NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594
March 23, 2011

SUB-GROUP CHAIRMAN'S ADDENDUM TO FACTUAL REPORT, DOCUMENTING EXAMINATION OF INSTRUMENT GAUGES

ANC10MA068

A. INCIDENT

Location:	Aleknagik, AK
Date:	August 9, 2010
Airplane:	de Havilland DHC-3T, N455A

B. GROUP

Sub-Group Chairman: Adam Huray
National Transportation Safety Board
Washington, DC
USA

Member: Ron Roberts
Electronics International Incorporated
Bend, OR
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C. SUMMARY

On August 9, 2010, about 1445 Alaska daylight time (ADT), a single engine, turbine-powered, amphibious float-equipped de Havilland DHC-3T (Otter) airplane, N455A, sustained substantial damage when it impacted mountainous tree-covered terrain, about 10 miles northeast of Aleknagik, Alaska. The airplane was registered to and operated by General Communication Corporation (GCI), Anchorage, Alaska, and the flight was being conducted under the provisions of 14 Code of Federal Regulations Part 91 when the accident occurred. Of the nine people aboard, the airline transport pilot and four passengers died at the scene, and four passengers sustained serious injuries.

The exhaust gas temperature, fuel flow, engine tachometer (RPM/N1 %), oil pressure/temperature, and engine torque gauges had been removed from the accident airplane for further examination. On February 22 and 23, the gauges were examined by the NTSB and Electronics International Incorporated (EI) at the EI facility located in Bend, OR. Electronics International Incorporated is the original manufacturer for these gauges.

D. DETAILS OF THE INVESTIGATION

1. Exhaust Gas Temperature (EGT) Gauge:

Part Number (P/N): E-1P Diff
Serial Number (S/N): 071722

Figure 1: EGT Gauge

The EGT gauge provides temperature readings in one-degree increments on a digital display. The unit features an over-temp light that will illuminate if the temperature exceeds a designated limit. The unit is designed to an accuracy of 1/2 percent in accordance with TSO C43a. See Figure 1.

The EGT gauge does not record EGT values in non-volatile memory. The gauge from the event airplane was visually inspected and functionally tested. The EI part number and serial number sticker, quality assurance sticker, and installation warning stickers were still intact. The face was dirty and there were nicks on the ring around the display. The cover appeared in good condition and the wires were intact up to and including the slip on connectors.

The unit was powered on the manufacturer's test bench. The 24 volt (V) backlight did not function; the 12V backlight was functional. The display read 20 degrees Celsius (C) ambient temperature at an actual ambient temperature of 21 degrees C. The calibration was checked by inputting a signal corresponding to 798 degrees C; the unit display read 792 degrees C. The "over temperature" light illuminated at an input signal equivalent to 615 degrees C; the unit was originally calibrated to illuminate the light at 620 degrees C.

A review of the unit history showed that the unit was shipped from EI on 12/17/2004 and EI had no records of repairs or other actions since that date.

2. Fuel Flow Gauge:

P/N: FP-5L
S/N: Unknown

Figure 2: Fuel Flow Gauge

The fuel flow gauge provides fuel flow readings to an accuracy of two percent or better in accordance with TSO C44a. The gauge has multiple display options that allow the user to monitor fuel flow, horsepower, fuel remaining, fuel used, and time to empty. Of these parameters, the unit is designed to store only the last "fuel remaining" value in non-volatile memory. The unit also contains one auxiliary channel. Provided there are inputs from a Global Positioning System (GPS), two push buttons may be used to change the display to show "fuel to destination" or "fuel reserve". The unit features a low fuel warning light and a high/low auxiliary limit warning light that can be set to monitor the auxiliary channel. See Figure 2.

The fuel flow gauge from the event airplane was visually inspected. There were no part numbers, serial numbers, or quality assurance stickers present on the unit. Two installation warning stickers were present on the top side of the unit cover. The front of the unit was dirty and there were a few nicks on the ring around the display. The "fuel to destination" button was bent downwards and the "STEP" toggle lever was also bent. Viewing the back panel, there was a gouge in the upper right corner and this corner was also dented inwards. The upper and lower halves of the cover were slightly out of alignment along the horizontal plane. The wires and cannon plug appeared in good condition.

The unit was connected to a test bench that supplied electrical power without supplying input signals. When powered, the unit displayed a fuel flow of 199.9 gallons per hour.[1]

[1] 199.9 gallons per hour is the maximum fuel flow rate the gauge is designed to display.

