NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C.

April 24, 2002

SYSTEMS / AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT OF THE INVESTIGATION

A. ACCIDENT MIA00FA030

LOCATION:	**Philadelphia, Mississippi**
DATE:	**November 27, 1999**
TIME:	**1445 central standard time (CST)**
AIRCRAFT:	**Bell 212, N8144M, operated by Houston Helicopters, Inc**.

B. GROUP MEMBERS

Group Chairman: Thomas R. Conroy, Air Safety Investigator
National Transportation Safety Board
Office of Aviation Safety
Regional Operations and General Aviation Division, AS-20, Washington, D.C. 20594

Mr. Ronald Price, Aerospace Engineer (Helicopters), NTSB, Office of Aviation Safety, Engineering Division, AS-40; served as Group Chairman until August 2001, including overseeing engineering examinations at Bell Helicopter TEXTRON, Fort Worth, T*exas* (BHT), December 8 - 9, 1999

Note: Two series of Materials Laboratory Examinations were conducted at Safety Board Headquarters. The first is addressed as "Materials Laboratory Factual Report" no. 00-141, dated October 19, 2000, by NTSB Materials Engineer Lori Lee Darrow (Attachment **6**, below). The second took place January 15 – 17, 200***2*** (also referenced below), the factual report of which will be released under separate cover by NTSB Senior Metallurgist Joe Epperson.

Party Coordinators: 1) Federal Aviation Administration (FAA):

Mr. Edward Aycock, Inspector
Flight Standards District Office (FSDO)
Jackson, Mississippi

Also representing FAA:

a) Mr. M. Kohner, FSDO, Fort Worth, Texas, represented FAA at the examinations at BHT, December 8 - 9, 1999

b) Mr. Al Michaels, National Resource Specialist, Dulles International Airport, Virginia, represented FAA during aircraft records examination at NTSB Southeast Regional Office, Aviation, Miami, Florida (SERA), September 5 - 6, 2001

2) Bell Helicopter TEXTRON, Inc. (BHT):

Mr. Roy Fox, Chief, Flight Safety
Fort Worth, Texas 76101

Note: Mr. Fox replaced Mr. Matthew Rigsby as party coordinator, December 2001, and represented BHT at Laboratory Examinations and a Technical Review at Board Headquarters, January 15 - 17, 2002. BHT Chief Metallurgist Clayton Darrow also participated in the January 15 – 17, 2002, examinations.

Mr. Rigsby served as BHTs' party coordinator from the time of the accident, including at the site, and at laboratory examinations at BHT, December 8 - 9, 1999 and September 11 – 12, 2001, as well as during a maintenance history review at the Safety Board's Southeast Regional Office, Miami, September 4 – 6, 2001.

3) Houston Helicopters, Inc. (HHI)

Mr. Stephen G. Smith, Chief Inspector
Pearland, Texas

Note: About August 2001, Mr. Smith replaced Mr. A. Grimes as HHI's party coordinator. Mr. Grimes represented HHI during the on-site investigation and examinations at BHT, December 8 - 9, 1999

C. SUMMARY

C.1 SUMMARY of ACCIDENT

On November 27, 1999, about 1445 CST, a Bell 212, N8144M, Bell serial no. 30706, registered to Houston Helicopters, Inc. (HHI), crashed near Philadelphia, Mississippi, while on a Title 14 CFR Part 91 positioning flight. Visual meteorological conditions prevailed at the time and no flight plan was filed. The helicopter was destroyed, and the airline transport-rated pilot and one passenger were fatally injured. The flight last departed Tuscaloosa, Alabama, the same day, about 1405.

Witnesses observed the helicopter flying from east to west, about 150 feet above ground level (agl), rolling back and forth. They then observed the main rotor blades (MRBs) contact the tail area, and the aft tail boom and tail rotor (TR) separate. Shortly after this, the main rotor (MR) separated, and the helicopter descended and crashed to the ground. A fire erupted during ground impact.

C.2 SUMMARY of INVESTIGATION/EXAMINATIONS

Under the direction of Investigator-in-Charge (IIC) Jeff Kennedy, of the NTSB's Southeast Regional Office, Aviation (SERA), Miami, Florida, a Systems Group (SG) was formed to examine and document the wreckage. On-site wreckage examination was conducted November 30 – December 1, 1999. Under SG Chairman (SGC) Ronald Price, the SG conducted wreckage examinations from December 3 - 9, 1999, including materials examinations at BHT's Engineering Laboratory, December 8 – 9, 1999.

The main transmission and main rotor installation (MRI), including fixed and rotating controls, and MRBs were recovered from the crash-site and shipped to the Engineering Laboratories of Bell Helicopter TEXTRON (BHT), Fort Worth, Texas, where the SG convened for examinations, December 8 - 9, 1999 (reference BHT Engineering Laboratories report, "Subject: Examination of Parts from a Model 212 Helicopter Operated by Houston Helicopters, Inc.," dated January 21, 2000, unsigned; **Attachment 1**). Included

in the December 8 - 9 examinations and discussed in the report were the following: Inspection of the MR grips for the color-coded red and white MRBs ("red" and "white" grips), and inspection of the pitch change horn (PCH) for the color-coded white MRB ("white" PCH). The "red" PCH was not found in the wreckage, and not found in accident site and flight path searches (for further description of these laboratory examinations, see "Tests and Research," section **4.0**, below).

Assisting the IIC, on-site, were party coordinators (PCs) for the Federal Aviation Administration (FAA), BHT, and HHI (Messrs. Edward Aycock, Matthew Rigsby, and A. Grimes, respectively). Convening at the BHT Engineering Laboratories for the December 8 - 9, 1999, examinations, under the direction of the SGC, were the PCs for BHT and HHI, and Mr. M. Kohner who represented the PC for the FAA.

The "pitch change link clevis, red blade, upper end"; and the "tail rotor gearbox output shaft," from the accident helicopter were sent to the Materials Laboratory, NTSB Headquarters, where they were examined and reported-on by Safety Board Materials Engineer Lori Lee Darrow, in Materials Laboratory Factual Report no. 00-141, dated October 19, 2000; reference **Attachment 6**, discussed below.

The SG reconvened September 5 - 6, 2001, at SERA for a records examination of the available operational and maintenance history of the "red" PCH and mating "red" MR grip. The IIC and new SGC (Thomas R. Conroy replaced Mr. Price, who had begun serving an extended period of active military duty) participated in the examinations, as well as Mr. Al Michaels, representing the PC for the FAA. The PCs for BHT and HHI (Mr. Stephen Smith replaced Mr. Grimes for HHI) participated as well.

