-hour inspection) and because the pitch control rod and retention plate attaching bolts are not sent in with the tail rotor (step 4 of the 1,500-hour inspection).

Attachment 4 contains the S-76 tail rotor 500-hour and 1,500-hour inspection procedures as found in S-76 Maintenance Manual No. SA 4047-76AA-2, Chapter 65-21-00.

## 5.2 TAIL ROTOR BLADE AND SPAR INSPECTIONS PERFORMED BY ERA HELICOPTERS

According to Era Helicopters, an airworthiness check, performed every 25 flight hours, is required prior to releasing the aircraft for flight. The airworthiness check requires an inspection of the tail rotor blades for cracks, security, and condition. Furthermore, the airworthiness check requires a tail rotor spar inspection identical to that prescribed by the 25-hour inspection checklist for the S-76.

Additionally, the tail rotor inspections prescribed by the manufacturer's 50-hour checklist and the 500-hour and 1,500-hour inspections have also been incorporated into Era Helicopters' scheduled inspections of the S-76 tail rotor.

## 5.3 TAIL ROTOR BLADE ASSEMBLY (S/N A137-00708X) MAINTENANCE HISTORY

The 'red'/'yellow' blade assembly, S/N A137-00708X, was manufactured by SAC on June 14, 1984. The spar, part number (P/N) 76101-05017-045 and S/N A116-01207, was manufactured on May 16, 1984. According to maintenance records, all life limited components to blade assembly S/N A137-00708X were original since blade assembly manufacture with the exception of both pitch horns, which were replaced on October 25, 2007 due to the original pitch horns exceeding their life limit of 12,000 hours. According to the manufacturer's airworthiness limitations, tail rotor blade spar P/Ns 76101-05017-044 and -045 have an "on condition" replacement time as long as the spar fits any of the following descriptions: 1) spar S/N 1755 and subsequent; an 'X' suffix added to the S/N; or ASB 76-65-40 was complied with. The 'red'/'yellow' blade assembly had a TSN of 12,222.3 hours at the time of the pitch horn replacement. Attachment 5 contains the component records for blade assembly S/N A137-00708X.

Blade assembly S/N A137-00708X was last removed from helicopter N578EH on January 7, 2012, with the cause for removal listed as paint erosion and a 1,500 hour inspection that was due. Blade assembly S/N A137-00708X was subsequently sent to Bell Helicopter Broussard, formerly Rotor Blades Inc. (RBI), in Broussard, LA. Work performed on the blade assembly by Bell Helicopter Broussard, under work order no. S76T-137-00708, included replacement of the polyurethane strips, rubber boots, and compliance with the 500-hour and 1,500-hour inspections. The airworthiness approval tag (FAA form 8130-3) for blade assembly S/N A137-00708X, signed on March 22, 2012, stated the blade was also refinished and balanced. On April 18, 2013, the FAA Baton Rouge FSDO discovered that the S-76 tail rotor blade 1,500-hour inspections were being improperly signed off because the first four steps of the 1,500-hour inspection were not being performed at Bell Helicopter Broussard; the airworthiness approval tags were stating the 1,500-hour inspection was being performed with no details on the specific steps performed at the facility, implying the full 1,500-hour inspection was complied with. Attachment 6 contains BHTI work order S76T-137-00708.

According to Era Helicopters, blade assembly S/N A137-00708X was kept in storage at Era Helicopters' facilities in Lake Charles, LA until January 29, 2013, when the blade assembly was installed on the accident helicopter. On January 29, 2013, the ATT was 6,759.8 flight hours and blade assembly S/N A137-00708X had a time since new (TSN) of 14,800.5 flight hours. The accident helicopter accumulated about 5.9 flight hours from the 'red'/'yellow' blade installation onto N574EH until the accident flight.

#### 5.4 RECENT TAIL ROTOR MAINTENANCE HISTORY FOR N574EH

After blade assembly S/N A137-00708X was installed on the accident helicopter, maintenance records showed that an airworthiness check was performed on March 3, 2013 using the criteria required by the Era S-76 helicopter emergency medical services<sup>11</sup> (HEMS) approved airworthiness inspection program (AAIP). The airworthiness check was directed by an Era Helicopters Fleet Campaign Directive (FCD) No. FCD-000119-2012, which required a maintenance supervisor or lead to perform an airworthiness check of the aircraft with the technician. The S-76 HEMS AAIP airworthiness check requires inspection of the tail rotor blades for cracks, security, and condition, including a tail rotor spar flex check and force-deflection check.

