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Sikorsky
A United Technologies Company

July 25, 2011

Mr. Robert Benzon
Major Investigations Division (AS-10)
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594

PSL-110-2011

Dear Mr. Benzon:

This letter contains Sikorsky Aircraft Corporation's (herein referred to as Sikorsky) response to the Letter of Petition that Carson Helicopters, Inc. (Carson) filed with the NTSB on March 11, 2011.

In summary, Sikorsky has thoroughly reviewed all of Carson's allegations, and found no new information that would change the conclusions of the Board. Sikorsky remains in concurrence with the Board's Findings of Probable Cause.

Further, Sikorsky has previously responded to Carson's allegations in writing, to the Chief of Major Investigations, the Investigator-in-Charge, and the Performance Group Chairman on November 08, 2010.

Our Executive Summary, prepared for the Board and submitted to the Chief of Major Investigations and the Investigator-in-Charge on December 02, 2010 also addressed these points.

A document containing a point-by-point evaluation of Carson's allegations is enclosed.

Please note that Sikorsky defers to General Electric Aviation to respond to the fuel control issues; and we have restricted most of our comments to the areas of aircraft performance and handling qualities. [Section B of the Carson Petition]

Very truly yours,

SIKORSKY AIRCRAFT CORPORATION

[redacted]

Christopher Lowenstein
Chief of Aircraft Safety Investigation

Enclosure: Detailed Response to Carson Letter of Petition (dated 07/25/2011), including three attachments.

cc: T. Haueter (NTSB)

Sikorsky Aircraft Corporation (herein referred to as Sikorsky) responds to the Carson Helicopter, Inc. (Carson) **Letter of Petition** to the NTSB (dated 11 March 2011) as follows:

A. ***"New Information Regarding Contamination and Contamination Sources"***

1. *"Contaminants found in the fuel control were significant and would affect operation of the unit"*

Sikorsky found no new information in this subject area. Carson's concerns of contamination were repeatedly reviewed and analyzed by the NTSB and all parties throughout the entire investigation.

The sound spectrum data shows no change in engine acceleration rates. This is the primary observable effect of contamination in fuel control units.

Carson's statement that *power available* may change, even while maintaining full N_G rpm is technically possible if the stator vane schedule is compromised, however, if that had been the case, the *other* or 'good' engine's N_G rate would have changed to compensate for the lack of power being produced by the 'bad' engine. Both N_G rates as recorded in the sound spectrum study remained normal, parallel, and nearly equal for ALL three H-44 take-off sequences. Further, they were within 0.3% of the prior day's topping check speed.

The aircrew *should have immediately aborted* all three H-44 takeoffs as the aircraft exceeded the N_G redlines on both engines. According to the pre-flight calculations, the aircraft should have had far greater performance. Reaching redlines on both engines should have alerted the crew that continuing each takeoff was neither advisable nor legal. At this time (nearly 30 seconds prior to impact on the final takeoff) an abort would still have been possible.

Finally, the torque callout by the copilot ("There's 85") indicated that while above redline on both engines, the aircraft was actually producing *greater* than specification power. By Sikorsky and USFS procedures, all mission planning must be conducted using specification power. Power *greater* than specification power is allowed to be used while obeying operational limits, such as N_G, and only to increase the safety margin, not to increase the aircraft's payload.

Sikorsky will allow GE Aviation to respond to all of **Section A, parts 1, 2,** and **3** in detail.

B. ***"The NTSB investigators utilized faulty data from Sikorsky for the GenHel simulations to determine aircraft performance in the final report"***

First, it should be noted that Sikorsky has already responded to all of these allegations by Carson several times. Carson continually resubmits the same complaints, with no new information. Sikorsky addressed these issues in our Executive Summary[1]; submitted to the NTSB on December 02, 2010 (copy attached); and in our response[2] to Carson's response to Addendum #2 to the Hover Performance Study, submitted to the NTSB on November 08, 2010 and November 16, 2010 (resubmitted to correct a typographical error).

Sikorsky's response, therefore, is nearly identical to our previous responses.

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1 **Sikorsky-prepared Executive Summary for NTSB;** http://dms.ntsb.gov/public%2F46500-46999%2F46774%2F455859.pdf

2 **Sikorsky document; SAC response to CHI issues;** http://dms.ntsb.gov/public%2F46500-46999%2F46774%2F454339.pdf; pp. 11-15.

Sikorsky ran numerous simulations as requested by the NTSB. Per the Performance Group Chairman's requests, Sikorsky used *both* Carson-provided data *and* data obtained from correctly instrumented and flown US Navy flight tests. In order to provide useful data for handling qualities analysis, flight loads prediction, and flight control system development, as well as piloted simulation and accident investigations, GenHel calculates the power required by the main rotor, tail rotor, accessories, and gearbox. These predictions must be accurate in order to perform the tasks noted above. The inputs to GenHel allow for tailoring of the model to specific aircraft and to changes in the rotor geometry, hover download, or other relevant parameters. These are a normal part of the usage of GenHel at Sikorsky. The inputs used for the CMRB analysis were typical and were not unusual in any way.

Carson's **Letter Sections B. 1. a, b, d,** and **e** allege that the configuration, trim tabs, and instrumentation on the NVH-3A blades had a negative effect on the blade's performance. Sikorsky disagrees. The correlation of the hover performance prediction (based on a model derived from NVH-3A flight test data with blades with trim tabs and one instrumented blade) with the S-61A hover 'spot check' data (acquired with blades without trim tabs or instrumentation) verifies that the trim tabs and instrumentation have a negligible impact on hover performance.

It should be noted that Sikorsky hover prediction model for the S-61A, although based on the model for the NVH-3A, was analytically corrected to account for hover performance applicable configuration differences (specifically the reduction of vertical drag associated with the removal of the tail cone strake, and the adjustment of vertical drag associated with the replacement of the sponson main gear with the land type main gear; as well as certain mission equipment and antennae). The conclusion is that the presence of trim tabs and instrumentation wiring does not measurably affect the hover performance. The subsequent *joint* Carson-Sikorsky flight testing, conducted in August/September 2010 validated that the measured performance of the CMRB was consistent with the USN/Sikorsky data when the configuration vertical drag differences were accounted for.[3]

Sikorsky has acquired vibration test data on six different occasions (three with trim tabs; and three without trim tabs) and has determined that an elevated 5/rev airframe vibration was noted with both configurations as compared to the original aluminum blades. This appears to be related to an increase in the blade lag stiffness that moved a blade lag mode closer to 4/rev, which is then transmitted to the airframe as a 5/rev vibration. In any case, 5/rev vibration (at the levels measured with composite and aluminum blades) does not affect hover performance.

Carson's allegation that the instrumented blade's strain gauge wires affected its performance is inaccurate. While Sikorsky prefers to do all performance testing with 'clean' blades; this is not always feasible, and we routinely fly with instrumented blades with little measurable effect on blade performance. Further, it should be noted that the strain gauge wires are mounted well aft of the center of lift of the blade and do not adversely affect performance. Only one of the five blades is instrumented.

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[3] **Attachment 1:** Sikorsky document "**S-61 Hover Performance and Effect of Trim Tab**"; dated June 22, 2011.