September 10 - 12, 2001, the SG again convened, at the following:

a. HHI's headquarters, Pearland, Texas (September 10-11), for examination of main rotor installation (MRI) components, stored there, and the preparation of selected

components for further examination. Present were the SGC and the PC for HHI, as well as the president of HHI and various HHI technicians.

b. On September 11, the SGC and HHI's PC transported by van selected MRI components to BHT's Engineering Laboratories, Fort Worth, Texas, including both the "red" and "white" MR grips, and "white" PCH (the "red" PCH remains un-recovered). Present for the examinations at BHT, September 11 - 12, 2001, were the SGC, the PCs for BHT and HHI, and various BHT engineers and technicians. BHT Engineering Laboratories report, "Subject: Examination of Parts from a Model 212 Helicopter Operated by Houston Helicopters, Inc.," dated September 26, 2001, unsigned (**Attachment 2**), addresses the September 11 - 12, 2001, examinations (see also section **4.0**, below).

The SG again convened, January 15 –17, 2002, at Safety Board Headquarters, for a Materials Laboratory examination of the color-coded red and white main rotor grips and the white pitch change horn (reference report from Safety Board Senior Metallurgist Joe Epperson, released under separate cover), as well as for a Technical Review of factual materials.

D. DETAILS OF THE INVESTIGATION

1.0 DAMAGE

Wreckage of the Bell 212 Twin turbine helicopter was found along a 1400-foot debris path that was oriented along a course to the southwest, about 233 degrees magnetic. The accident site was nearly level and contained numerous small-diameter pine trees. A post-crash fire consumed a substantial portion of the forward fuselage as well as forward portion of the tail boom.

Note: An unsigned report was submitted by the BHT Party Coordinator to the IIC, entitled, "Factual Observations of Aircraft Mishap…," dated December 13, 1999 (reference **Attachment 3**). Contained in the report are sections describing "On-Scene Examination,"

"Records Research," 17 photographs of the site and wreckage, and a 1-page "Wreckage Diagram" or sketch of flight path and main component locations.

Beginning the wreckage examination at the front of the helicopter, the forward fuselage, including pilot compartment, was substantially consumed by fire. The pilot seats were burned-away, except for the seat frames (reference photograph **3.1** of **Attachment 3**). The main cabin was also consumed by fire. An assembly comprising the engines, engine mounts, and attached portion of airframe was found resting on its right side; it sustained substantial fire damage. The forward section of tail boom was extensively damaged by fire, including the tail boom-to-main fuselage attach points, back through the tail boom structure to a point aft of the synchronized elevator. The aft portion of the tail boom was separated from the forward section by means of a diagonal fracture that evidenced a MRB strike (reference photographs, **Attachments 4.a** and **4.b**, and photograph **3.4** of **Attachment 3**).

The main transmission, MRBs, aft portion of the tail boom, tail gearbox (TGB), tail rotor blades (TRBs), and portions of the windshield evidenced separation from the helicopter in flight, and were distributed along a debris path extending back on the route of flight to the northeast of the main wreckage. These components did not exhibit any fire damage, and showed no evidence of sooting, heat discoloration, or staining. The main transmission was integral up to and including the main rotor mast (reference photographs, **Attachments 4.c** and **4.d**.). The MR was separated from the mast. The mast exhibited an oval fracture face and evidenced main rotor head (MRH) to mast impact prior to separation (reference photographs, **Attachments 4.e** and **4.f**, and photograph **3.9** in **Attachment 3**). The main transmission was located about 300 feet northeast of the main wreckage; the aft portion of the tail boom was found about 450 feet east-northeast of the main wreckage; and the MRH and attached MRBs were found about 1200 feet east-northeast of the main wreckage. Fragments from the upper windshield or "greenhouse" were found in a wide area that began about 1400 feet northeast of the main wreckage (reference "Wreckage Diagram," last page of **Attachment 3**).

The entire MRI was accounted-for in the wreckage, except for the PCH for the "red" MRB and the majority of the pitch change link (PCL) that attaches to the "red" PCH at the PCL's lower rod end. The "red" PCL's upper rod end was found in the wreckage, still attached to the mixing lever within the stabilizer bar assembly. It exhibited a fracture surface and the majority of the "red" PCL remains missing beyond that surface (reference photographs **Attachment 4.g** and **4.h**; and "Main Rotor Installation" drawing, page **6-4**, Item **3,** contained in **Attachment 5**). The fractured "pitch change link clevis, red blade, upper end" was sent to the Safety Board Materials Laboratory for examination (reference Materials Laboratory (ML) Factual Report, no. 00-141, dated October 19, 2000, contained as **Attachment 6** and discussed further, below).

The "red" grip remained in place in the MRI. The surface of the "red" grip exhibited two boreholes that mated with two bushing that were part of the departed and missing "red" PCH. The mating grip surface exhibited a blackish residue near the PCH boreholes, and the blackish area extended beyond the boreholes (reference photograph **3.7**, "RED blade Grip," in **Attachment 3**). The FAA FSDO examiner, who, as party coordinator, examined the wreckage at the crash site, stated, in part, in his "Inspector's Statement" (**Attachment 7**),

> The blade grip with the missing pitch horn showed evidence of fretting (black deposits) where the pitch horn attached. In addition the holes[,] w[h]ere the pitch horn mounts, showed severe amounts of fretting and black deposits. The inserts had pulled out of the grip holes and could not be located (probably still with pitch horn).

The crash-site and an extended area back-up the wreckage path were searched extensively, including by Boy Scout parties; the "red" PCH and most of the "red" PCL were not found.

Note: **Attachment 5** is comprised of 40 party-submitted pages that provide some of the component part and serial nos. for the accident helicopter, as well as

weight/balance/performance data, and systems/components descriptions and drawings from "Bell 212 Twin" and related maintenance manuals/documents).

2.0 DRIVE SYSTEMS and FLIGHT CONTROLS

Pre-impact continuity of the flight control system was not established. There were separations in the system (reference photographs, **Attachments 4.i, 4.j,** and **4.k**), and post-crash fire consumed the majority of flight controls in the cockpit area. Flight control continuity was established beginning at the diagonal fracture separating the aft tail boom, back through the TGB bellcrank, immediately prior to the separated TGB.

Note: The TGB output shaft was recovered and found fractured on both ends. The TGB output shaft, and fractured and remaining PCL clevis for the "red" MRB were both examined at the ML, NTSB Office of Research and Engineering, Washington, D.C. The TGB output shaft fractures were found "…typical of torsional overstress separation." Scanning electron microscope (SEM) was used to assist in examin*ing* the clevis, which "…revealed elongated ductile dimples, consistent with a shear overstress separation. No fatigue striations or other microscopic features typically associated with progressive crack growth were noted…." (reference ML Factual Report, no. 00141, dated October 19, 2000, **Attachment 6**).