The gauge is designed to retain the last recorded "fuel remaining" value prior to power removal, which can be accessed by using this test bench configuration and setting the unit to display "REM." When this procedure was performed the unit displayed 0 gallons fuel remaining. The time to empty was 00:00 and the used fuel display was continuously increasing in counts.

The fuel remaining, fuel used, and time to empty functions are influenced by the fuel flow rate. The unit continued to display a fuel flow rate of 199.9 gallons per hour even when an artificial fuel flow signal was provided from the test bench.

The auxiliary channel displayed 34.9 counts when a 35 count calibration signal was inputted. The fuel to destination and fuel reserve functions were not functionally tested since they required GPS inputs. All of the light emitting diodes (LED) functioned during the power up sequence. The 12V and 24V backlights did not function when powered on the test bench.

A review of the unit history could not be performed since a unit serial number was not identified.

3. Engine Tachometer (N1) % Gauge, marked RPM:

P/N: R-1-N1
S/N: 103765

Figure 3: Tachometer

The engine tachometer features a digital display and an analog display that is made up of 17 LEDs arranged in a 210 degree arc. The digital display can also provide tachometer time, flight time, and the peak RPM recorded for the flight.[2] See Figure 3.

[2] The tachometer time keeps a running total time of engine RPM at or above 96%. Flight time starts recording when engine RPM is 96% or greater and stops recording and resets to 00.00 when the engine RPM falls below 96%.

The engine tachometer from the event airplane was visually inspected. The unit cover had previously been removed and partially reinstalled at the NTSB laboratory. The face plate was dirty and slightly bent on the upper left and lower left corners. The rear plate was also slightly distorted. The EI part number and serial number sticker, quality assurance sticker, and installation warning stickers were still intact. “4187=100%” was hand written next to the part number. The wires and cannon plug appeared in good condition.

The cover was removed and an internal visual inspection was performed. The inter-connect wires supporting the S103001A circuit board were bent, such that the circuit board was positioned forward of original build (see Figure 4). Multiple soldered locations were covered in a flaky yellow residue (see Figure 5).