A tail rotor ground balance and a tail rotor light-on-wheels<sup>12</sup> (LOW) balance were performed and signed off by the operator's technician on March 7, 2013, and by the operator's inspector on March 9, 2013. The tail rotor ground balance resulted in a reading of 0.06 inches-per-second (IPS) while the tail rotor LOW balance resulted in a reading of 0.12 IPS. The records for the tail rotor balance weight quantity and location were not retained by Era Helicopters.

Attachment 7 contains the Era Helicopters task tracking cards for the tail rotor and the package for the AAIP performed on March 3, 2013.

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<sup>11</sup> According to Era Helicopters, N574EH was inducted for maintenance on November 27, 2012 for conversion from a HEMS configuration to an offshore transport configuration.

<sup>12</sup> The S-76 tail rotor LOW balance requires a qualified pilot to increase main rotor collective pitch until the helicopter is light on its wheels at a minimum of 50% dual engine torque.

## 5.5 TAIL ROTOR OVERHAUL AND REPAIR PERFORMED AT BELL HELICOPTER BROUSSARD

Because of the relatively low time in service from the ‘red’/‘yellow’ blade assembly’s last 1,500 hour spar inspection, the Airworthiness Group examined the S-76 tail rotor 1,500-hour inspection procedures for deficiencies and maintenance actions that could either damage the spar or affect the stresses on the spar. One particular action that was examined during the spar inspection is removal of the pivot bearing. Pivot bearing compression screws are used to compress the pivot bearings in order to remove them from the tail rotor blade assembly. Within the pivot bearing replacement procedures, found in Sikorsky S-76 Maintenance Manual No. SA 4047-76AA-2, exists a caution during the installation of the pivot bearings that states: “Ground support compression screw is not flight hardware. Make sure compression screw is removed before completing maintenance.” The Airworthiness Group determined that a compression screw within the pivot bearing would increase the stiffness of the pivot bearing and could increase the bending stresses on the spar during blade flapping.

On July 23, 2014, representatives from the NTSB, the FAA, SAC, BHTI, and Era Helicopters convened at Bell Helicopter Broussard to evaluate: 1) whether it was possible for a compression screw to remain installed within the tail rotor spar pivot bearing during final assembly of a tail rotor blade set; 2) the likelihood of detecting of a compression screw left within the pivot bearing after final assembly of the blade set; and 3) the likelihood of detecting a cracked or delaminated spar via the flex check. The testing was focused on only the tail rotor blade set and did not extend to a simulation of a blade set installed onto an actual helicopter. A scrap, assembled tail rotor blade set, consisting of one spar with two blades attached to the spar, and associated attaching hardware was provided by SAC for the purposes of testing.

### 5.5.1 PIVOT BEARING COMPRESSION SCREWS

The pivot bearing replacement procedures, found in chapter 65-21-01 of Sikorsky S-76 Maintenance Manual No. SA 4047-76AA-2, requires the use of a compression screw, CR Industries P/N B40-926377 with a 7/8 inch long grip, for compressing the pivot bearing in order to facilitate removal or installation of the pivot bearing from the tail rotor blade assembly (**Photo 24**). A compression screw is included with each new pivot bearing; the screw is partially installed within the screw slot of the new bearing.



**Photo 24. Exemplar compression screw, P/N B40-926377.**

According to BHTI, the Bell Helicopter Broussard facility had modified the compression screw by cutting a slot in the compression screw head in order to facilitate a flathead screwdriver. Bell Helicopter Broussard stated they modified the compression screws “about 10 years ago” in order to allow for increased torque when compressing the pivot bearings. When asked about the tooling control processes in place to prevent a compression screw from being inadvertently left within the pivot bearings, the facility stated the same two modified compression screws had been used for about the last 10 years for “all S-76 tail rotor [pivot] bearing removals and replacements”, and provided a photo dated January 16, 2014 of the “same modified screws” (**Photo 25**). The compression screws were discarded by Bell Helicopter Broussard in late-January 2014; the NTSB was not informed of this action until June 18, 2014, at which time the NTSB requested Bell Helicopter Broussard replicate the modified compression screws for the purposes of testing (**Photo 26**). The grip length of the modified compression screw set was measured to be about 7/8 inches.