2.1 MAIN ROTOR CONROLS

The MR control system was examined from the transmission mounts up through the MRBs. The system was impact-damaged and fractured in several locations. The controls could not be manipulated because of numerous separations. As noted above, the grips for the color-coded red MRB ("red" grip) and white MRB ("white" grip) were recovered in the wreckage, as well as the pitch change horn for the white MRB ('white" PCH), but the mating "red" PCH and most of the attached "red" PCL were not found (reference photographs contained as **Attachments 4.l, 4.m**, showing the "red" and "white" main rotor grips, attached as part of the assembly to the fractured upper portion

of the main rotor mast, and **Attachment 4.n**, showing the attaching portion of the "white" PCH, including both bushings, photographed at the wreckage site). The face of the "red" grip (where it had been joined with and pressed against the mating surface of the "red" PCH, by means of two steel bushings that were part of the PCH assembly) was found unevenly discolored and the paint/primer on the face of the "red" grip was blackened (reference on-site wreckage photographs: **3.7**, "RED blade grip," in **Attachment 3,** and **Attachments 4.o, p, q, and r.**). The photograph contained as **Attachment 4.s**, shows the surface of the "white" grip, where it was joined-with the "white" PCH. The "white" PCH was found separated from the "white" grip (evidenced occurring at impact, reference BHT Engineering Laboratories report, dated September 26, 2001 (**Attachment 2**), described above (also reference section **4.0, "**Tests and Research," below). The grip-to-PCH mating surface on the "white" grip did not have the black-in-color residue that was found on the "red" grip.

Note: The two PCH bushings are secured in the grip holes by means of two torqued bolts (one for each bushing) that pass through the center of the bushings and are threaded into steel Rosan inserts, installed near the bottom of the grip holes (reference BHT-212-CR&O (Component Repair and Overhaul manual), Section 62-00-00, page **35**, "Figure 62-11. Main rotor hub outboard section (Sheet 1 of 2)," items 11, 14, 15, and 16; and page **64**, procedures regarding "10. Pitch horn (14, figure 62-11)"; both pages are contained within **Attachment 8,** which contains pages 33 through 78 of Section 62-00-00).

2.2 TAIL ROTOR DRIVE

The aft portion of the tail boom was examined for failures and malfunctions. The aft portion was fractured diagonally from left to right, separating the tail rotor drive shaft. The vertical stabilizer was integral to the aft portion of the tail boom. The 42-degree and 90-degree gearboxes were integral to their respective attach areas. The TRBs and tail rotor hub (TRH) were separated from the TR drive shaft and found near the TGB.

3.0 AIRCRAFT and COMPONENT HISTORIES

According to the aircraft records, the accident BHT Model 212 helicopter, serial no. 30706, was manufactured and delivered 05/16/1975, with an FAA Standard Airworthiness Certificate, Transport Category, Registry no. N90222, dated 5/7/75 (reference **Attachment 9**). It was originally sold to Petroleum Helicopters, Inc. (PHI), and used in the service of offshore oil support and associated missions.

Department of Transportation, FAA; and Transport Canada historical documents, **Attachment 10**, contain the following subsequent history for the helicopter: HHI acquired helicopter registration N90222, from PHI May 26, 1983 (reference Bill of Sale) and placed it into offshore and general service missions. HHI conveyed helicopter N90222, aircraft serial no. 30706 to Notlef, Inc., of Port O'Connor, Texas, November 15, 1984. A certificate dated April 6, 1994, shows "Deregistration of United States Civil Aircraft," Aircraft Registration No. 90222, Serial Number 30607, and the helicopter was "Exported to: Canada" (verbal evidence indicated that during this period the helicopter was leased to a Canadian company and continued in operation). Records further indicate that N90222, aircraft serial no. 30706 was sold by NotLef, Inc. (signed, Felton Baker, President), to HHI, June 6, 1994, and subsequently, "Aircraft Serial Number 30706, Registration Mark C-FSAI" was "…removed from the Canadian Civil Aircraft Register effective July 7, 1995." On October 7, 1995, HHI made an "Aircraft Registration Application" the United States Department of Transportation (DOT), FAA, for "Aircraft Serial No. 30706," as United States Registration Number N8144. The DOT, FAA record then shows that Aircraft Serial No. 30706, U.S. Registration Number N8144M was sold October 15, 2001, by HHI (President Felton M. Baker) to Mr. Baker, Friendswood, Texas. Lastly, the DOT, FAA record shows Aircraft Registration Application by Felton M. Baker of U.S. Registration Number N144M, Aircraft Serial No. 30706, October 15, 2001.

The helicopter was inspected by HHI in accordance with Part A, "Scheduled Inspections," BHT-212-MM, Chapter 5. **Attachment 11** contains "Work Order no. 03-99-

044, page 1 of 3," dated April 12, 1999, at "ACFT Total Time 11,243.7" which states, "Work Performed: Completed 100 Hr. and Annual Inspection."

An HHI "Pilot and Maintenance Report," under "Pilots Enter Discrepancies," contains an entry, "25 & 50 HR Insp Due." Next to the entry, under "Mechanics Enter All Maintenance Performed," the following is entered: "C/W [complied with] 25 HR & 50 HR Insp PER MAINT MANUAL And found A/C 8144M A/C T.T. 11288.7 to be in Airworthy Condition, 23 September 99" (reference HHI Maintenance Form 10, page 09957, contained in **Attachment 12**). The entry is signed and an A&P mechanic's no. is entered.

An "HHI Maintenance Form 10" entry for the accident helicopter, contains signatures and A&P numbers indicating the completion of daily and preflight inspections on "11/5/99." The entry records, in part, "…that the Daily inspec. Has been accompl…[at] A/C Total Time 11,302.2" hours (page is contained in **Attachment 12**). During records examination, the operator's Chief Inspector stated that November 5, 1999, was the last duplicated-entry for the helicopter at home base, prior to departure on a "ferry" flight beginning November 17, 1999. Flight away from home base continued until the accident flight on November 27, 1999.