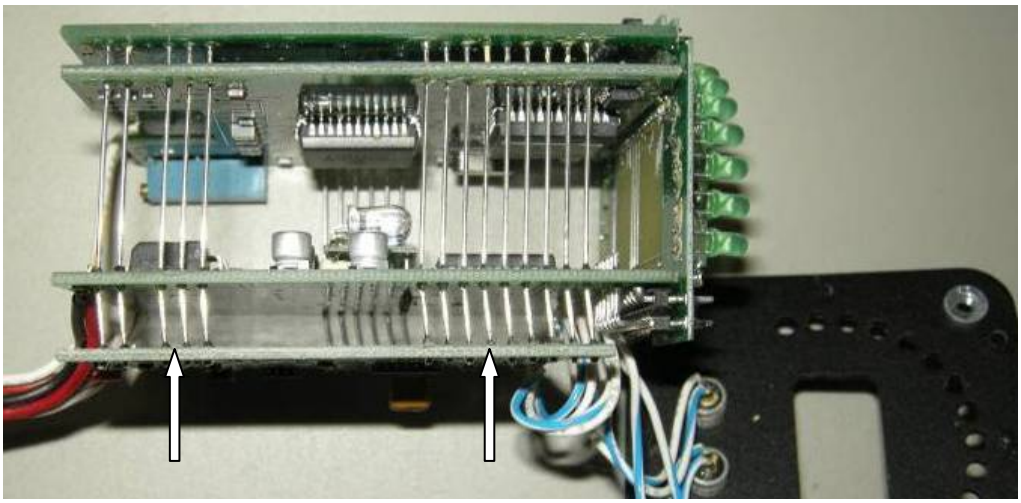

Figure 4: Bent inter-connect wires

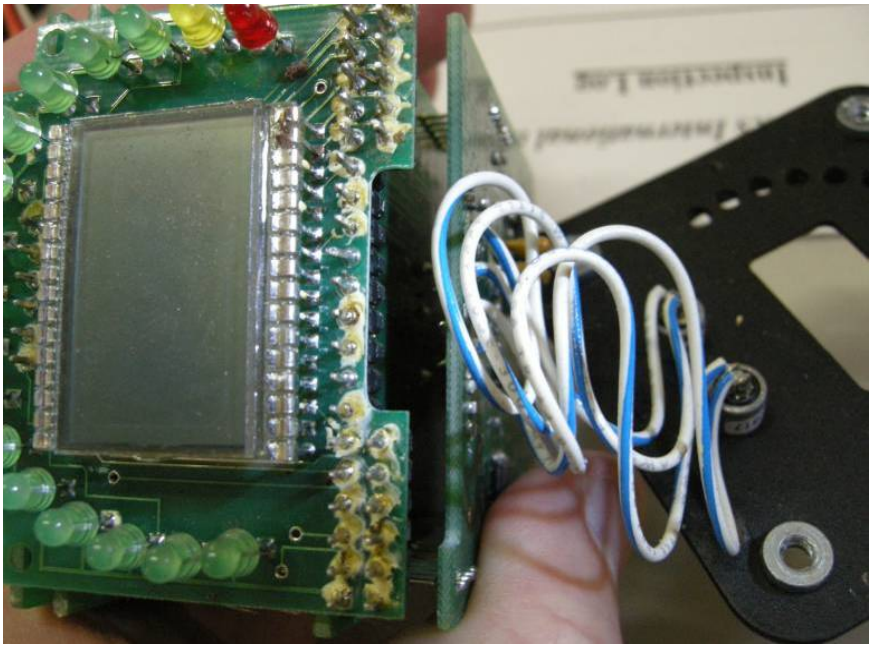

Figure 5: Yellow residue around pins

The 93C46WP6 (ST B803Q) memory chip was removed. This part is a surface mount S08 chip. To facilitate the memory download, wires were soldered to each of the chip leads. The open ends of these wires were then connected to a chip reading device that also converted the binary words to ASCII hex for each memory location. The data was then output to a terminal emulator program called "PuTTY" and the information was copied to a Word document. The Word document can be found in Appendix A. The following is a summary of the information contained in the memory chip:

> The unit records RPM values every three minutes. The first value is recorded three minutes after power up and is always placed in memory location 0D. The unit can store values in 39 memory locations before it will wrap around and begin to overwrite the oldest memory location. A marker labeled "FFFF" is written one memory location after the most recent written record.
>
> The following RPM records were obtained from the download, with the first data record recorded at location 0D and the last data record followed by the last recording marker: 68.1%, 98.7%, 99.5%, 96.1%, 96.1%, and 96.1%.
>
> The following data was also recorded in the non-volatile memory:
> Total Tachometer Time (time above 96% RPM): 470.8 hours
> Flight Time (time above 96% RPM): 12 minutes
> Peak RPM reached during the flight: 99.8%

The 93C46WP6 memory chip was soldered back into the unit. The unit was powered and all LEDs came on during the power up sequence. The relevant sections of the acceptance test procedure (R-1 Cal Procedure dated 2/12/09) were accomplished and the results were as follows:

> Power up and LED sequence: Passed
> Input signal equivalent to 143.3 %; display read 143.1 %
> LED calibration: Passed
> LED dimming: Passed
> 12V and 24V backlights functioned properly: Passed
> Linear Operating Range: Passed
> Display segments functioned properly: Passed
> 7.5V to 40V input power: Passed
> Flight Time, Tachometer Time, and Peak Reading functions: Passed

A review of the unit history showed that the unit was shipped from EI on 7/15/2008 and EI had no records of repairs or other actions since that date.

4. Oil Gauge:

P/N: OPT-1
S/N: Unknown

Figure 6: Oil Gauge

The oil gauge features dual 90 degree analog displays for oil pressure and temperature, with a digital display that shows oil pressure to 1 psi or oil temperature to 1 degree Celsius. The unit measures both pressure and temperature with an accuracy of 2% in accordance with TSO C47/C43a. See Figure 6.

The oil gauge was visually inspected. There were no part numbers, serial numbers, or warning stickers present on the unit. A quality assurance sticker was present on the bottom side of the cover. The face plate and back plate were slightly deformed and the upper and lower halves of the cover were out of alignment along the horizontal plane. The top rear of the cover had a deep gouge. The front of the unit was dirty and the switch was towards the “TEMP” side. A white/orange wire was kinked, but otherwise the wires and cannon plug appeared in good condition.