**Photo 25. Modified compression screws used at Bell Helicopter Broussard.** [photo courtesy of BHTI]



**Photo 26. Replicated modified compression screws used for testing at Bell Helicopter Broussard.**

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### 5.5.2 COMPRESSION SCREW AND PIVOT BEARING TESTING

The NTSB requested Bell Helicopter Broussard to utilize the same tooling that would have been used for tail rotor blade assembly S/N A137-00708X. A modified compression screw set was used to remove the pivot bearings from the test blade set. In order to document the condition of the spar from the test blade set, the pivot bearing and associated hardware were removed from the test blade set. The spar was visually examined for evidence of cracks and delamination and the pivot bearing retainer was tap tested for evidence of disbonds; no evidence of anomalies were found on the spar and pivot bearings. A test was performed to determine if the compression screw was able to be turned enough to cause the screw to protrude through the spar-side of the pivot bearing (through the pivot bearing plate which inserts into the retainer bonded to the spar). Turning the screwdriver by hand, it was observed to be extremely difficult to torque the screw enough to result in the screw protruding through the spar-side of the pivot bearing plate.

The test blade set was reassembled with the modified compression screw set still installed on both pylon-side and outboard-side pivot bearings. The blade with the pivot bearings with the modified compression screws still installed was labeled '1', while the blade with the pivot bearings without compression screws installed remained unlabeled. The nuts for the balance bracket on blade side '1' were initially run on finger-tight. After the test blade set was completely assembled, a visual examination of the outside of the blade revealed that there were no visual clues that would alert a mechanic or technician that a compression screw was still installed in a pivot bearing. The test blade set was then installed onto a blade paint stand via two studs with nuts securing the blade through two elliptical plug holes. A flex check was performed on the two sides of the blade.<sup>13</sup> A flex check of the blade without compression screws installed exhibited relatively free movement about the flapping direction. A flex check of the blade with compression screws installed was noticeably harder to move in the flapping direction, but the blade was able to be moved by hand. Similarly, when the pitch horns were manually moved to twist the blades, the blade with compression screws installed were noticeably harder to twist compared to the blade without the compression screw installed. The balance bracket nuts were torqued to 55 inch-pounds with no audible evidence heard of disbonding of the pivot bearing retainer. A flex check and blade twisting via pitch horn manipulation were performed again, with no noticeable difference from the initial testing when the balance bracket nuts were finger-tight. The test blade set was subsequently removed from the paint stand and the pivot bearings were removed. The spar was visually inspected for evidence of cracks or delamination and the retainer was tap tested for evidence of disbonds, none of which were found.

### 5.5.3 FLEX CHECK TESTING

A flex check was performed using the 'black'/'blue' spar from N574EH, already known to contain cracks. The 'blue' tail rotor blade and the 'black'/'blue' spar, both from N574EH, were reassembled using their original pivot bearings and attaching hardware. Only the 'blue' blade was assembled because the side of the spar for the 'black' blade completely fractured. The reassembled partial blade set was installed on the paint stand and a flex check was performed to listen for audible evidence of cracks and delamination. When performing the flex check, a faint

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<sup>13</sup> When the flex check is performed on the helicopter, the pitch horn would remain connected to the pitch beam via the PCLs and would remain stationary during the check. The available stand at Bell Helicopter Broussard could not simulate a stationary pitch horn during the flex check, but was instead manually held by investigative personnel. Thus when the blade was moved in the flapping direction, the pitch horn would move slightly.

but still audible “clicking” sound was heard. The ‘blue’ blade was subsequently removed and only the ‘black’/‘blue’ spar was installed on the paint stand. Flexure of the spar in this configuration resulted in a louder, but still relatively faint, audible “clicking” sound.