The above "HHI Maintenance Form 10," dated "11/5/99," also contains under "Pilot and Maintenance Report," space for "Pilots <u>To</u> Enter Discrepancies," and "Mechanics Enter All Maintenance Performed." Next to three "…Discrepancies" that are entered are three "Maintenance [actions] Performed," as follows (all three Maintenance Performed actions are accompanied by a signature and "A&P mechanic's number):

"Check M/R servo alignment" [action] "Realigned lateral servos"

"Track and Balance M/R [action] "Performed track & Bal. Check & adjust"

"adjust autorotation RPM" [action] "adjusted auto RPM per M&M"

The "Next Inspection Due, 100 Hr. A B [was entered as] 11,343.7" hours.

This photographically-duplicated page is the last maintenance entry that was recovered for the accident helicopter.

Subsequent flight times (from flight on November 17, 1999, to final flight hours) and any associated maintenance write-ups or inspections (the HHI Chief Inspector stated) would have been recorded in the aircraft logs, which were not duplicated because the helicopter was away from home base. The logs were recovered burned and obliterated in the wreckage. **Attachment 13** contains flight times subsequent to November 5, 1999, beginning with a flight on November 17, through the accident flight on November 27, 1999. The Chief Inspector further stated that this data was obtained from daily call-in records from the helicopter crew to the operator's main facility, Pearland, Texas.

Note: BHT's "Factual Observations…." Report (**Attachment 3**, discussed above) also summarizes aircraft "Records Research" that occurred prior to that report's publication date, December 13, 1999. Subsequent aircraft/maintenance records examinations took place during a reconvening of the SG at SERA, September 5-6, 2001, that concentrated on the history of the PCH and grip for the "red" MRB, and during a Technical Review of factual materials with Party Coordinators, which was carried-on concurrently with Materials Laboratory examinations of the accident "red" and "white" main rotor grips and "white" PCH (see NTSB Materials Laboratory report, released under separate cover), at Safety Board Headquarters, January 15 – 17, 2002. Records and manuals also were examined at a reconvening of the SG at BHT's Engineering Laboratories, September 11-12, 2001, and elsewhere. Records examinations described in the December 13, 1999, BHT report, and subsequent records examinations and reports are also discussed in Section **4.0,** below.

3.1 HISTORY of ACCIDENT MR HUB, PCHs, and MR GRIPS

Records indicated that the "red" PCH, Part No. 204-011-120-5, serial no. HT-834, and "white" PCH were originally installed on a Bell 212 on May 10, 1976, and sold as an

export airworthiness helicopter to the government of Singapore, then sold by Singapore on a different aircraft to Bristow Helicopters. Reference a letter from the president of MSI Helicopters, Inc., (**Attachment 14.a**) dated September 17, 2001, to SGC, comprising pages 2 through 4, of 8 faxed pages from MSI Helicopters. The letter states, in part,

> …Singapore Airforce purchased 3 Civilian Bell 212 Helicopters from Bell. The [Bell] S/N's were 30785, 30787, and 30791. They gave them the designation #210 (30785), #211 (30787), and #212 (30791)….
>
> …the helicopter was originally purchased by Singapore, and …the pitch horns changed between all three of these helicopters numerous times, as shown by the Component Log Cards.

A copy of a "Component Log Card" for "Pitch Horn" part no. "204-011-120-5," serial no. "HT-624," (accident "white" PCH) containing entries for "Installation [and] Removal Details" from 1978 to 1985, is contained as page 5 of the above MSI fax (reference **Attachment 14.b**); and a copy of two pages of "Component Log Card[s]" for "Main Rotor Hub Assy," part no. "204-012-101-29," serial no. "ADA-53552" containing entries for 1978 to 1987, is contained as page 6 of the fax (reference **Attachment 14.c**). A "Change of Serviceability Log" for helicopter "(212) S/N 30791," referenced in the letter, above, is contained as pages 7 and 8 of the fax (reference **Attachment 14.d**). The investigation recovered separately a "Component Log Card" for "Pitch Horn" part no. "204-011-120-5," serial no. "HT-834" (serial no. of the accident "red" PCH), containing entries from "Installation" "21 May 1978" at "Comp. Hrs. NIL" to "Removal" at "1634.9 Total Comp. Hrs." date not listed (last "Removal [of] Pitch Horn [follows last] Installation [entry on] 11/10/85 [at] 1509.6 Comp. Hrs." (reference **Attachment 14.e)**

A December 16, 1999, letter from the president of HHI to the IIC (reference **Attachment 15**), also addresses the Singapore Air Force's purchase, usage, and sale of three helicopters associated with the accident "red" PCH during that period. It states in part,

Historical Service Record for the Pitch Horn S/N HT-624 were tracked by a/c no's until 11-10-85 and then assigned to Main Rotor Hub Assy P/N 204-012-101-29, s/n no. ADA 53552.

As you can see, for some unknown reason, these Pitch Horns, and later Main Rotor Hub Assy s/n ADA 53552 were swapped around continuously between these 3 Bell 212's, a/c nos. 211, 210, and 212.

On September 5-6, 2001, the SG reconvened at SERA, and met with the IIC. All then-available records had been forwarded to SERA, and a maintenance/operational history of the "red" PCH and grip was accomplished. The outline in section **4.2.1,** below, summarizes a retracement of records, and specifically regards the accident "red" PCH and MR grip**,** from the date of the accident back to original installation following manufacture.

The September 2001, reconvening of the SG also inquired into MSI-provided information to the president of HHI including historical information regarding the accident "red" PCH while in service with the Singapore Air Force (reference letter from MSI to HHI, dated December 13, 1999; **Attachment 16,** contains the 2-page letter). **Attachment 17** contains two December 14, 1999, letters from MSI to HHI, that discuss disposition of the "red" PCH, during the period 1985, '86, and '87 (**Attachment 17** also includes 3 pages of records that were attached to the MSI correspondence, as well as a fax cover sheet).

Also examined the reconvening of the SG at SERA were two "Serial Number Check List[s]" (SNCLs), provided by HHI, and a "Computer Run Sheet" (reference **Attachments 18.a, 180.b, and 18.c**, respectively). Each of these attachments regards the status of components on the accident helicopter, N8144M, and specifically regards the accident "red" and "white" PCHs, as follows:

1) SNCL (**Attachment 18.a**) indicates an aircraft total time of 11,153.8 hours, but is not dated. By reference to the data on

accompanying aircraft records, the date at 11,153.8 total flight hours is March 25, 1997. The SNCL states that the "2 [PCHs are serialized as] HT834 [and] HT624."

2) A second SNCL from HHI, at an aircraft total time of 11,159.0 hours (reference **Attachment 18.b),** and, extrapolated from accompanying documents, regards aircraft status on April 4, 1998, states that the "red" and "white" PCHs are serialized as HT829 and HT624, respectively.