The cover was removed and an internal visual inspection was performed. The inter-connect wires supporting the S110301 circuit board were bent, such that the circuit board was positioned forward of original build. The displacement was visually similar to what was seen in the tachometer (see Figure 4). Multiple soldered locations were covered in a flaky yellow residue similar to what is shown in Figure 5.

The 93C46W6 (ST B413W) memory chip was removed. This part is a surface mount S08 chip. To facilitate the memory download, wires were soldered to each of the chip leads. The open ends of these wires were then connected to a chip reading device that also converted the binary words to ASCII hex for each memory location. The data was then output to a terminal emulator program called “PuTTY” and the information was copied to

a Word document. The Word document can be found in Appendix B. The following is a summary of the information contained in the memory chip:

> The unit records pressure and temperature values every four minutes. The first value set is recorded four minutes after power up and is always placed in memory locations 0F (pressure) and 10 (temperature). The unit can store up to 23 sets of data in 46 memory locations before it will wrap around and begin to overwrite the oldest memory locations. A marker labeled "FFFF" is written one memory location after the most recent written record.
>
> The following pressure and temperature records were obtained from the download, with the first data set recorded at locations 0F and 10 and the last data set followed by the last recording marker:
>
> 100 psi, 60 degrees C
> 106 psi, 59 degrees C
> 105 psi, 59 degrees C
> 105 psi, 58 degrees C

The 93C46W6 memory chip was soldered back into the unit. The unit was powered and all LEDs came on during the power up sequence. The relevant sections of the acceptance test procedure (OPT Cal Procedure dated 2/12/09) were accomplished and the results were as follows:

> Power on test: Passed
> Ambient temperature was 21 degrees C; unit displayed 20 degrees C
> Input signal equivalent to 798 degrees C, unit displayed 796 degrees C
> Input pressure signal equivalent to 100 psi, unit displayed 99 psi
> Input pressure signal equivalent to 5 psi, unit displayed 5 psi
> 12V and 24V backlight operation: Failed
> LED dimming: Passed
> LED arc limits: Passed
> Digital display operation: Passed
> Input voltage range 7.5V to 40V: Passed

A review of the unit history could not be performed since a unit serial number was not identified.

5. Torque Gauge:

P/N: M-1T-NS
S/N: 064583

Figure 7: Torque Gauge

The torque gauge features a 210 degree analog LED display and a digital display. The unit is designed to be accurate to 1% in accordance with TSO C45. See Figure 7.

The torque gauge was visually inspected. The Electronic International Incorporated part number and serial number sticker, quality assurance sticker, and installation warning stickers were still intact. “60psi=100%” was hand written next to the part number. The front face was dirty and the upper left corner was deformed. The cover and back plate were slightly deformed, and when viewing the back plate there were three gouges on the lower right quadrant. A red wire and a red/white wire were found severed, approximately 4 inches from the cannon plug. Several other wires were nicked and the green wire was kinked in this general area. The cannon plug appeared in good condition.

The cover was removed and an internal visual inspection was performed. Multiple soldered locations were covered in a flaky yellow residue similar to what is shown in Figure 5.

The 93C46W6 memory chip (S/N ST K040M) was removed. This part is a surface mount S08 chip. To facilitate the memory download, wires were soldered to each of the chip leads. The open ends of these wires were then connected to a chip reading device that also converted the binary words to ASCII hex for each memory location. The data was then output to a terminal emulator program called “PuTTY” and the information was copied to a Word document. The Word document can be found in Appendix C. The following is a summary of the information contained in the memory chip:

The unit records torque values every four minutes. The first value is recorded four minutes after power up and is always placed in memory locations 05. The unit can store values in 46 memory locations before it will wrap around and begin to overwrite the oldest memory location. A marker labeled "FFFF" is written one memory location after the most recent written record.

The following torque records were obtained from the download, with the first data record recorded at location 05 and the last data record followed by the last recording marker: 12%, 53%, 48%, and 51%.

The 93C46W6 memory chip was soldered back into the unit. The unit was powered and all LEDs came on during the power up sequence. The relevant sections of the acceptance test procedure (M1 Cal Procedure dated 2/12/09) were accomplished and the results were as follows:

Analog LED arc: Passed
Digital display operation: Passed
12V and 24V backlights: Passed
LED dimming: Passed
Input signal equivalent to 100%, unit displayed 119%
Input signal equivalent to 167%, unit displayed 217%
Input signal equivalent to 8%, unit displayed 000%

Approximately two full turns of the potentiometer adjustment were required to calibrate the unit to display "167%" when a signal equivalent to 167% was inputted from the test bench.