Carson further alleges in **Letter Section B. 1. c.** that the Sikorsky GenHel simulation did not take into account the smaller tail rotor and sponson gear that were fitted on the NVH-3A. This is incorrect. Sikorsky accounted for the tail rotor change, the tail cone strake, the sponson vs. fixed landing gear difference, the antennae and other classified gear, (for comparison to S-61A test aircraft *N3173U*) and also added the corrections for the difference in fuselage length and the Fire King tank download (for comparison to the S-61N accident aircraft *N612AZ*). While some of these corrections were fine-tuned during the 12 months of GenHel runs; the basic differences in configuration were always taken into account.

Carson's concluding allegation in **Section B. 1.** that "No results from this dataset are useful to this investigation." is inaccurate. In August and September 2010; a *joint* Carson-Sikorsky flight test was conducted using a Carson aircraft and Sikorsky instrumentation package. The aircraft (S-61A *N3173U*) was equipped with standard Carson CMRBs (no blade instrumentation and no trim tabs). Sikorsky's performance predictions that were made *a priori* were found to be accurate by flight test. This further indicates that Sikorsky can and does accurately analytically predict rotor performance.

Just prior to these actual performance tests, Carson informed Sikorsky Aircraft that ALL of their *short-body* test data, including Rotorcraft Flight Manual Supplement (RFMS) #5, #6 *short* (there are two different Supplements #6) and #9, were found to be incorrect and should not be used. Carson provided no further explanation. Carson did not inform their customers or the FAA that their *FAA-approved* data was invalid until November 29, 2010[4] [5] (just before the NTSB's Probable Cause Hearing) despite Sikorsky's written recommendation[6] to do so, which was presented to Carson on August 11, 2010.

Further, Carson has, in the past, made claims that the *short-body* S-61A provides a substantial performance gain as compared to a *long-body* S-61N. However, the actual measurements made during the Carson/Sikorsky testing on the *short-body* S-61A showed performance figures that were *less than* Carson's RFMS #8 data for the *long-body* S-61N.

Carson **Letter Section B.2.** states that "The FAA-approved performance charts have been repeatedly validated and are the most accurate flight representation of the accident aircraft." This is inaccurate. The *short-body* performance charts were also FAA-approved and were developed using the same Carson methodology used for the *long-body* RFMS data. Carson rescinded[7] two of their *short-body* performance improvement STCs in November 2010 after being notified by Sikorsky in August 2010 that our analysis had determined that all of the *short-body* RFMS data substantially over-predicted the CMRB performance.

Carson **Letter Section B.2.b.** states that by using Carson's data in the GenHel simulation, the aircraft is predicted to have sufficient performance to clear the trees. Sikorsky ran simulations at the NTSB's request using both the disputed Carson data and the validated USN/Sikorsky data. The NTSB Performance Group determined that the USN/Sikorsky data was consistent with the physical accident evidence.

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4 **Attachment 2: Carson Alert Service Bulletin (ASB) C61B163-101-1;** *dated November 29, 2010.*

5 **Note:** Carson ***RFMS #9*** also provides performance data for *short-body* S-61 aircraft; however, it is not referenced in Carson's ASB.

6 **Attachment 3: Sikorsky Letter to Carson; "Safety and the S-61 Program";** *dated August 11, 2010.*

7 **Attachment 2: Carson Alert Service Bulletin;** *Op. Cit.*

As noted[8] in Table 1 of Attachment 3; Sikorsky's prediction of the performance benefit from the CMRB as compared to the legacy aluminum blades is consistent, ranging from 828 to 840 lbs; a variation of 12 lbs, based on the minor differences in aircraft configuration. In contrast, Carson's claims vary widely from 1332 to 2004 lbs. This is a variation of 672 lbs.

The Sikorsky GenHel simulation data was all run at the request of, and under the supervision of, the NTSB. The final set of data that is contained in the Addendum was completely determined by the NTSB. It is important to note that if the blades performed as Carson stated in RFMS #8, with the engines operating as recorded on the CVR, the aircraft *will* clear the trees, despite being substantially overweight. Conversely, using Sikorsky's performance modeling experience and the data acquired over more than fifty years of professional engineering flight test shows the helicopter will impact the tree. The two different temperatures used by the NTSB in their final simulations resulted in predicted tree impact locations that bracketed the actual impact site.

Carson **Letter Section B.2.c** states that Carson commissioned an independent 'flight test'. This is incorrect. The pilot for their 'flight test' was a former Carson employee, not an independent pilot. Sikorsky has already responded to this unscientific 'flight test' via email to the NTSB Investigator in Charge, Performance Group Chairman, and Chief Scientist on April 23, 2010. In that response, we noted that the 'flight test' was not instrumented, not telemetered, not conducted under continuously monitored ambient conditions; and never reached a steady state inflow condition. In addition, there were no objective observers monitoring this event.

Carson **Letter Section B.2.d** states that the "...FAA [approved] charts are accurate, unbiased, and conservative..." and **B.2.e** states that the *only* data that should have been presented to the Board was the FAA-approved chart information..." Until August 2010, the same statement could have been made about Carson's FAA-approved *short body* performance charts (RFMS #5, #6 short, and #9). It was only after Sikorsky demonstrated that the RFMS data was incorrect that Carson issued an Alert Service Bulletin[9] revoking them, 3½ months after Sikorsky's safety warning letter[10].

Sikorsky responds to the **Appendix** to the **Letter of Petition**; as follows:

Paragraph 2 of the **Appendix** states, "Note that performance analysis is not included in this list," implying that GenHel cannot or should not be used for performance analysis.

This is incorrect. In order to provide useful data for handling qualities analysis, flight loads prediction, and flight control system development, as well as piloted simulation and accident investigations, GenHel calculates the power required by the main rotor, tail rotor, accessories, and gearbox. These predictions must be accurate in order to perform the tasks noted above. The inputs to GenHel allow for tailoring of the model to specific aircraft and to changes in the rotor geometry, hover download, or other relevant parameters. These inputs are a normal part of the usage of GenHel at Sikorsky. The inputs used for the CMRB analysis were very typical and not unusual in any way.

Paragraph 3 of the **Appendix** implies that corrections based on actual flight test were inappropriate.

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8 **Attachment 1: "S-61 Hover Performance and Effect of Trim Tab"**; *Op. Cit.; page 7.*

9 **Attachment 2: Carson Alert Service Bulletin;** *Op. Cit.*

10 **Attachment 3: Sikorsky Letter to Carson;** *Op. Cit.*

As noted in the first response, GenHel provides accurate performance (power required) predictions. In the case of this particular accident investigation, there were two major activities involved. The first was to model the differences in the accident aircraft (S-61N) from the test aircraft (NVH-3A). The differences were accounted for in GenHel using changes to the vertical and frontal drag calculated by the aerodynamics group.

The rotor model was created using the airfoil data provided by Kevin Noonan, the airfoil designer. Chord, twist, and tip geometry were provided by Carson. The rotor model was run on an NVH-3A configured GenHel model and the skin friction drag and radial induced velocity factor adjusted to match data obtained from Sikorsky flight tests. This rotor model was then used for the S-61N accident simulation.

Paragraph 4 of the **Appendix** again implies that the corrections applied to the GenHel model were inappropriate.

Sikorsky Aircraft is not aware of any free-flight helicopter simulation that will provide accurate performance predictions without corrections based on actual flight test data. The inputs used in GenHel to tailor the rotor model to measured flight test data were typical and normal.

Paragraph 5 of the **Appendix** opines that the GenHel model is overly sensitive, because a 5 knot headwind would make the takeoff possible. This paragraph reiterates Carson's opinion that the corrections to GenHel were inappropriate.