3) An HHI "Aircraft Maintenance System [computer-generated] Aircraft Status Report (reference **Attachment 18.c**), indicating an aircraft total time of 11,302.2 hours, states, "Date of last flight 11/05/99 [and the PCHs are recorded as] component serial no[s]. HT-834 [and] HT-624."

In a telephone interview, January 16, 2002, an HHI maintenance employee, who stated that during the above-described 1997 – 1999 period he held the position "overhaul mechanic," stated that the "HT-829" entry (dated "4/4/98" and referenced as **Attachment 18.b**, above) was "a mistake," and that the person who made the entry was no longer employed by the operator. The interviewed employee stated that the person making the entry, in recording the serial numbers, may have looked-up to the "red" PCH while it was positioned in-line with the main rotor hub's data plate, and mistakenly copied the last three numbers of the hub's serial no.

The BHT "Historical Service Record," (HSR) maintained by HHI, for "M/R Hub Assy., part number 204-012-101-029G, lists the serial number for the MR hub as "FB-71829," (reference A**ttachment 19.a.**) and the MR hub was recovered in the wreckage with that serial no. on the data plate. No record, other than one page provided as **Attachment 18.b**, indicates that a PCH serialized as "829" was installed on the

helicopter, and there was no other record found that indicated that HT834 had been replaced by another PCH subsequent to its installation on the accident helicopter.

The HSRs for both accident PCHs indicate that they were initially installed on "1/12/93 [on MR hub serial no. FB-71829, at] hub hours 2500.0." The HSRs further indicate "removal [on] 7/14/95 [and reinstallation of the PCHs onto to the same/accident main rotor hub on] 3/25/96 [and] removal [of the PCHs on] 3/20/98 [and reinstallation on the same/accident main rotor hub on] 4/3/98" (reference **Attachment 19.b**, for the "red" PCH serial no. HT-834, and **Attachment 19.c**, for the "white" PCH, serial no. HT-624). There is no indicated "removal" or replacement of the PCHs, subsequently, in the record.

The HSR for the "red" MR grip, serial no. GD9312-6, recovered in the wreckage, (reference **Attachment 19.d**, and also BHT Engineering Laboratories report, dated 26 September 2001, **Attachment 2**, and NTSB Materials Laboratory Report, released under separate cover) indicates that the "part number [grip] 204-011-121-009 [was] Removed at Hub Hrs. [blank] July 1985 [at] Comp. Hrs. Since New 4334.1 [and] Since O/H 1959.6 [and] Installed on Hub No. FB-71829, By (Activity) HHI, Installed at Hub Hrs. 2500.0, Comp. Hrs Since New 4334.1, Since O/H – 0 -." Following "Removal Data [for] 2/2/94 [at] Removed at Hub Hrs. 2518.6, Comp. Hrs. ++.7, Since O/H 18.6 [for] Overspeed Insp," the second and last "Installation Data" entry on this HSR form is for "Date 2/10/94, Installed on Hub No. FB71829, by (Activity HHI, Installed at Hub Hrs 2518.6, Comp. Hrs. 4352.7, Since O/H 18.6." There is no subsequent "Removal" on this HSR form.

A separate HSR form submitted for the accident "red" M/R Grip, "Serial Number GD 9312-6 [states] Installed on Hub No. ADA-08684, By (Activity) BHT, Installed at Hub TT –0-, Comp. Hrs. Since New –0- [and] Since O/H –0-." Under "Removal Data" on the second HSR form is entered "Date July 85, Removed at Hub TT 4334.1, Comp Hrs Since New 4334.1, Since O/H 1959.6, Reason for Removal Sent to Bell for repair."

HHI "FAA Repair Station Work Order GURR498E, no. 2-941712 [dated] 2/11/94" [signed by the repair station] inspector" (reference **Attachment 20**, containing referenced and additional "HHI, FAA Repair Station No. GURR498E" forms and associated pages) states under "Work Performed,"

> C/W [complied with] Conditional Inspection Bell 212-CR&O Chap 62 Para 20 Page 36 to 44 for overspeed Insp.
>
> C/W overhaul Inspection I/A/W [in accordance with] Bell CR&O Manual & all maint manuals.
>
> T.T. [total time] 2518.6. TSO [time since overhaul] - 0 -. MR Hub FB 71829

In telephone interview, the HHI maintenance employee, referenced above, who stated that his title was "overhaul mechanic" during the above period, also stated that the PCH was separated from the grip as part of a post-overspeed inspection, but this action was not recorded on a HHI FAA Repair Station no. GURR498E," maintenance document. He further stated that the "removals" of the PCHs listed in the HHI HRS were for "strap inspections," and did not involve separations of the PCHs from the grips.

The HSR for the accident "M/R Hub Assembly, FB-71829" (**Attachment 19.a**) also states that following removal of the MR hub on 7/14/95, from aircraft N49673, it was installed on 3/25/96, on the accident aircraft, "N8144M Installed at A/C Hrs. 11050.2 [and] Comp. Hrs. Since New 2785.5." From the HSRs for the MR Hub and the PCHs, the compiled times for the PCHs indicate that from a "Comp. Hrs. Since New [of] 1634.9" for each PCH upon installation on the accident hub, on "1/12/93," the two PCH/MR grip assemblies compiled an additional 556.6 flight hours as installed in the accident MR hub. Of those 556.6 hours, the two accident PCH/MR grip assemblies accumulated 266.9 hours while the accident MR hub was installed on Bell 212, N49673, operated by HHI, and 289.7 flight hours on the accident helicopter, N8144M.

The HSRs referenced above (**Attachments 19.a – c**) state that the PCH were installed in the MR hub on "1/12/93" at "Installed at Hub Hrs. 2500.0" and the MR hub was installed on aircraft N49673 at "M/R Hub Assy" "Comp. Hrs. Since New 2500.0"

The HSR for "M/R Hub Assy, FB-71829" (**Attachment 19.a**) also states, under the title "Historical Service Record, [a penned entry] 2400 HR. O/H." Under the "technical Directives and History of Overhaul" section of the HSR, page 1, it also states, in part,

> Component assembled from new & used serviceable parts under HHI work order 11-92-1637 Hub Total Time Srt @ 2500.0 Total Time, Time Since Overhaul 0.0, date 1/12/93

There is no indication in the documents from where the time "2500.0" is compiled.