A review of the unit history showed that the unit was shipped from EI on 5/1/2008 and EI had no records of repairs or other actions since that date.

6. Performance Charts:

Hartzell Propeller Inc. provided Figure 8 as an engineering estimate of thrust performance for a DHC-3T, based on the torque and RPM values that were found in the non-volatile memory of the gauges removed from the accident aircraft.

DeHavilland Otter DHC-3
950', ISA -7°F
Propeller Model: HC-B4TN-5NL/LT10890N 4-Blade, Diameter = 109.5"
Single Engine Nacelle, 18" diameter spinner

RPM=1529 (96.1%)

Torque	48% 415 Hp	51% 441 Hp	53% 459 Hp
Airspeed (KTAS)	Thrust (lbs)	Thrust (lbs)	Thrust (lbs)
60	1502	1577	1628
80	1281	1351	1398
100	1097	1161	1204
120	946	1004	1045
140	817	873	910
160	706	758	793

Figure 8: Estimated Thrust for Torque Values Obtained Directly from Torque Gauge Memory

A linear model was derived from the differences in the actual torque and the displayed torque discovered during the functional testing of the torque gauge (see Figure 9). The torque values obtained from the memory download were then applied to this model and additional approximate "actual torque" values were obtained. Hartzell Propeller Inc. provided Figure 10 as an engineering estimate of thrust performance for a DHC-3T based on these additional actual torque values. Figure 11 depicts estimated thrust performance for all six torque values.

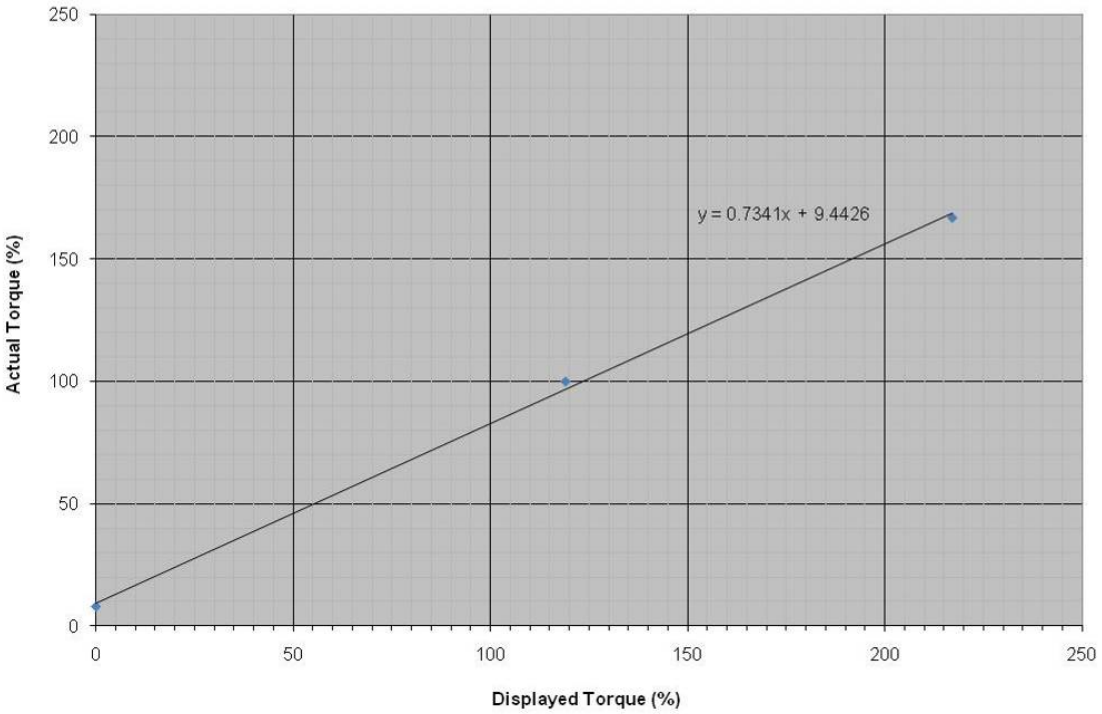

Figure 9: Actual Torque vs Displayed Torque for Torque Gauge S/N 064583

DeHavilland Otter DHC-3
950', ISA -7°F
Propeller Model: HC-B4TN-5NL/LT10890N 4-Blade, Diameter = 109.5"
Single Engine Nacelle, 18" diameter spinner