As noted above, there are no free helicopter simulations that do not require tuning to correctly predict the power required in hover and forward flight. In addition, the effect of even small amounts of wind in substantially reducing *or* increasing helicopter power required is well known in the industry. A classic example of this is the Oregon Air Force Reserve HH-60G accident on Mount Hood in May of 2002. This case was presented in detail in Sikorsky's Submission[11] to the NTSB on May 28, 2010.

Paragraph 6 of the **Appendix** implies that Sikorsky's use of the Sikorsky/USN obtained NVH-3A flight test data instead of Carson's data was inappropriate.

This is incorrect. It should be noted that this same performance data obtained from the NVH-3A was used to estimate the performance of the S-61A flight test performed at Carson. The Sikorsky predictions using the same updates and corrections as were used in GenHel agreed exactly with the 2010 *joint* Carson-Sikorsky flight test data; demonstrating the validity of the Sikorsky model of the CMRB. It also showed the CMRB performance was worse than the data as provided in the FAA-approved RFMS #8. Although this aircraft was instrumented by both Carson and Sikorsky, and flown by a Carson pilot; Carson was apparently unable to obtain any usable data from this test. Sikorsky instrumentation was monitored and recorded by our flight test engineers and technicians; and thus we have full confidence in our recorded data from this test.

[11] **Sikorsky Submission to NTSB, 28 May 2010;** http://dms.ntsb.gov/public%2F46500-46999%2F46774%2F444650.pdf

Internal Correspondence

To: [redacted]

Fm: [redacted]

Re: S-61 Composite Main Rotor Blade Hover Performance and Effect of Trim Tabs

Dt: June 22, 2011

cc: [redacted]

1.0 Executive Summary

This document contains engineering data and analysis needed to appropriately respond to performance related portions of the Letter of Petition filed with the NTSB by Carson Helicopters, Inc. (CHI) on March 11, 2011. In particular, the response herein addresses section B of the letter and emphasizes the effect of the adjustable trim tab on composite main rotor blade (CMRB) hover performance. Information will be presented that supports the conclusion that there was not a significant effect on performance due to the adjustable trim tab with tabs deflected in the upward position, nor was there any due to the blade instrumentation, both of which were installed on the test aircraft (AC_614) used during Sikorsky Aircraft Corporation's (SAC) VH-3 Lift Improvement Program. Subsequent joint CHI/SAC flight tests in 2010 of an S-61N (AC_173U), configured without trim tabs or blade instrumentation, confirmed the hover performance of the CMRB to be consistent with the LIP tests when vertical drag differences of the configurations were accounted for.

GenHel simulations included performance that was consistent with the model based on the VH-3 LIP flight tests with the composite main rotor blades.

2.0 Background

2.1 Background Introduction

To best understand the hover performance issues that have persisted between CHI and SAC, it is necessary to consider a brief review of each of the following: 1) CHI CMRB development and claims, 2) SAC VH-3 Flight Test Programs, 3) Joint CHI/SAC Hover Performance "Spot Check" Test and 4) Configuration Differences. The difference in calculated hover performance of the CMRB between CHI and SAC ranges from about 500 lb to nearly 1200 lb, based on a hover out of ground-effect (HOGE) operating condition at a pressure altitude of 6000 feet and 23°C (ISA + 20°C). A number of factors affect the wide range of discrepancy in HOGE weight and they will be addressed below.

2.2 Performance Claims from CHI's development of Composite Main Rotor Blade

Seeking gains in S-61 aircraft performance, CHI et al reported in an AHS paper in June 2002 that their design study indicated an 1800 lb improvement in hover lift could be expected from a new main rotor blade. In discussions with CHI, they have described a number of test programs that have been conducted to satisfy requirements of FAA Supplemental Type Certificates. According to CHI, various S-61 configurations were tested with the CMRB, including long and short fuselages, with fixed landing gear, rescue hoists, etc. CHI has stated that these tests were conducted at different sites, including high altitude locations. A number of STCs have been issued that establish different performance levels for the new configurations. SAC has examined the performance charts contained in the various STCs and found that they fall into two basic categories in terms of levels of hover performance. That is, of six CHI Rotorcraft Flight Manual Supplements (RFMS) that have been examined, RFMS numbers 5 through 10, three (RFMS #5, #6 and #9) indicate about 500 lb of additional hover lift relative to the other supplements (RFMS #6, #7, #8 and #10) for the CT58-GE-140 power available at 6000 ft 23°C. CHI stated in a meeting on June 22, 2010 that the degradation was due to the hover download effect of the long body (50 inch fuselage stretch) relative to the short body. Note that RFMS #6 had a long body version and a short body version. RFMS #7 and RFMS #8 are in fact labeled S-61L/N (long body configurations), but it is noted that RFMS #10 (dated July 9, 2008) is labeled S-61A/V typically known to be a short body configuration (even though its performance is consistent with the other long body supplements).

CHI also contends that the UK Royal Navy and QinetiQ Group, plc have conducted extensive flight tests that support their claims of performance improvements from the CMRB.

2.3 Sikorsky's VH-3 Flight Test Programs

Sikorsky Aircraft recently completed a VH-3 Lift Improvement Program (LIP) for the U.S. Navy. This evaluation quantified hover performance characteristics associated with the legacy aluminum main rotor blade and the composite main rotor blade configurations. The data set generated during the LIP testing included sea-level performance data collected at West Palm Beach, FL for both the aluminum and composite main rotor blades. In addition, the data set included high altitude performance data collected at Montrose, CO (elevation 5,700 ft) with the composite blades. It should be noted that the sea level performance data with the legacy aluminum blades demonstrated a strong correlation with the performance prediction model created based on the data obtained during the VH-3 Performance Improvement Program (PIP) completed in the mid-1990's.

The resulting predicted performance model curve for the legacy aluminum main rotor blades based on PIP data is presented in Figure 1 (blue dashed line). The data obtained on the aluminum main rotor blades during the LIP evaluation are superimposed on this chart (blue circles). The data obtained on the composite main rotor blades is also presented in Figure 1 (black diamond's represent sea level data; red square's represent high altitude data). The CMRB predicted performance model curve created based on the data shown is also presented in Figure 1 (red dashed line).