A letter from the president of HHI to the IIC, dated August 24, 2001 (**Attachment 21**) addresses component histories, including locations, of the accident "red" PCH and "red" grip, and their installation as an assembly into the MRI of accident helicopter, as well as the wreckage examination of the "red" Grip. The letter states in part,

> The Bell Helicopter investigative report [dated January 21, 2000, **Attachment 1**] and laboratory examination of the grip of the subject helicopter established that there were no Rosan fittings or locks in the grip. Those fittings serve to secure the pitch horn-to-grip bolts by which the horn would be bolted to the grip. The red pitch horn and its hardware were never found although the clevis which would have attached the horn pitch link was still attached in the wreckage.
>
> You may have noted in the previously provided maintenance records and specific historical service record for the main rotor grip GD93126 (the red grip), that the grip was sent to Bell Helicopter for overhaul in 1985. It was

not until 1994 that it was subsequently put back into service (installed on the main rotor hub assembly of the accident helicopter).

In 1985, Houston Helicopters sent the grip to Bell Helicopter for overhaul. Bell overhauled the grip per their overhaul record QRMMF10330. The 1985-1986 [blurred word] planning document establishes that the Rosan inserts and lock rings were drilled out and removed, and the holes were then bored out (see Bell record DP0003562 [blurred words] inspected. But there is nothing in the planning document (or any other document) to indicate that, indeed, the replacement Rosan fittings were inserted or that the replacement lock rings were inserted. Nevertheless, the grip was issued a maintenance release with serviceable parts tag on October 1, 1986, and returned to Houston Helicopters where it was stored for future use.

In 1992, the grip was removed from storage for use. At that time, it was discovered that the Rosan inserts had not been installed by Bell Helicopter during the 1985 overhaul. The red grip was sent back to Bell and reworked under Bell maintenance document QRMMF14439 by installing Rosan inserts and lock rings. The 1992 bill of materials on the back of the work orders indicates that the size Rosan inserts and lock rings be used were a-08, i.e., the factory original size that would have been proper to use if the inserts had not been drilled out. A new maintenance release dated April 6, 1992, was prepared and forwarded with the part to Houston Helicopters.

In response to the preceding letter, BHT stated by letter to the investigation, in part,

This comment from the August 24, 2001, letter [from the president of HHI to the IIC] is totally incorrect. There is nothing in the Bell overhaul

records that contain any information that the Rosan inserts and lockring holes were bored out. The entry for boring a hole on DP-0003562 [referenced attachment to the BHT letter, contained here as **Attachment 22.a**] references the MRB disposition of item #3 [(referenced attachment to BHT letter, contained here as **Attachment 22.b**] on the oversizing and special blade bolt bushing installation, not the Rosan insert and lockring holes. The blueprint drawing shows that the main rotor bushing hole diameter to be 2.900 / 2.901 inches in diameter. The MRB disposition was to open this hole to 2.9345 / 2.9350 to allow acceptance of the special fabricated blade bolt bushing [referenced attachment to BHT letter, contained here as **Attachment 22.c**). This authorized repair was on the outboard end of the grip and not at the pitch horn attach area.

There is an entry on DP-0003562 to "remove discrepant Rosan inserts by drilling through lock ring with a drill bit which will just clean up serrations on inside diameter." This operation does not extend down into the Rosan insert hole and also does not extend beyond the lockring material into the diameter of the lockring counterbore hole. This operation would not be a boring out of the holes as Houston Helicopters states.

4.0 TESTS and RESEARCH

4.1 EXAMINATIONS at BHT, December 8-9, 1999

The main transmission and main rotor system were initially examined at BHT's engineering facilities, December 8-9, 1999 (reference BHT Engineering Laboratories report, dated January 21, 2000, **Attachment 1**). These examinations found that the fracture surfaces of all flight controls and mounting areas received at BHT (including the "red" grip and "white" grip and PCH) exhibited failure modes consistent with overload failures. The "red" grip boreholes appeared to be elongated and were measured in detail during the December 8-9, 1999, examinations at BHI. Table I in **Attachment 1**

graphically provides the "Diameters of the pitch horn bushing holes in the 'red' main rotor grip."

The laboratory report also states, in part,

> Inspection of the "red" main rotor grip revealed evidence that the pitch horn had worked out of the attachment holes in the grip. … The holes also had "arrest marks" or lines left by the bushing edges and steel inserts as they walked out. Also the hole walls where the pitch horn bushings had been in contact with were worn.
>
> Inspection of the threads where the steel inserts had been located indicated the threads in the "red" grip had fractured by shear overstress. After removal of the primer that was present in the holes, it was observed that there were two threads near the bottom of the hole which had not been reached by the fully engaged insert. A portion of one of the remaining non-engaged threads in the upper hole had a partial thread imprint on it. The imprint was in the crest of the internal thread.
>
> Inspection of the "white" pitch horn and main rotor grip revealed no evidence of working at the pitch horn attachment area.

4.2 RECORDS EXAMINATIONS, at SERA and SAFETY BOARD HEADQUARTERS

The SG reconvened at SERA, September 5-6, 2001. Present were the IIC, new SGC, and party representatives from the FAA, BHT, and HHI (reference names, above). The reconvened SG reviewed the history for the not-found "red" MR PCH and recovered "red" grip; tracing records from the date of the accident back through installations on various MRHs, inspections, and MRH assemblies installation on aircraft, to their separate component manufacturing dates. The SG again reconvened for a Technical Review of

factual materials, concentrating on maintenance records, as well as materials laboratory examinations, at Safety Board Headquarters, January 15 – 17, 2002. The following summary, section **4.2.1**, referenced in section **3.1**, above, summarizes the recovered records information.

4.2.1 SUMMARY of HISTORY of PCHs and "WHITE" GRIP

Summarizing the above records and testimony, according to the HSRs for the PCHs, the accident "red" and "white" PCHs (serialized as HT834 and HT624, respectively) were installed "1/12/93" on [the accident] HUB FB-71829," at a total time "since new" for both PCHs of 1,634.9 hours, and a total time since new for the "red" grip (serial no. GD9312-6) of 4,334.1 hours (reference **Attachments 21. b – c**). The accident hub was then installed on helicopter N49673, on "6/16/93" (reference HRS for "M/R Hub Assy, serial no. FB-71829," reference **Attachment 19.a**). The accident MR hub was then removed from helicopter N49673 as part of a post-overspeed inspection, recorded as "C/W overspeed Insp – OH," "1/13/94' (reference **Attachment 19.a**). The HSR further states on page 2, "Time/Date Effectivity 2Feb 94," "WO [work order] # 2-94-1712, C/W Conditional Inspection for overspeed. Assy O/H'd I/A/W all Bell Instructions per CR7O and maintenance manuals T.T. 2518.6 TSO – 0 -. There is no specific reference to the PCHs and grips on the "M/R Hub Assy" HSR (**Attachment 19.a**), and no reference to their removal from the hub or their separation for "post overspeed inspection" on the HSRs for the accident PCHs, as described above (reference **Attachment 19.b – c**). There are two subsequent "removal[s]" of the PCHs from accident hub "FB-71829," on "7/14/95 Removed at Hub Hrs. 2785.5 [and] 1920.4 Comp. [component] Hrs. Since New [for] Reason for Removal [blank]; and on "3/20/98 Removed at Hub Hrs. 2894.3 [and] Comp. Hrs Since New 2-29.2 [for] Reason for Removal Straps Retire." The maintenance personal interview referenced above stated that these "removal" entries for the PCHs on their HSR was for "strap inspections" and did not involve separation of the PCHs from the MR grips.