## 6.0 HISTORICAL S-76 TAIL ROTOR SPAR FAILURES

On September 9, 1986, a Sikorsky S-76B helicopter, registration N93AE, performed a precautionary landing without incident about 12 seconds after takeoff when the pilot heard a loud bang followed by a severe vibration.<sup>14</sup> The ‘yellow’ tail rotor blade fractured and separated from the tail rotor in flight, followed by the ‘red’ tail rotor blade. Both fractures on the spar occurred about midpoint between the elliptical centering plug and the outboard blade attachment point. The investigation found waviness in the composite plies of the ‘red’/‘yellow’ spar caused by a manufacturing anomaly, which led to reduced static strength of the spar. The spar had a TSN of about 0.5 flight hours. Due to the findings of this investigation, SAC released ASB No. 76-65-40 on July 15, 1987 to perform an inspection of the tail rotor spar for evidence of “waviness” of the plies and modified the spar manufacturing process to eliminate the potential for this anomaly. FAA Airworthiness Directive (AD) No. 86-19-14 was released on January 30, 1987 to remove certain serial numbered tail rotor blade assemblies from service and to replace them with a serviceable part. The AD stated that parts serialized with the suffix “X” were considered serviceable parts.

On August 19, 1991, a Sikorsky S-76A+ helicopter, S/N 760223, performed a precautionary landing on an offshore platform after the crew experienced a heavy vibration that lasted about 4 seconds.<sup>15</sup> The precautionary landing took place about 15 minutes after the crew experienced the heavy vibrations. Upon landing, two opposing tail rotor blades (part of an assembly sharing a common spar) were found to have departed the tail rotor. The missing tail rotor blades were never recovered. A small central section of the affected spar was found between the retention plates. The affected components were sent to SAC’s materials engineering lab for investigation. Lab examination revealed evidence consistent with one of the tail rotor blades fracturing first, and the resultant shift in the center of gravity and imbalance in centrifugal forces led to the opposing blade to eventually fracture as well. The remnant spar did not show evidence of ply waviness consistent with a manufacturing anomaly, rubbing of the plies consistent with spar delamination, or a material defect. The tail gearbox housing exhibited a partially circumferential overload fracture across three of the flanges used to attach the output housing to the center housing. Maintenance records revealed the tail rotor spar had a TSN of 1,571 hours, with 1,507 hours accumulated on the incident helicopter.

## 7.0 CORRECTIVE ACTIONS

On March 27, 2013, in a precautionary measure to assess the condition of their S-76 fleet, Era Helicopters released FCD No. FCD-000125-2013 that required an inspection of all flight controls and flight critical components for proper security and attachment. This inspection focused on the security of attaching nuts and confirmation that appropriate cotter pin and safety wire installations were present.

On April 26, 2013, as a follow on precautionary measure to assess the condition of installed S-76 tail rotor blades, Era Helicopters released FCD No. FCD-000130-2013 requiring 1) an inspection of S-76 tail rotor spars for disbonding via a flex check and 2) a visual inspection (without removal) of the pivot bearing installation. There was one blade assembly that was reported to have a suspected crack in

<sup>14</sup> More information about this incident, NTSB case number NYC86FA232, is available on the NTSB website at <http://www.ntsbt.gov/aviationquery/index.aspx>.

<sup>15</sup> No record of this event was found in NTSB databases.

the pivot bearing, observed via video borescope (**Photo 27**). No defects were noted in the remainder of Era Helicopters' S-76 fleet. The suspect blade assembly was removed and shipped to SAC for further inspection. Representatives from the NTSB, FAA, SAC, and Era Helicopters examined the suspect blade assembly and pivot bearing. Examination of the pivot bearing under a video microscope found a seam of adhesive in the area of the suspected crack, but did not find evidence of cracks, disbonding, or excessive wear within the elastomers of the pivot bearing.



**Photo 27. Suspected crack observed on the pivot bearing via video borescope.** [photo courtesy of Era Helicopters]

Since the April 2013 discovery that the 1,500-hour inspection was being signed off improperly at Bell Helicopter Broussard, the facility has since corrected their 1,500-hour inspection sign off by annotating the specific steps of the 1,500-hour inspection that were completed by the facility.

After the modified compression screws were discarded, Bell Helicopter Broussard stated they would use unmodified compression screws for future pivot bearing removals and installations. The facility also stated they would utilize a shadowbox toolkit<sup>16</sup> specific to the S-76 tail rotor blade 1,500-hour inspection with tools, including the pivot bearing compression screws, colored in yellow for better visual identification.

Chihoon Shin  
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<sup>16</sup> A shadowbox toolkit is a toolkit which outlines each tool contained within the kit and usually contains tool used for a specific work process. A shadowbox toolkit helps a mechanic or technician account for all tools at the end of a work process based on whether all tools are within their outlined areas. This method of tool accountability is used to reduce the likelihood of inadvertently leaving tools within a component that is being worked on.