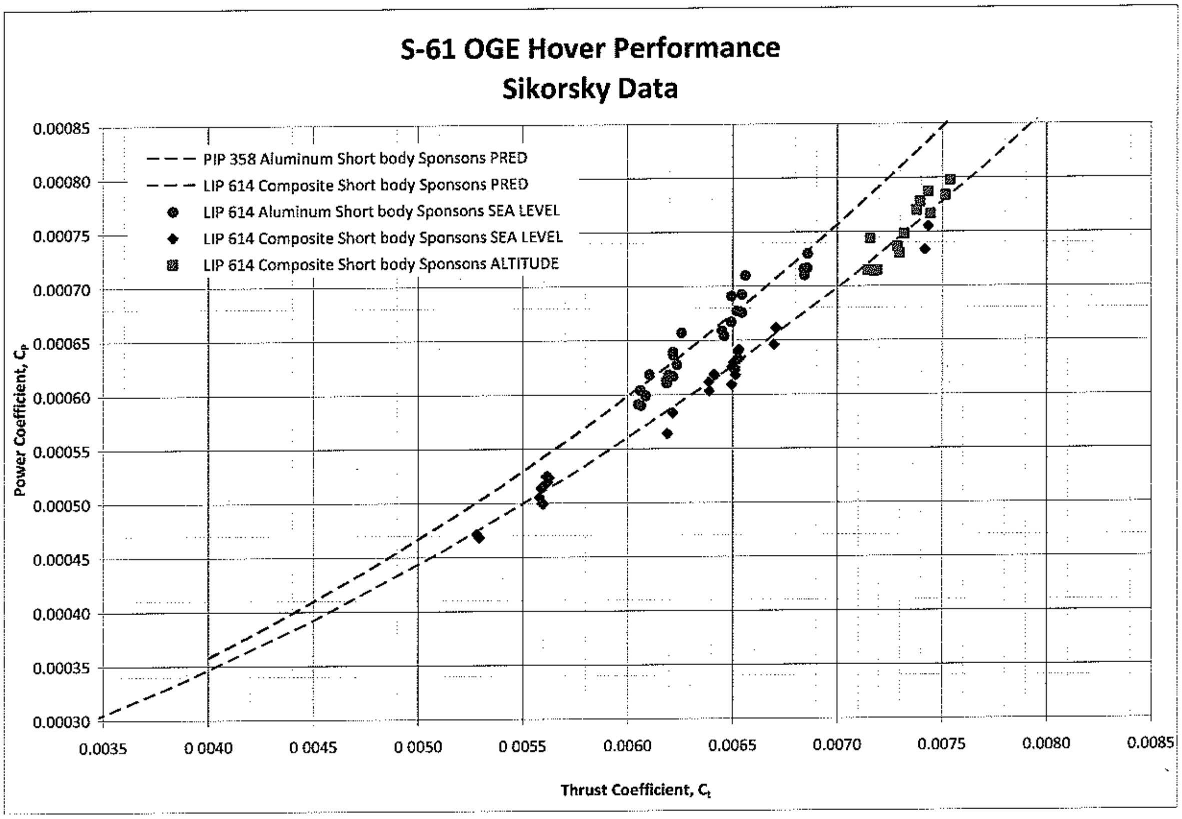


Figure 1: Predicted Performance Model Curves – Aluminum vs Composite

Subsequent to the creation of these performance curves, it was noted that composite blade performance charts created based on the LIP data did not correlate well with the performance charts contained in the CHI RFMS #6 long, #8 and #10 for the composite blade configuration, as shown in Figure 2. It should be noted that the Sikorsky predicted performance model curves were analytically adjusted to account for configuration differences between the PIP aircraft, LIP test aircraft and the Carson S-61N (SAC 173U) aircraft. For clarity, the progression of the analytical adjustments to the Sikorsky generated curves are shown. Not shown on Figure 1 is the more optimistic CHI short-body performance, RFMS #5, #6 and #9, which would show even worse correlation. Note that the short-body RFMS performance is compared to the pre-test predictions in the chart contained in the attached Item 1 that is discussed in the next section.

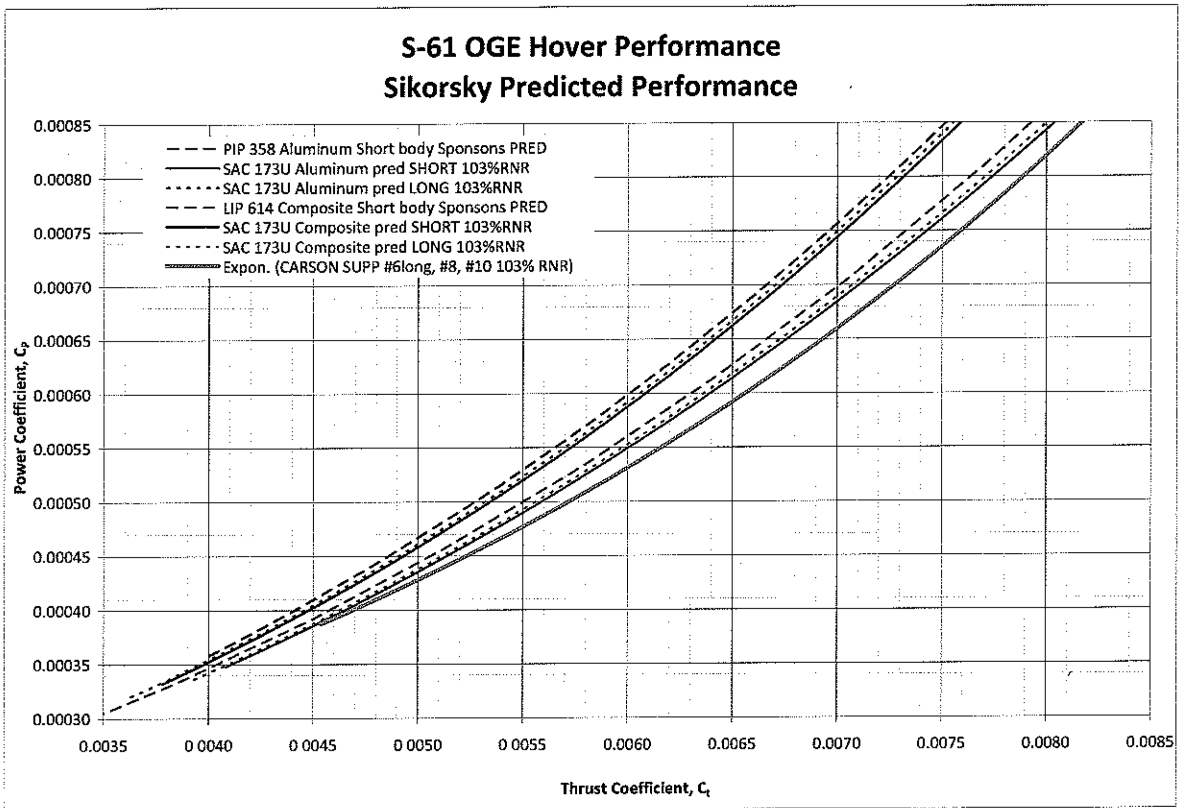


Figure 2: Predicted Performance Model Curves - Comparison

2.4 <u>Joint CHI/SAC Hover Performance "Spot Check" Test</u>

Due to the observed discrepancy in the predicted performance model curves, a joint Sikorsky / Carson hover performance test was conducted that was intended to resolve the differences and to provide a basis for flight manual charts in support of initial 2010 S-61N aircraft deliveries to the U.S. Dept. of State. All flight testing occurred at Carson's flight facility in Perkasie, PA primarily during August and September of 2010. This evaluation was designed to collect a limited amount of performance data to provide a "spot check" of the existing performance models.

It should be noted that just prior to the conduct of the spot check tests, CHI made a statement that retracted the validity of the performance in their "short body" supplements. No explanation was given. This is why only RFMS #6 long, #8, #10 are shown with the non-dimensional performance curves in Figure 2.

Performance data obtained during the subject "spot check" employed the free hover test method. All testing was a joint effort with expertise and equipment provided by both Carson and Sikorsky Aircraft. Testing was conducted on a short body S-61N aircraft (Tail Number: N3173U) supplied by Carson Helicopters. Both aluminum and composite main rotor blades were tested and the CMRB did not have trim tabs installed or safety of flight instrumentation. An instrumentation package was installed to record engine torque, main rotor speed and radar altitude. Sikorsky Aircraft also provided its weather balloon system for measuring wind at the altitude of the rotor plane of the aircraft (typically ~100 ft for OGE hover performance). Several pre-weighed concrete blocks were lifted during the test to obtain a range of main rotor thrust loadings. The test aircraft was weighed pre and post flight to accurately determine the test gross weight. Calibration of the scales was confirmed by both teams. Wind conditions were marginal during the test period (data was obtained in winds ranging from ~2 to 6 kts). Only data points obtained in winds of 3 kts or less were included in the subsequent analysis.