Also from these records, the following is a summary of the history of the accident "red" and "white" PCH and MR grip, prior to their instillation on accident MR hub, serial no., FB-71829, 11/12/93:

1992, the accident "red" PCH and grip were joined as an assembly by HHI

April 16, 1992, "red" grip returned to BHT by HHI. Reported that grip did not contain Rosan inserts.

August 1990, "red" PCH on Singapore Air Force helicopter no. 005, sold to HHI, per MSI-PO 204-011-120-007

October 1986, BHT overhauled "red" grip at 4,334.1 hours total time, sent to HHI.

September 1979, accident "red" grip, serial no. GD-9312-6 installed new in Bell 212 serial no. 30964, on MRH assembly serial no. ADA-08684

May 10, 1976, accident "red" PCH installed new on Singapore Air Force helicopter designated no. 211, BHT serial no. 30784, on MRH serial no. 53552.

4.3 PCH and GRIP, INSPECTION INTERVALS and RETIREMENT TIMES

Supplementary aircraft records and operators/maintenance manual examinations were conducted, and are herein summarized:

BHT-212-MM (maintenance manual), Section 4-00-00, page **6**, rev. 3, "Table 4-1. Mandatory airworthiness limitations schedule (Cont)" (reference **Attachment 23**) provides

an "Airworthiness Life [for the accident PCH, as follows]: Main Rotor Controls; Component, Pitch Horn; Part Number, 204-100-120-005; Airworthiness Life, 3000 Hours." For the PCL, Table 4-1, continued on page **7**, provides: "Component, Pitch Link; Part Number 204-011, 127,001 and –003; Airworthiness Life, 9000 Hours." There is not a retirement time listed for the MR grip; it was stated by maintenance inspection personnel that took part in the September 4-5, 2001, and were familiar with the inspection schedule for the MRI that retirement of the MR grip was dependent "on condition," as found during usage and inspection of the entire assembly.

The MR grip has an inspection schedule of "Each 1200 hours of Component Operation or 24 Months; Whichever Occurs First" (ref. "Special Inspections," BHT-212-MM, 5-00-00, Rev. 5 (reference **Attachment 24,** pages **127-130**), containing "Inspection Task Description," "Main Rotor Hub Grip 204-011-121," and "Figure **5-4,** Inspection of main rotor hub grip tangs (1200 hours)." Figure **5-4** shows three shaded areas on the grip, to be inspected in accordance with these criteria. An attached PCH is also shown as part of the assembly drawing in Figure **5-4**, as well as two bolt heads for two bolts that pass through the PCH and PCH bushings into the receiving grip boreholes, and that portion of the grip that is mated with the face of the PCH; none of these areas are shaded as an "area to be inspected." BHT noted in the investigation, "…the inspection is required in the detailed text portion in the CR&O, Chapter 62, page 52, paragraph 30, which states in part, "Inspect rosan inserts for security and damaged threads…."

BHT-212-CR&O, 62-00-00, Rev. 4, page **52** in **Attachment 25** (containing pages 52 and 53), states, "30. Remove grip tang buffer pads (1A, figure 62-14) (if installed). Inspect grip (1) surfaces for mechanical and corrosion damage. (Figure 62-21 for limits.) Replace grip if corrosion pitting on tang surfaces under buffer pads exceeds limits. Inspect rosan inserts for security and damaged threads. Inspect diameters, bushing loose in the grip, gap between bushing flange and grip, with between grip tangs and bearing liner inside diameter to limits of figure 62-19. Fluorescent penetrant grip, refer to BHT-ALL-SPM." (A maintenance inspector stated during the investigation that there are 7 rosans, other than the two receiving the PCH bushing bolts, installed in both MR grips.) Page **53** shows a sketch

of the grip as part of "Figure 62-18. Blade bolt, drag brace, and pitch horn damage limits (Sheet 1 of 2). The part no. 204-0110120 pitch horn is sketched, and the PCH bushing receiving boreholes are in a shaded area symbolized by a circled no. 3. Figure 62-18 provides an outline for "Type of Damage" and "Maximum Depths and Repair Areas Allowed." For "Number of Repairs" for the grip boreholes, it provides for "Two Per Segment." In the investigation, BHT noted that "… the damage and repair limits are specified for part no. 204-011-0120 pitch horn (circle 3) for all portions of the PCH and vary as noted by three crosshatched symbols which include all surfaces of the PCH…[and further, that] Figure 62-18 provides an outline for 'Types of Damage' and 'Maximum Depths and Repair Areas Allowed.' For 'Number of Repairs' for the grip boreholes, it provides for 'Two Per Segment.'"

4.4 EXAMINATIONS at BHT, September 11-12, 2001

During the week following the records examination at SERA, the SG reconvened at BHT (September 11–12, 2001), for further engineering and records examinations of the MR "red" and "white" grips, and "white" PCH

The examinations included re-inspection of the of the "red" and "white" grips and "white" PCH, and sectioning or cutting-through the two PCH bushing bore hole centers on the "white" grip (the "red" PCH bushing boreholes had been sectioned during the December 8-9, 1999, examinations at BHT's Engineering Laboratories, and microscopic examinations within the "red" and "white" PCH bushing holes ((reference drawing showing location of boreholes, in BHT-212-CR&O (Component Repair & Overhaul manual), section 62-00-00, Rev. 3, page **57** (**Attachment 8**), for the part no. 204-011-121 grip; and photographs showing the laboratory-sectioned "red" (on December 8-9, 1999) and "white" (on September 11-12, 2001) grips)).

