Comments on Sikorsky Aircraft Corporation Accident Submission

Accident: NTSB Case Number LAX08PA259

Aircraft S61N-- N612AZ

Submitted by Carson Helicopters, Inc.

6 July 2010

Carson Helicopters appreciates the effort by Sikorsky Aircraft Corporation (SAC) in submitting their analysis of the accident investigation for the Weaverville, CA helicopter crash of 5 August, 2008. Carson has studied the Sikorsky Aircraft Corporation (SAC or Sikorsky) submission and is aware of several factual inaccuracies in the report. These inaccuracies have a direct bearing on Sikorsky's calculations and analysis

1. Sikorsky's calculation of the Carson Composite Main Rotor Blades lift capability is inaccurate

On page 4, Section 2, Power Required, SAC states that SAC did a comparison of the legacy Sikorsky aluminum blades to the Carson composite main blades (CMRB) and determined that" the actual performance gain was less than had been predicted by Carson, both in their RFMS performance charts and in their published rotorcraft industry technical papers."

This statement is not correct. SAC conducted its flight tests with a different configuration aircraft (S-61A) than that utilized by Carson. The correct statement would be to say that with a different aircraft configuration and limited testing, the SAC tests showed results that were different from the Carson flight tests. However, it is very important to note that the Carson flight tests were conducted under the sanction of the FAA and were part of the FAA certification process for the CMRB program. The resulting performance charts are certified by the FAA to represent the actual performance witnessed during flight testing and are the certified charts in the flight manual for this configuration aircraft.

When SAC characterizes that the actual performance gain was less than that "predicted" by Carson, they are actually saying that the RFMS performance charts as certified by the FAA are wrong. In actuality it is the SAC results that are "predicted" since these results were not complete nor conducted with the same configuration aircraft and cannot be accurately compared to the approved performance charts. *<u>The RFMS charts are based on actual test flight data, as certified by the FAA.</u>*

Additionally, it should be noted that the Carson RFM composite blade flight charts were approved by the same FAA test group that certified the Sikorsky S-92 helicopter flight charts. It is difficult to understand

SAC questioning the veracity and approval process of the FAA -certified performance charts when they have utilized the same FAA test group for their own aircraft.

1. **Carson composite blade performance is supported by multiple flight test data sets**

There is no need to speculate concerning the comparison between the FAA approved supplemental charts and a Sikorswky test using a differently configured S61 in order to determine the aircraft performance with the composite blades. As discussed in Carson's party submission, following the accident Carson commissioned an independent test flight with an exemplar S61N aircraft equipped similarly to the accident aircraft that was test flown at weights and density altitudes exceeding the accident aircraft. The performance of the aircraft verified that shown by the CMRB approved charts in every circumstance. This test data is part of the NTSB public docket and clearly demonstrates under real world conditions that the performance charts for the Carson CMRB are accurate and repeatedly attainable using normal pilot inputs (*Whipple Aviation Services Flight Evaluation report, NTSB public docket*).

In addition, the lift increments measured in the original Carson long body tests (the Supplement 8 FAA charts) are supported by two other flight test programs; 1) Carson back-to-back tests on a short body S-61, and 2) independent testing and flight calculations of a Sea King (British version of the S61) helicopter by QinetiQ in Great Britain. The UK Royal Navy commissioned this verification for acceptance of the blades and charts for use by the Navy Sea King fleet. It is only the SAC testing that does not agree with these four actual flight test data sets.

SAC states in this section that "No back-to-back comparison testing on identical aircraft was documented during Carson's STC testing for FAA approval of the CMRBs." In point of fact, Carson conducted separate extensive back-to-back testing using the same S-61A helicopter at three different density altitudes (sea level, 6000 ft and 10000 ft.). The results of this testing are publicly available and were published in:

Curtiss, H.C., Carson, F., Further Developments of the S-61 Helicopter. Paper presented at the 31st European Rotorcraft Forum, Florence , Italy, September 2005.

2. **Sikorsky's calculations in the fire tank downwash study are wrong**

Sikorsky states that Carson's RFMS no. 8 charts did not account for the 103 lb. vertical drag of the Fire King tank. This figure was calculated by SAC utilizing a downwash strip chart. As previously documented by Carson to the NTSB, the SAC measurements from the downwash study for the tank are based on faulty data and are not correct.

Specifically:

1) The SAC downwash study shows the tank location on the fuselage from station 186 to station 290. This is incorrect. The tank location on the fuselage is from station 213 to station 320, or <u>30 inches</u> more to the center of the fuselage and the rotor disc

than the location in the study. This will necessarily have a very important effect on the strip loading coefficient, and will undoubtedly reduce any downwash loading in the calculation.