The performance data obtained during this test is presented in Figure 3. Test data is superimposed on the predicted performance model curves that were established prior to the test. The predictions are a mathematical model that is based on the LIP test results for the CMRB with an adjustment for configuration vertical drag differences between LIP 614 and SAC 173U, discussed in the next section. Inspection shows that the aluminum and composite blade OGE hover performance spot check results correlate with the Sikorsky Aircraft performance model predictions derived from the VH-3 Performance Improvement Program (PIP) and VH-3 Lift Improvement Program (LIP) data. Note that performance predictions were made prior to the acquisition of any test data as evidenced by the following Item 1 (as submitted by email prior to the test).

From: [redacted] SIK
Sent: Monday, August 02, 2010 7:11 PM
To: [redacted]
Cc: [redacted]
Subject: Preliminary Hover Test Predictions

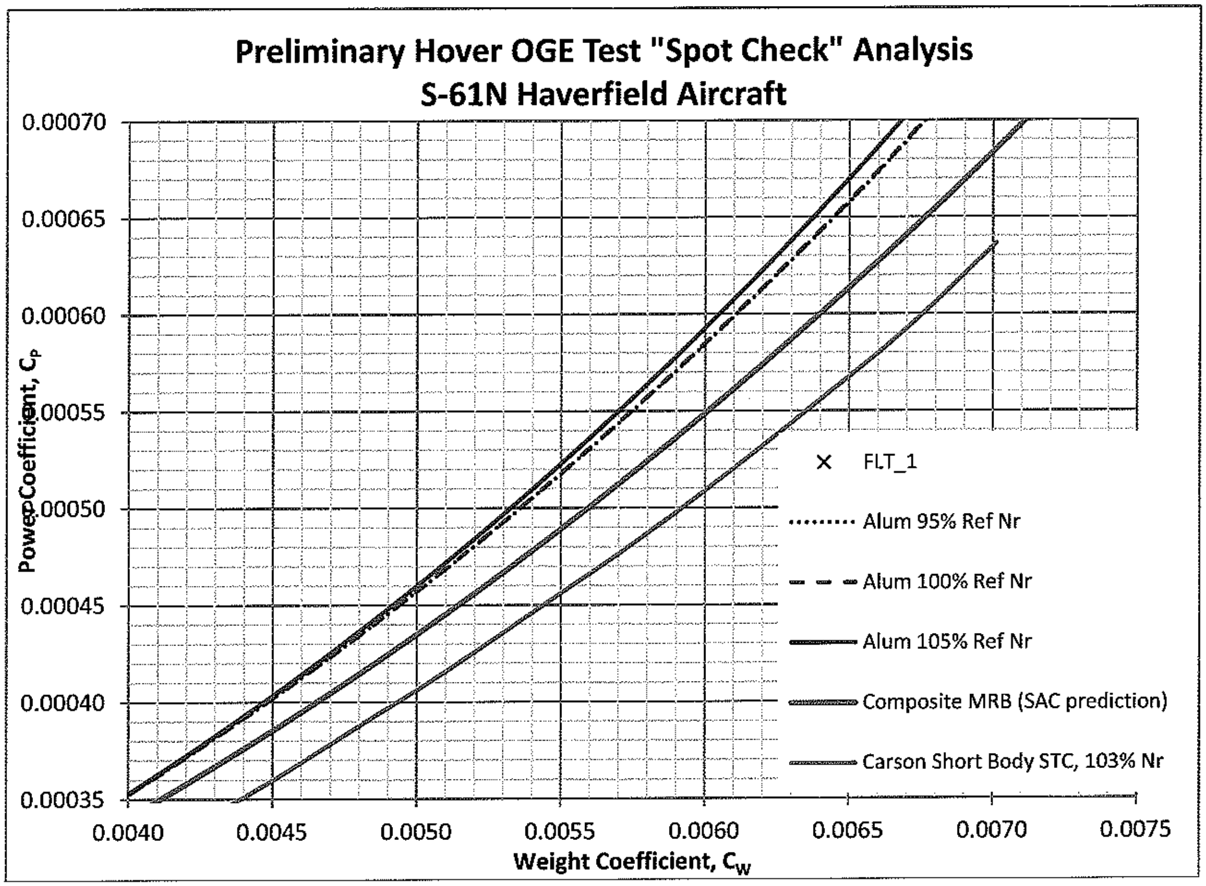
Pat,

I understand that some initial hover performance data may be acquired tomorrow on the Haverfield aircraft, as long as conditions are relatively calm. In the spirit of cooperation and honesty, I am providing you with an Excel file that compares the pre-test predictions in a non-dimensional format. It includes Sikorsky's predictions for the aluminum blades and composite blades, as well as the Carson STC chart performance for the short-body configuration. The STC data and conversion to non-dimensional parameters are included in the file. Hopefully we'll soon get some performance data that can be added to the chart.

I am planning to be there tomorrow in the mid-morning. I will soon be going on vacation, starting next Thurs Aug 12 through the end of the month. I hope we get a chance to get a chance to discuss the results soon.

Regards,

[redacted]
Sikorsky, Aerodynamics
(203) 386-[redacted]



