

## A New Main Rotor for the Sikorsky S-61

H.C. Curtiss, Jr.  
Princeton University  
Princeton, NJ

Frank Carson, Jeff Hill  
Carson Helicopters  
Perkasie, Pa

Todd Quackenbush  
Continuum Dynamics, Inc  
Ewing, NJ

### **Abstract**

The aerodynamic design of new main rotor blades for the Sikorsky S-61 is discussed. Design criteria are described and the geometry of the new blade is shown. Results of an extensive flight test program conducted to obtain a Supplementary Type Certificate for these blades are presented. The flight test program included an examination of the performance and stability and control characteristics, and measurement of the structural loads. The load measurements were direct comparisons of the aircraft as currently equipped with metal blades to the same quantities on the aircraft with new composite blades. The flight test data show that the new blades provide a considerable increase in the hover lift capability and a significant improvement in the translational flight performance. Oscillatory control loads with the new blades are shown to have amplitudes comparable to those of the aircraft with metal blades and the vibration characteristics of the aircraft are not significantly changed by the new blades. Pilot comments indicate that the handling characteristics of the aircraft are improved with the new blades.

### **Introduction**

About 10 years ago, Carson Helicopters studied the performance gains that might be expected if new main rotor blades were designed for the Sikorsky S-61 helicopter. A new design would take advantage of the advances in airfoil

development, modeling capability, and materials that have taken place since the Sikorsky S-61 was designed c. 1957. It was considered that a performance improvement should be possible along with an increase in blade life. Carson Helicopters uses Sikorsky S-61 helicopters for a variety of tasks including heavy lift and logging operations and so emphasis in the blade design study was placed on the improvement in hover performance that might be expected.

Investigation of changes in blade geometry including new airfoils, variations in twist and tip shape were undertaken using the EHPIC code of Continuum Dynamics, Inc (Refs. 1 and 2). In addition to a gain in the hover efficiency, an equally important requirement was that a new rotor blade design should not produce an increase in the oscillatory loads experienced by the helicopter and its components in flight, resulting in a consequent reduction in component lifetime. A conservative approach was taken to satisfy this requirement. The mass, mass distribution and stiffness characteristics of the new blade design were selected to match the metal blade characteristics as closely as possible. Such an approach was considered desirable due to experience with replacement blades for another helicopter (Ref. 3), and pessimistic estimates regarding achieving these goals in the literature (Ref. 4).

The results of the design study indicated that a considerable increase in hover lift capability (1800 lbs.) could be expected. With this favorable result, Carson made the decision to proceed with the development program. Critical components of the aircraft were identified, and the test helicopter was instrumented to measure the impressed loads in various critical locations.

---

*Presented at the American Helicopter Society  
58<sup>th</sup> Annual Forum, Montreal, Canada, June 11-  
13, 2002, Copyright © 2002 by the American  
Helicopter Society International, Inc., All rights  
reserved*