RPM=1529 (96.1%)

Torque	44.7% 386 Hp	46.9% 405 Hp	48.3% 418 Hp
Airspeed (KTAS)	Thrust (lbs)	Thrust (lbs)	Thrust (lbs)
60	1415	1472	1510
80	1201	1254	1289
100	1024	1072	1104
120	878	922	952
140	754	796	824
160	647	686	712

Figure 10: Estimated Thrust for Torque Values Derived using Figure 9

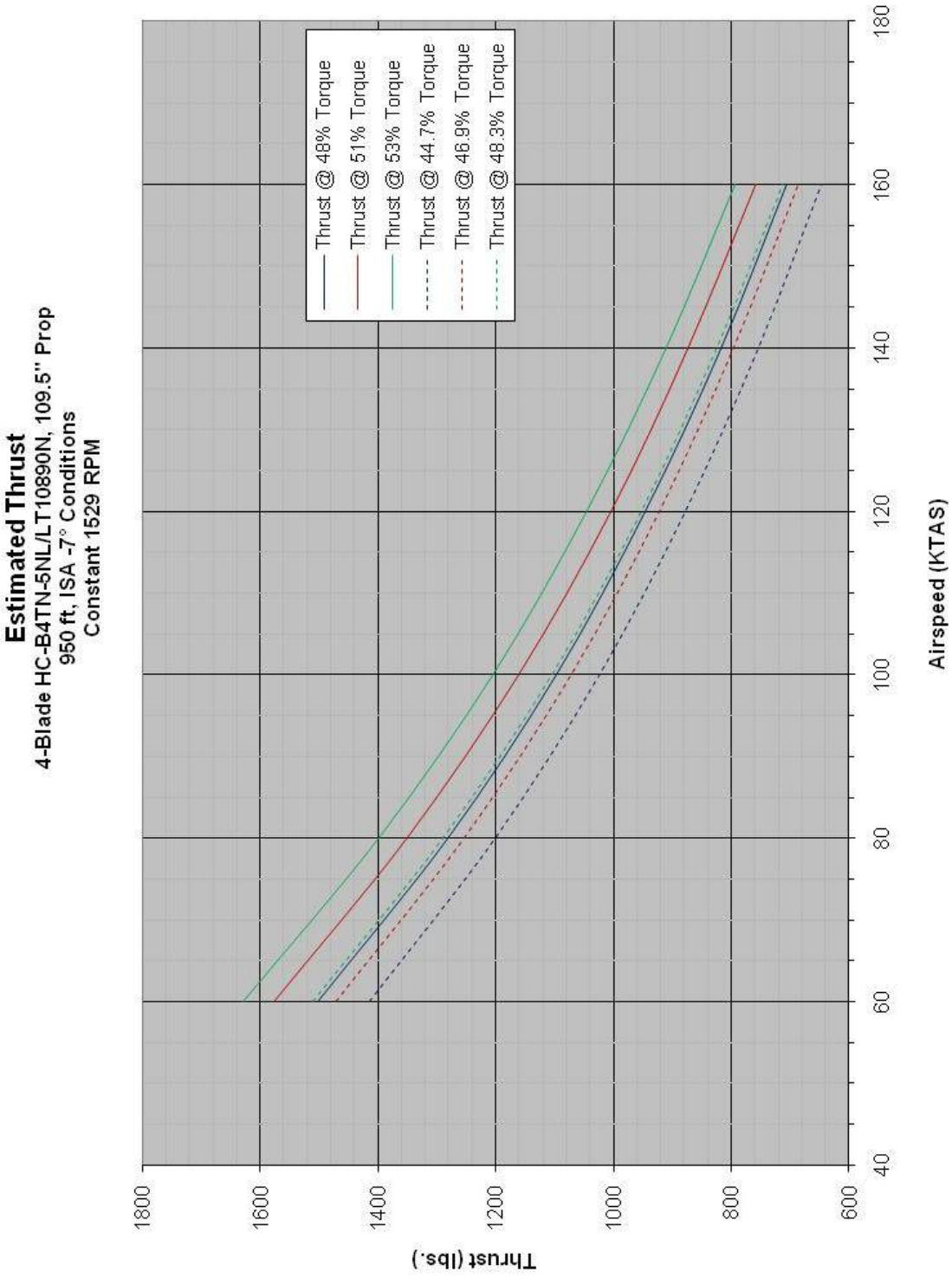

Figure 11: DHC-3T Estimated Performance

Adam Huray
Mechanical Engineer

Appendix A: Data Extraction for R-1-N1, S/N 103765, N455A

00 0000 - Unused
01 0847 - Tach time in hours (Units, 1/10, Hundreds, Tens)
02 0001 - Tach time in hours (First two bytes: Thousands)
03 0012 - Flight time (time above 96% RPM)
04 0998 - Peak RPM reading for flight
05 0930 - Programmed low limit
06 0005 - Programmed step
07 1010 - Programmed high limit
08 7D02 - Counter for storing data
09 1005 - Programmed snap (first two bytes)
0A 0960 - Tach start/stop trigger level
0B 0960 - Flight start trigger level
0C 0960 - Flight stop trigger level
0D 0681 - 1st record, 3 minutes after power applied to the unit.
0E 0987
0F 0995
10 0961
11 0961
12 0961 - Last recording for event flight
13 FFFF - Last recording marker
14 0964
15 0963
16 0960
17 0835
18 0706
19 FFFF
1A 0000
1B 0000
1C 0000
1D 0000
1E 0000
1F 0000
20 0000
21 0000
22 0000
23 0000
24 0000
25 0000
26 0000
27 FFFF
28 0000
29 0000
2A 0000
2B 0000

2C 0000
2D 0000
2E 0000
2F 0000
30 0000
31 0000
32 0000
33 0000 – Last memory block available for data storage
34 0000 – Unused (and below)
35 0000
36 0000
37 0000
38 0000
39 0000
3A 0000
3B 0000
3C 0000
3D 0000
3E 0000
3F 0000

Appendix B: Data Extraction for OPT-1, S/N: Not Available, N455A