Item 1: Pre-Test Performance Predictions for Perkasie Spot Check Hover Tests

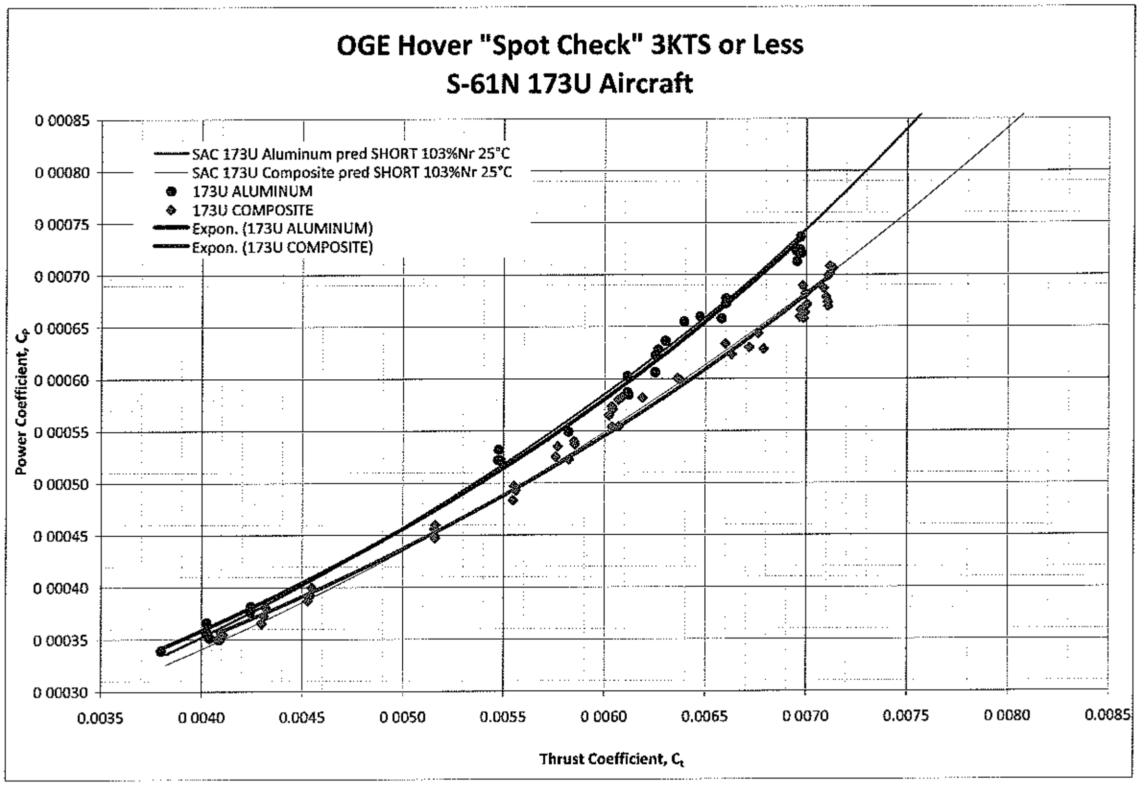


Figure 3: Performance "Spot Check" Data

2.5 <u>Configuration Considerations</u>

There are a number of differences in the aircraft configuration between the Sikorsky LIP test of the CMRB and the spot check test. Most of these differences pertain to the download, or vertical drag, on the fuselage from the rotor wake in hover, such as from the sponson gear on the VH-3 (LIP 614) relative to the fixed landing gear on the S-61 (SAC 173U). This and other vertical drag items are shown in Figure 4. This material was reviewed with CHI on June 22, 2010 in preparation for the spot check test. Note that -1.43% is identified near the bottom of Figure 4 as the adjustment in vertical drag from the VH-3 (LIP 614) to the S-61N Short or SAC 173U as tested. As described above, these configuration effects were accounted for in the pre-spot test predictions of performance that were verified by the acquired data.

In addition to the configuration items that affect the vertical drag, there were a few other known differences between the configurations. These include differences in tail rotor size, adjustable trim tab installation and main rotor blade instrumentation wiring. The tail rotor on the S-61 (SAC 173U) spot check aircraft was 3.25 inches greater diameter than the tail rotor on the VH-3 (LIP 614) test aircraft. While this can make a difference for maneuvering flight, information was reviewed with CHI at the June 22, 2010 meeting that showed the tail rotor size difference to have a negligible impact on steady hover performance particularly for existing installed power available. Blade trim tabs and instrumentation are addressed in the next section.

Vertical Drag Summary

		Fe sq. ft.	Dv %GW	
SH 3H		36.5	4.0%	**SER 611570, SER 611619**
Remove	Radome	-3.5	0.00%	
	MAD Gear	-1	0.00%	
	Marine Marker Pack	-1.5	0.00%	
	Antennae	-0.5	0.00%	
SH 3A		30.0	4.0%	**SER 611570, SER 611619**
Remove	Rescue Hoist	-0.7	0.00%	
	Landing Gear Pods (Sponsons, strut fairings)	-6.95	0.50%	SER-611344 and analysis
Add	Fixed Landing Gear	14.36		Analysis
	Composite Main Rotor	0	0.30%	Analysis
	Long body (50 inch plug)	0	0.43%	Analysis
	10' 7.25" DIA TR and larger tail	0	0.00%	
S-61N Long	**Long body, fixed gear, composite rotor**	**36.71**	**4.23%**	**Estimated**
Remove	Long body (50 inch plug)	0	-0.43%	
S-61T (S-61N)	**Short body, fixed gear, composite rotor**	**36.71**	**3.80%**	**Estimated**

		Fe sq. ft.	Dv %GW	
SH 3A		30.0	4.0%	**SER 611570, SER 611619**
Remove	Rescue Hoist	-0.7	0.00%	
	Aux. Flotation	-0.6	0.00%	
Add	Aux. Powerplant	1.8	0.00%	
	Antennae	3.5	0.00%	
Basic VH 3D		34.0	4.0%	**SER 611619, SER 611912**
Add	APR/AAR Forward	0.14	0.01%	
	APR/AAR Aft	0.31	0.08%	
	ALE-47	0.88	0.00%	
	AVR-2 Forward	0.5	0.06%	
	AVR-2 Aft	0.51	0.02%	
	Tailcone Strake	0.42	0.76%	
	Misc.	0.1	0.00%	
VH-3D SLEP/PIP (Aluminum Blade)		**36.86**	**4.93%**	**SER 611912**
Add	Composite Main Rotor	0	0.30%	Analysis
VH-3D LIP (hover test configuration w/ Carson blades)		**36.86**	**5.23%**	

Delta from VH 3D LIP to S 61N Short 1.43%
Delta from VH 3D LIP to S 61N Long 1.00%

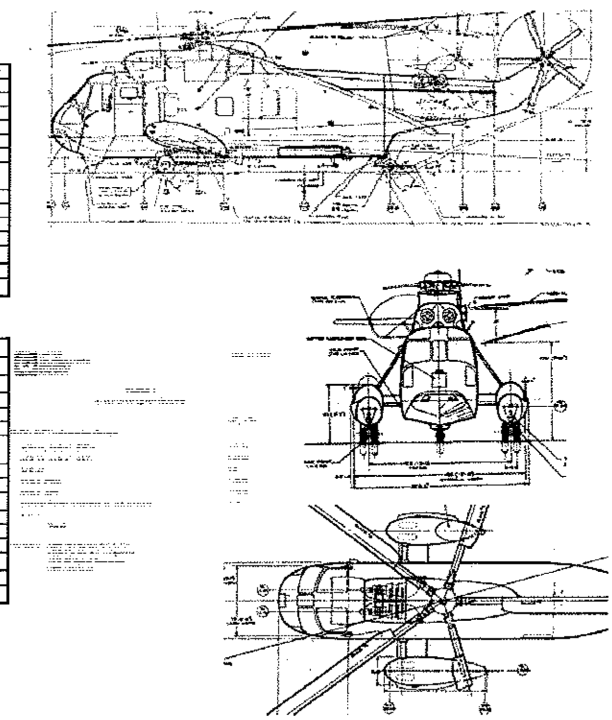


Figure 4: Vertical Drag Considerations

2.6 <u>Background Summary</u>

To summarize the various elements discussed above, Table 1 is provided that compares hover performance from the different CHI RFMS's to Sikorsky's calculated hover performance from the model that is based on VH-3 LIP test program.

The Sikorsky data is calculated for the following configurations: 1) an S-61 short-body with fixed landing gear, 2) an S-61 long-body with fixed landing gear, 3) the S-61 Fire King (long-body with fire tank installed and fixed landing gear), and 4) the VH-3D.

Note that the fire tank is estimated to add 0.54% of vertical drag. The power available for the data in Table 1 is read from the takeoff rated charts for the CT58-GE-140-1, -2 engines. At 6000 ft 23°C, and at 103% Nr, approximately 82% torque per engine is available, or 2052 shp (total).