2) The tank surface is not flat as was assumed by the SAC study. All outside and inside edges of the tank have radiused and rounded smooth edges with surfaces that will spill air and affect perceived downwash quite differently than a solid flat surface.
3) Carson has conducted flight testing at similar density conditions to the accident aircraft both with the tank on and off the aircraft and there was no difference in performance of the aircraft or its ability to hover with payloads that are directly in accordance with the RFMS performance charts. That data has been supplied to the NTSB.

In sum, the "corrections" applied by SAC to derive their assumed payload numbers for the Carson CMRB equipped aircraft are: 1) calculated based on an incorrectly configured aircraft; 2) have inaccurate downwash vertical drag figures applied to them, and 3) are wholly unsupported by comparison to several other sets of relevant flight test data. This means that any analysis conducted from the basis of these figures is erroneous from the outset.

3. Sikorsky's description of the Main Rotor Blades is incorrect

On page 5, section G.2, SAC states that the blade twist is increased from the original aluminum spar 6 degree linear twist to a non-linear twist of 9.48 degrees for the CMRB. Both of these numbers are incorrect. The original aluminum blade has 8 degrees of linear twist. In the aerodynamic portion of the blade, the Carson CMRB has 12 degrees of linear twist. There is a short region of positive twist at the root of the blade so that no rigging change is necessary to install the new blades in place of the aluminum blades (*reference Prof. H.C. Curtiss, professor emeritus, Princeton University*).

On page 6 of this section, SAC has a paragraph devoted to a description of Sikorsky-identified concerns with the manufacturing and design of the CMRB identified by SAC during a study of the blades for US Naval use. The paragraph describes some modest changes that SAC recommended for construction, based on their experience with loading on the legacy aluminum blades, and leaves the reader with the impression that SAC has identified problems with the construction of the blades.

In fact, the Carson CMRB program was FAA approved and put into use in 2003, after extensive design and testing phases. Since then, more than 100 sets of these composite blades have been put into service, with more than *200,000 flight hours* accumulated in real world conditions. These flight conditions include repetitive heavy-lift construction flying, heli-logging in mountain terrain, wildland firefighting worldwide, and extensive hostile environment flying by the Royal Navy and commercial operators in the war zone in Afghanistan. Much of these flight conditions involve repetitive heavy loads at high altitude. There has not been a single flight failure of a Carson composite rotor blade, nor has there been a single safety of flight issue identified due to the Carson CMRB.

The reality is that the entire paragraph at the top of Page 6 is pure speculation by SAC and completely irrelevant to this accident.

4. **Sikorsky omits important facts critical to the investigation**

Pages 5 through 15 of the SAC report entail a detailed description of the condition and teardown of the blades, inputs, and engines. We note that nowhere in this 10 page section of thereport does SAC detail any information about the teardown of the Fuel Control Units (FCU) and subsequent discovery of significant foreign particle contamination contained inside the # 2 Fuel Control Unit and Pressure Regulating Valve (PRV). Many of the discovered particles were in the 2.5 to 30 micron size range, which is significantly smaller than the 40 micron filter specified by the manufacturer at the time of the accident. Despite omitting any discussion of the contamination in the accident aircraft's FCUs, Sikorsky is aware of the threat posed by such contamination. On January 15,2010 Sikorsky issued a service alert to operators of the S61 aircraft, detailing the possibility of contamination entering the FCU and PRV of the FCU and causing potential loss of power issues. The service alert specifies directs operators to switch to a 10 micron filter to help alleviate the situation. This entire informational aspect of the accident is conspicuous by its absence from the Sikorsky report.

5. **The Environmental Conditions and Performance planning sections contain speculations that are unsupported by fact**

SAC has included a paragraph on page 17 under Environmental Conditions discussing possible leading edge contamination on the blades at the time of the accident. This paragraph regarding the possible effects of contamination on airfoils is supported by footnote 36, which cites the following: " History has shown that other advanced airfoils used on fixed wing aircraft such as the ATR-72 (modified NACA 43018/43013) have reacted to leading edge contamination very differently than did older, simpler airfoils." And "………resulting in unpredictable performance in near-stall conditions."

This footnote refers to NACA 43018/43013 airfoils as "advanced" airfoils. These airfoils were developed and tested in the 1931-35 period (*NACA Report No.610*) and were considered obsolete by 1945 (*NACA Report No. 824*). The citation of these airfoils to support SAC claims is completely irrelevant to this aircraft and to any understanding of the causes of this accident.

The second sentence of that paragraph refers to unpredictable behavior in "near-stall conditions". The average lift coefficient of the main rotor blades in the maneuver of interest under discussion here is 0.6 or less, which is not close to stall conditions for the rotor blade airfoils (*reference Prof. H.C. Curtiss, professor emeritus, Princeton University*). These footnote comments do not support the SAC speculation contained in the paragraph regarding environmental conditions and are inaccurate.

On page 17, under section L, subsection Performance Planning the SAC submission states "Sikorsky/USN engineering flight test data indicates that Carson's blade performance charts documenting the power required to hover are incorrect." And "….Carson's RFMS No.8 charts did not account for the estimated 103 lbs. of vertical drag produced from the fire king tank."