00 0040 - LED trigger levels (through location OB)
01 0055
02 0070
03 0090
04 0110
05 0121
06 0055
07 0070
08 0085
09 0100
0A 0110
0B 0127
0C FFFF - Unused
0D FFFF - Unused
0E FFFF - Unused
0F 0100 - 1st record, 4 minutes after power applied to the unit.
10 0060
11 0106
12 0059
13 0105
14 0059
15 0105
16 0058 - Last recording for event flight
17 FFFF - Last recording marker
18 0057
19 0105
1A 0058
1B 0105
1C 0059
1D 0086
1E 0072
1F FFFF
20 0039
21 0000
22 0038
23 0000
24 0037
25 0000
26 0036
27 0000
28 0036
29 0000
2A 0035
2B 0000

2C 0034
2D 0000
2E 0034
2F 0000
30 0033
31 0000
32 0032
33 0000
34 0032
35 0000
36 0032
37 0000
38 0031
39 0000
3A 0031
3B 0000
3C 0030 – Last memory block available for data storage
3D FFFF - Unused (and below)
3E FFFF
3F FFFF

Appendix C: Data Extraction for M-1T-NS, S/N 064583, N455A

00 FFFF - Unused
01 0025 - Programmed low limit
02 0005 - Programmed step
03 0101 - Programmed high limit
04 0004 – Snap (first two bites)
05 0012 - 1st record, 4 minutes after power applied to the unit.
06 0053
07 0048
08 0051 - Last recording for event flight
09 FFFF - Last recording marker
0A 0056
0B 0054
0C 0030
0D 0012
0E FFFF
0F FFFF
10 0031
11 0028
12 0011
13 0000
14 0000
15 0000
16 0000
17 0000
18 0000
19 0000
1A 0000
1B 0000
1C 0000
1D 0000
1E 0000
1F 0000
20 0000
21 0000
22 0000
23 0000
24 0000
25 0000
26 0000
27 0000
28 0000
29 0000
2A 0000
2B 0000

2C 0000
2D 0000
2E 0000
2F 0000
30 0000
31 0000
32 0000 - Last memory block available for data storage
33 0000 - Unused (and below)
34 0000
35 0000
36 0000
37 0000
38 FFFF
39 FFFF
3A FFFF
3B FFFF
3C FFFF
3D FFFF
3E FFFF
3F FFFF