Table 1 Comparison of HOGE Gross Weight Data at 6000 ft 23°C (ISA+20), 103% Nr

	Gross Weight (lb) to Hover OGE			ΔGW (CMRB - Alum)		Δ(CHI - SAC)
	Aluminum	SAC_CMRB	CHI_CMRB	SAC	CHI	Δ(lb)
* S-61 Short-body + fixed landing gear	16505	17345	18273	840	1768	**928**
** S-61 Long-body + fixed landing gear	16433	17269	17765	836	1332	**496**
** S-61 Fire King (Long + Tank + fixed gear)	16344	17176	17765	832	1421	**589**
** VH-3D (Short-body + mission equip)	16269	17097	17765	828	1496	**668**
* VH-3D (Short-body + mission equip)	16269	17097	18273	828	2004	**1176**

* CHI CMRB HOGE GW based on RFMS #5, #6 short, #9
** CHI CMRB HOGE GW based on RFMS #6 long, #7, #8, #10

3.0 Effect of Adjustable Trim Tabs and Blade Instrumentation

As discussed above, pre-test performance predictions were made for the S-61N spot check test using a mathematical model that was based on the LIP 614 tests with adjustments for estimated vertical drag differences. Figure 3 shows the strong correlation that exists between the SAC 173U results and the predictions. The predictions assumed a negligible effect from trim tabs and blade instrumentation. Again, since the LIP 614 tests had trim tabs and instrumentation when the S-61N (SAC 173U) spot check vehicle did not have either, the strong correlation in Figure 3 provides a likely indication that any effect of the adjustable trim tab or blade instrumentation was extremely minimal and therefore is not a source that might corrupt the quality of the rotor performance. Additional considerations of the instrumentation and trim tabs are given below.

3.1 Instrumented Main Rotor Blade

One of the five composite main rotor blades from the LIP 614 test was instrumented for safety of flight data acquisition to acquire blade bending and loads data. This results in some out of contour deviations over a portion of the lower surface of the blade span. While the lower surface of the blade is less sensitive to contour deviations than the upper surface is, for performance testing, it is preferred to remove the instrumented blade and replace it temporarily with a clean blade. Not all tests are conducted in this way as availability of additional blades and schedule or cost constraints sometimes dictate that the instrumented blade remain on the test aircraft during performance tests. The instrumented blade was installed on LIP 614 during performance tests. No additional analysis was considered to quantify this effect, but as discussed above, the strong correlation of the S-61N SAC 173U results with the pre-test predictions indicate that the blade instrumentation did not have a significant effect.

3.2 Adjustable Trim Tabs

Each of the five composite main rotor blades from the LIP 614 test had 20 inch adjustable trim tabs installed as shown on Figure 5. For the duration of the LIP 614 tests the tab position was very similar to the fixed cusp integral blade tab that is adjacent and inboard of the trim tab. CHI has indicated that the fixed cusp angle is 6 degrees upward.

An analysis was undertaken to estimate the effect of the trim tab in the upward position. The first part of the analysis included a computational fluid dynamics (CFD) study to determine the effect of the tab on the airfoil section lift, drag and moment characteristics. Figure 6 shows the incremental changes in coefficient form that were applied to 2-D airfoil data tables and used in a lifting line hover method to determine the rotor performance change due to the tab. Figure 7 shows the result of the lifting line analysis in terms of isolated rotor Figure of Merit vs. CT/s as well as in terms of rotor CP vs. CT. The study results indicate a very small and negligible effect of the trim tab in the configuration tested. This result is consistent with the indication described above based on the strong correlation of SAC 173U test results with the pre-test predictions.