As demonstrated by the facts presented in our earlier discussion of the SAC report, the reality is that there are multiple sets of existing certified flight test data and back-to-back tests that confirm that the blade performance charts are entirely accurate (original Carson FAA approved flight data, 2005 back-to-back flight test data presented in a technical paper, Carson Cat A and high altitude flight testing done for expansion of the STC in 2007, independent calculations done by QinetiQ in Great Britain, and an independent flight test done in 2009 replicating and exceeding flight conditions for the accident). In fact, the only test data that do not match up with these documented results are the SAC engineering data which were done with a differently configured aircraft under unknown conditions. As discussed above, the SAC vertical drag study done on the fire king tank is factually wrong, and does not match empirical real-world testing. Any SAC calculations of weight capability based on these multiple erroneous data are incorrect and not useful.

6. The Sikorsky GenHel Performance Analysis is based on inaccurate data and is incorrect

The Section M, Sikorsky Aircraft Performance section that begins on page 17 is an attempt by SAC to model predicted aircraft performance via computer simulation under different flight conditions. It states that "The major features of the GenHel simulation are its generic formulation and the continuous verification and validation by comparison to hundreds of hours of Engineering Flight Test Data." However, by SAC's own admission in this report, all of their figures for this case in the modeling program are based on, 1) one limited set of flight test data conducted by Sikorsky with an S-61A variant helicopter that is not the same configuration aircraft as the accident aircraft and, 2) utilizes drag coefficients for the fire king tank that are based on a study that has already been proven wrong, due to improper fuselage placement of the tank in the study (*by 2.5 feet*) and incorrect accounting for drag surfaces. In other words, SAC used one limited set of faulty flight data which was then "corrected" to produce GenHel models for predicted aircraft performance.

The results of the six "actual power available" studies are all incorrect and the power margins shown do not even agree with the NTSB Hover Study findings. However, beyond theoretical modeling comparisons, the results do not remotely agree with the actual independent flight test conducted by Whipple Aviation Services and supplied to the NTSB. For example, finding No. 6 on page 19 of the GenHel description states that according to the SAC/GenHel data, at 19,008 lbs. gross weight "the aircraft cannot HOGE, because it has a negative margin (-878 lbs) and in all departure scenarios….the aircraft crashes."

In the actual flight test with an exemplar S-61N helicopter, the aircraft was flown at gross weights of 19,100 lbs and above at density altitudes equal to or above the accident conditions. The aircraft picked up a load of water sufficient to achieve the gross weight of 19100 lbs at 5,800 ft. above MSL, then ascended to a density altitude that was the same as the accident conditions and came to a stationary hover 400 ft. out of ground effect. In fact, then applying maximum collective input of 22.5 degrees, the rotor speed decayed to 94%NR and stabilized there and a small positive rate of climb developed. The aircraft was also flown at 19, 500 lbs. and 19,400 lbs., and in each case achieving a stabilized OGE hover at a density altitude greater than that in the accident. The full collective inputs were repeated. It was found during these flight tests that the only way to obtain a rotor speed decay below 94% NR as indicated in the accident, was to significantly reduce the torque of one engine by 27% from 97% to 70% and this large reduction did produce a further decay of the rotor speed.

These tests affirmed previous flight test data validated by the FAA in the certification process and the back-to-back flight testing done by Carson in previous test scenarios. In all, seven test flights with weights ranging from 18,500 lbs. to 19,500 lbs. were completed with the aircraft hovering out of ground effect and able to fly away with positive rates of climb using normal pilot inputs. According to the SAC GenHel modeling, this should have been impossible.

The SAC GenHel program was "corrected" by Sikorsky to try to model the proper aircraft response because SAC does not possess accurate flight data to input into the program. This is not speculation on the part of Carson, but is a simple statement of hard fact as demonstrated by multiple real-world flight tests that completely contradict the synthetic study produced by SAC.

Carson has repeatedly offered to both the NTSB and to SAC separately to fly additional tests with a CMRB-equipped aircraft, and is now proceeding on its own initiative to conduct a back-to-back flight test with both legacy metal blades and Carson CMRB on the same aircraft. Carson has conducted similar in-house tests with its own aircraft on multiple occasions, and in every case the composite blades lifted a minimum of 2,000 lbs. more than the legacy metal blades at equivalent torque settings, validating the FAA approved flight charts for the aircraft.

The NTSB should be extremely cautious about accepting synthetic power studies and resultant conclusions based on demonstrably poor and incorrect primary data that contradicts all known validated flight test data for the composite blades, including a flight test done under the same payloads and density conditions as the accident aircraft. There is no benefit to utilizing flawed modeling studies when a significant amount of applicable real flight data are available that conclusively demonstrates the true performance of the CMRB and the aircraft.