On October 16, 2001, BHT submitted an engineering report regarding the September 11-12, 2001, examinations, "Examination of Parts from a Model 212 Helicopter operated by Houston Helicopters, Inc.," 5 pages, dated 26 September 2001, unsigned

(**Attachment 2**). Table I of **Attachment 2** provides "Diameters of the Pitch Horn Bushing Holes in the 'White' Main Rotor Grip," and can be compared with the diameters of the PCH bushing holes (boreholes) in the "red" MR grip, described in BHT Engineering Laboratories Report, January 21, 2000 (**Attachment 1**) as "Diameters of the pitch horn bushing holes in the 'red' main rotor grip."

4.5 MANUALS and RECORDS RESEARCH SUBSEQUENT to September 11-12, 2001, at BHT

During the September 11-12, 2001, examinations at BHT, a drawing was provided which indicated that the upper pitch-bushing grip holes (bore) diameters are .687 to .688 inches. The BHT CR&O does not provide maximum bore diameters. BHT noted, "but uses a difference of borehole diameter measurements (taken 90 degrees apart) to determine acceptability as noted in 'Figure 62-21. Main rotor grip, yoke, yoke nut, and trunnion damage limits (Sheet 1 of 5)' on page 57, Chapter 62 of the BHT-212-CR&O…."

BHT-212-CR&O, 62-00-00, Rev. 4, page **68**, contained in **Attachment 8**, states,

> c. Replace rosan inserts in grip if loose or threads are damaged. (2) Inspect clean up threads and counterbore. If threads are worn or hole is badly deformed, use next oversize insert…. NOTE Bushings can only be replaced by repair facilities approved by Bell Helicopter Textron.

Regarding the preceding quotation, "c." BHT stated, "…This bushing note only applies to the following instruction which is the blade bolt bushing. Bell does not authorize the use of next oversized rosan insert in the pitch horn borehole location."

Attachment 29.a is a FAX from Bell to HHI, which states in part: "The grip to pitch horn inserts are critical and cannot be oversized." BHT-212-MM CR&O, page states, "…grip must be replaced when holes are out of limits…."

BHT-ALL-SPM (standard practices manual), 8-00-00, page **6** (of pages 5 and 6, which comprise **Attachment 26**) states, in part,

> 8-8. Studs and inserts – Replacement, Materials Required, Refer to chapter 13 for specification and source. 1. Replace studs as follows: NOTE These instructions are applicable to studs of the standard type which thread directly into the cases and sleeves. B. Select a replacement stud; generally the next large oversize will be required to obtain correct driving torque. NOTE Studs listed in the applicable illustrated Parts Catalog provide a listing of a standard and four oversize studs by increments of .003 inch (0.007 mm). 2. Repair cases or sleeves which have loose or missing locked-in inserts or studs as follows: NOTE These instructions are applicable to the studs and threaded inserts which have a serrated locking ring. The locking ring inner teeth engage a serrated collar of the stud or insert; the locking ring outer teeth broach into the material of the case…. a. Remove threaded inserts as follows: (1) Select a drill equal in diameter to serrations between locking ring and inserts. Drill to depth equal to ring thickness.

BHT-212-IPB (Illustrated Parts Breakdown), 62-99-00, Rev. 5, page **22** (contained in **Attachment 27**) provides a listing for the insert for the Hub assembly, main rotor, in accordance with Figure 62-2, under insert (Rosan) it provides part no. "RD206SB8."

BHT Technical Bulletin, No. 212-99-170, dated 02-10-99, "SUBJECT: IMPROVED PITCH HORN TO MAIN ROTOR GRIP ATTACHMENT HARDWARE" (**Attachment 28**) provides for increased strength PCH bushing bolts, and PCH grip hole inspection criteria during replacement with the increased-strength bolts. There is no indication in the records that the accident MRH received the "Improved…Attachment Hardware." The Technical Bulletin states in part,

> DESCRIPTION:

> Bell Helicopter has investigated a few incidents where one of the grip to pitch horn attachment bolts, Part Number AN6H22A failed. The investigations revealed that the bolts failed in fatigue due to low torque or corrosion. A new bolt part number NAS6606H27, is now approved for installation, along with a revised installation procedure, which will prevent future failures of this nature [note: this bolt was authorized February 1999, and not required. It was not in use on the accident main rotor head].
>
> APPROVAL:
>
> The engineering design aspects of this bulletin are FAA/DER approved.
>
> It provides for PCH grip hole inspection criteria:
>
> ACCOMPLISHMENT INSTRUCTIONS:
>
> Inspect faying surfaces of grip and pitch horn for fretting damage. Apply prime MIL-P-2337 or MIL-P-85582 to the faying surfaces of the grip and pitch horn.
>
> Install pitch horn onto to [sic.] grip…. Torque 160 to 190 inch-pounds and secure heads with lock-wire

In section 4.3, above, borehole damage is manual-referenced (ref. **Attachment 26**), the two PCH bushing holes are not in the shaded areas on the grip that are referenced on page **57** (ref. BHT-212-CR&O), 62-00-00, Rev. 3, page **57** (contained in **Attachment 8**) "Figure 62-21. Main rotor grip, yoke, yoke nut, and trunnion damage limits (Sheet 1 of 5)," provides a chart providing Type of Damage and Maximum Depths and Repair Areas Allowed. The grip boreholes are shown, and are not in the shaded areas on the grip.

On September 10, 2001, BHT's Product Support Engineering offices in Mirabel, Quebec Canada (BHT Canada) sent a 1-page faxed letter to HHI's Chief Inspector (Maintenance). The letter (**Attachment 29.a**) states, in part, "Fatigue tests on the M/R Grip were never accomplished with oversized rosan inserts installed therefore Bell Helicopter cannot approve the installation of any oversized inserts. Please specify exactly which inserts you wish to replace. The grip pitch horn inserts are critical and cannot be oversized."

Subsequent to the examinations at BHT's engineering laboratories, September 11-12, 2001, BHT Canada sent two additional 1-paged faxed letters, dated October 19, 2001, to HHI's maintenance director, "Subject: 212 Grip Pitch Horn Bores." The first letter (**Attachment 29.b**), as indicated by the time stamp on the fax, states, in part,

> The pitch horn is an interference fit with the grip. The bore dimensions in the grip are .687 to .688 and have a wear limit per the CR&O of .002 for ¼ of the circumference. Bore damage in excess of these dimensions will require grip replacement.

The second letter (**Attachment 29.c**) states, in part,

> The bolt hole damage limits as listed in the CR&O for the grip, apply to all bolt holes and horns. There is a faint representation of the black dot but due to the orientation of the grip in the figure it dies not allow for a solid black dot to be present in the bolt hole area for grip attachment. The limit however still applies to all bolt holes and bores.

The retirement time for the PCH is 3,000 total flight hours. There is not a designated retirement lifetime for the main rotor grip.

Thomas R. Conroy