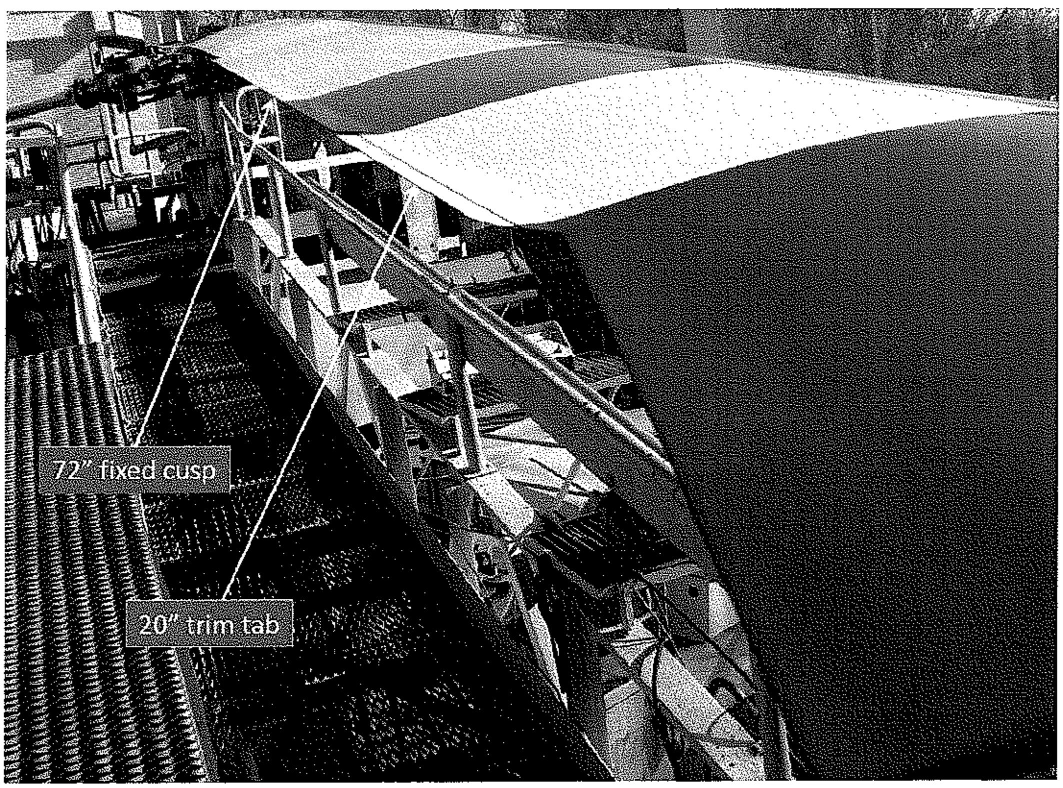


Figure 5: CMRB with 20" trim tab on Sikorsky's balance stand

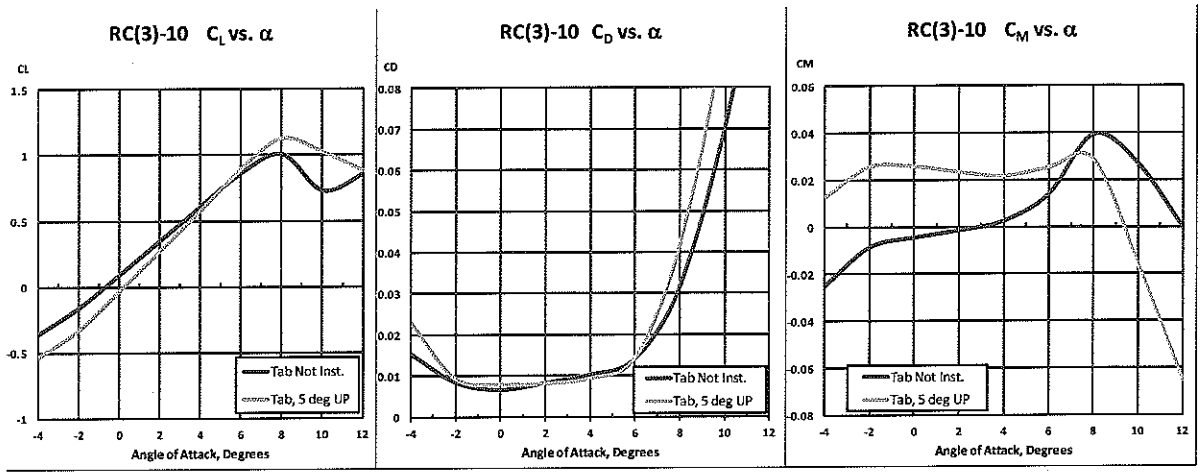


Figure 6: CFD predicted airfoil characteristics with trim tab at 5° up, M = 0.58

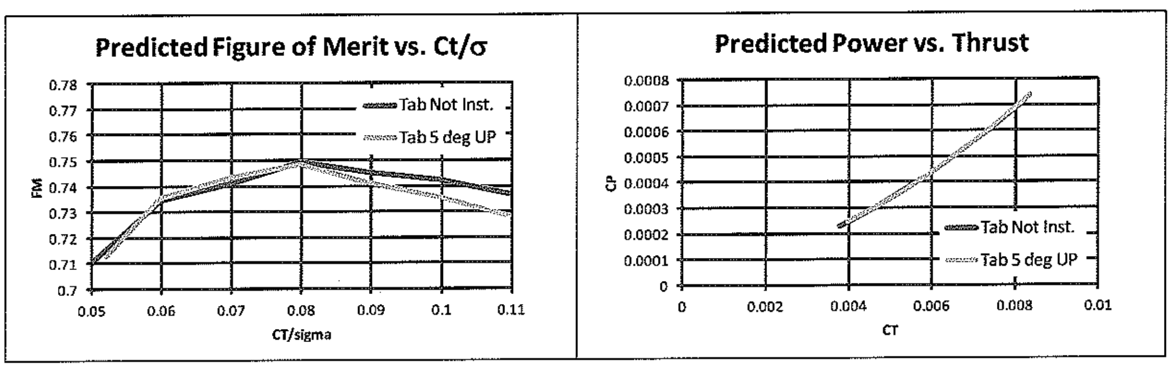


Figure 7: Lifting line method hover predictions for CMRB without tab and tab 5° up

4.0 <u>GenHel Performance Modeling</u>

The GenHel simulation program that was used to estimate takeoff flight profiles was calibrated at the conditions of interest to ensure that its performance representation (power required as a function of weight, altitude, temperature and airspeed) for this study was accurate and consistent with the model based on Sikorsky's LIP program hover performance test. Vertical drag corrections were also accounted for appropriately.

5.0 Conclusions

Based on the discussion above, the following conclusions have been made:

- The test data from the joint CHI/SAC evaluation correlated well with the Sikorsky Aircraft predicted performance models (as adjusted for configuration vertical drag differences) which are based on data obtained during the VH-3 Performance Improvement Program (aluminum blade only) and the more recent VH-3 Lift Improvement Program (aluminum and composite blade data).
- The effect of upward deflected trim tabs and instrumentation on one main rotor blade, as was tested in the VH-3 Lift Improvement Program, was very minor and a negligible factor for hover performance.
- GenHel simulations included performance that was consistent with the model based on the VH-3 LIP flight tests with the composite main rotor blades.
- At 6000 ft, 23°C, the CHI RFMS performance charts for a long-body (Fire King) configuration indicate a hover weight that is 589 lb greater than what Sikorsky calculates using performance models based on the VH-3 LIP tests and after making corrections for configuration vertical drag differences.

CARSON HELICOPTERS INC.

November 29, 2010

ALERT SERVICE BULLETIN
C61B163-101-1

Subject: Rotorcraft Flight Manual Supplements (RFMS) used with STC SR01771NY (Increase of Out of Ground Effect (OGE) Hover Performance for the S61A and S61N Helicopters in accordance with Carson Helicopters, Inc. Report No. CHI-03-1002 Rev. IR dated March 24, 2003.)

1. Planning Information

   A. Effectivity

   Model: Sikorsky S61 models S61A, S61V, and S61N aircraft with 50" reduced length fuselage using composite main rotor blades (STC SR1585NY) and increased OGE Hover Performance (STC SR01771NY).

   B. Description

   Recent performance testing on another program could not validate the performance charts found in STC SR01771NY, RFMS 5 (Short fuselage S61N) and RFMS 6 (S61A and S61V serial number 61271.

   C. Compliance

   Compliance is essential.

   D. Accomplishment Instructions

   Remove RFMS 5 for short fuselage S61N aircraft and RFMS 6 for S61A or V aircraft from the aircraft flight manual immediately.

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CARSON HELICOPTERS INC.

November 29, 2010

ALERT SERVICE BULLETIN

No.C61B163-101-1

E. Recommended operations requiring OGE/IGE Hover Performance charts.

The FAA approved RFMS's for use with STC SR02382NY (Increase of OGE and IGE hover performance for long and short fuselage aircraft) should be used until revisions are approved to STC SR01771NY RFMS's.

For S61N aircraft (long or short) use Supplement No. 6 dated 5/18/2007.

For S61A and S61V aircraft use Supplement No. 10 dated 7/9/2008.

F. Approval

The contents of this Alert Service Bulletin were approved by the FAA on December 2, 2010

G. References

Sikorsky Flight Manual SA 4045-82.

NATOPS Flight Manual NAVAIR 01-0230HCL-1.

Carson STC SR1585NY (Installation of composite main rotor blades).

Carson STC SR01771NY (Increase of OGE Hover performance).

Carson STC SR02382NY (Increase of OGE/IGE Hover Performance).

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Sikorsky
A United Technologies Company

August 11, 2010

Carson Helicopters, Inc.
32-H Blooming Glen Road
Route 1 Box 94
Perkasie, PA 18944

Attention: Mr. Frank Carson, President

Safety and the S-61 Program

Reference (a): Supplement Type Certificates SR02382NY(Supp. 6); SR02487NY (Supp. 7); SR02507NY (Supp. 8)

Dear Mr. Carson,

At the request of David Adler, I would like to introduce myself and arrange for a short meeting and tour of your facility in Perkasie. I am the Chief Safety Officer for Sikorsky Aircraft Corporation (Sikorsky) and as such, have been very involved in the potential safety issues and progress in regard to the sale of S-61s to the United States Department of State (DoS) in particular and the S-61T program in general. As we near delivery of the first complete S-61 for the DoS, I would be especially interested in touring your facility, understanding your processes and in general, gaining a better understanding of how my department's experience and expertise may be of service to you as we continue to move forward together.

One of the issues that we have been following closely involves the Carson Main Rotor Blade (CMRB). As you may know, as a result of testing and analysis of the CMRB on a VH-3 aircraft, Sikorsky has a reasonable belief that the STC Performance Charts in regard to the CMRB may be inaccurate and may overstate the performance of the blades, thereby creating a potential flight hazard for operators. Sikorsky's analysis of the CMRB is on-going, the performance characteristics are not yet finalized and a joint Sikorsky/Carson hover performance flight test is now in progress. This should be completed in the next four to eight weeks and will validate the performance of the CMRB on an S-61N aircraft. In the meantime, Sikorsky believes that it is Carson's responsibility as the STC holder to notify operators who may be relying upon the CMRB Performance Charts and the FAA that those charts may be inaccurate.

Please contact me directly if you have any questions in this regard or if there is anything we can do to assist you in the interim and please let me know when you might be available for me to come down.

With best regards,

[redacted]

David Eherts
Chief Safety Officer
SIKORSKY AIRCRAFT CORPORATION