Update: The CarterCopter and Its Legacy

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Rod Anderson is the fifth person to fly in the CarterCopter, and flew right seat for several weeks in May 2001 as flight test engineer. He was first to propose the CarterCopter flight simulator -- which he prototyped in cooperation with X-Plane software creator, Austin Meyer. Rod serves as Carter's VP of Marketing and resides in Prescott, Arizona.

The remains of the CarterCopter Technology Demonstrator (CarterCopter or CCTD) are stored in an airport hangar in Texas. I have not seen them. I have only seen photos of the June, 2005, crash, but to my knowledge, the photos have never been released. No one was hurt, and most of the aircraft remains intact. If the aircraft had not landed in a large patch of mesquite trees, it could probably have been repaired. After long deliberation, it was decided that the money needed to rebuild the CarterCopter would be better spent on prototyping and flight-testing a new aircraft, which would incorporate everything learned from the 7-years of flying the CarterCopter.

The beginning, middle and end to the saga of the CarterCopter, as a flying test-bed, has been written. The eventual ramifications of the technology it helped pioneer will determine its place in the history books. Once slowed-rotor/compound (SR/C) aircraft are a common sight, then hopefully a museum, large corporation, or wealthy individual will fund the cost of rebuilding the CarterCopter so it can be put on permanent display in a major museum. It was the first to achieve the mu-1 ratio, which it did at 170 mph with an impressive L/D ratio of 7:1. To put this accomplishment into perspective, it took 44 years from the first manned flight to break the sound barrier, 66 years to put a man on the moon and 102 years to break the mu-1 ratio. The rotorcraft curator at the Smithsonian NASM has expressed an interest in the CarterCopter on several occasions.

The CarterCopter proved that the a notional study conducted by Georgia Tech, a national Rotorcraft Center of Excellence, was correct. The study proposed that SR/C aircraft had the potential for high-speed performance, with an operational envelope exceeding that of fixed-wing aircraft and helicopters. The report cautioned that slowed-rotor dynamic considerations could be the limiting factor. On its last flight before the accident, the CarterCopter clearly demonstrated that its slowed-rotor dynamics are not a limiting factor by breaking a rotorcraft record established 49 years ago by a US Army experimental SR/C aircraft called the McDonnell XV-1 Convertiplane, shown below.

The record was for an engineering term called mu-ratio, which has direct bearing on the total drag produced by a rotorcraft's rotor. The mu-ratio of any rotorcraft in flight is determined by simply dividing the rotorcraft's forward airspeed by its rotor-tip speed relative to the aircraft; generally, the lower the mu-ratio, the higher the rotor RPM and drag. We all know that if we lower the total drag on a car, it can go faster and farther on less gas. The same is true for rotorcraft. Helicopters normally fly at low mu-ratios of 0.3 and suffer very high rotor drag -- which results in low airspeeds and ranges. The Carter-Copter flew with a stable rotor at an amazing mu-1.0, breaking the XV-1's previous record of mu-0.95. Of special importance is that the flight test data indicates the technology used to break the record should routinely permit SR/C aircraft to fly at mu-2 ratios or higher. Low rotor RPM and drag will permit speeds of 400 mph or better in addition to unrefueled ranges of 2500 miles

All Carter SR/C aircraft can take off and land vertically. Travelers will need much less time to travel point-to-point than they need today when flying in fixed-wing aircraft. In the near future, the small wings and the slowly turning rotor of a Carter SR/C aircraft will be the recognized hallmark of efficient, high mu-ratio flight. Vertical takeoffs and landings combined with safe, fast, and affordable air travel will become an everyday part of aviation and the true legacy of the CarterCopter. Someday, before the CarterCopter is rebuilt for museum display, I'd like to take the cabin "egg", the landing gear and the remains of the high-inertia rotor on tour to show people some of the Carter technology that insures survivability of an aircraft's occupants when something goes terribly wrong. If nothing else good comes from the accident, it proved Jay Carter's point that aircraft can be designed to be safe -- regardless.

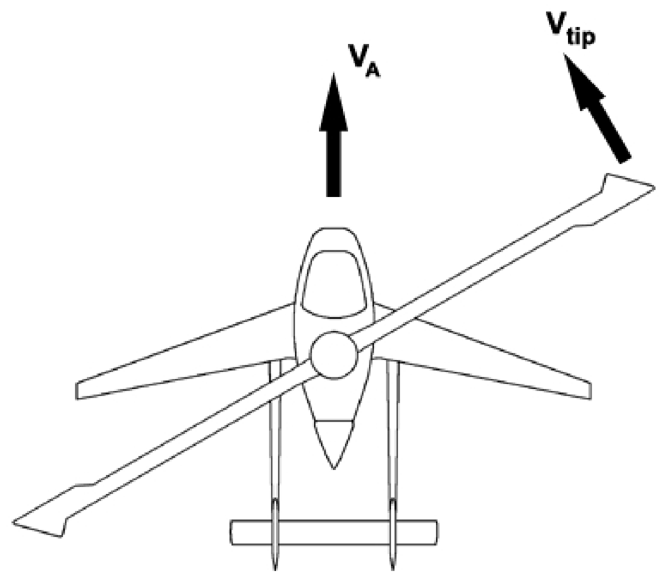
IMPORTANT FINDINGS FROM THE CARTERCOPTER'S MU-1 FLIGHT:

- The CarterCopter demonstrated stable mu-1 flight, something no rotorcraft had done before. The pilots reported that the aircraft flew so smoothly that no vibration or sound indicated they were in a rotary wing aircraft -- much less one flying at 170 mph at a mu of 1.
- The CarterCopter achieved a lift to drag ratio (L/D) of 7:1 at 170 mph; comparable to GA fixed-wing airplanes and much better than conventional rotorcraft.
- L/D increased as airspeed increased -- from 100 mph up to the maximum speed of 170 mph achieved during this flight. The trend indicates that it would have continued to increase at least a little, at higher airspeeds.
- The increase in L/D with airspeed was due to the wing coming out of a deep stall, which also caused flow separation on the lower aft section of the fuselage. Both of these high-drag conditions can be corrected in future SR/C aircraft.
- The L/D achieved at 170 mph exceeded that of Carter's initial performance estimates calculated years previously -- showing that the initial estimates were conservative.

For additional information on the accomplishments of the CarterCopter and the accident that followed, look for the hyperlinks under the photo of the CarterCopter on the front page of the Carter web site, http://www.cartercopters.com/. The website provides a tail camera video, strip chart data, a review of the events, and additional flight-test findings.

A LITTLE MORE ON MU

Mu is the English spelling of the Greek letter μ. It can be pronounced "mew" or "moo," with "mew" being the most prevalent. It is commonly used to represent a ratio in rotorcraft engineering, sometimes called the rotor tip advance ratio. To put it about as simply as it can be put into words, the μ ratio is the ratio of the forward speed of the aircraft to the rotor tip speed relative to the aircraft. To put it into a picture, which is worth a thousand words:



$$\mu = \frac{V_A}{V_{tip}}$$

Where Vtip is the tip speed of the rotor, V_A is the speed of the aircraft, and μ is the mu ratio.

In hover, μ is equal to zero. As the rotorcraft flies faster, μ increases. The airspeed of the advancing blade increases and the airspeed of the retreating blade decreases. When μ reaches a value of 1.0, the retreating blade of the rotor has reversed airflow over its entire length. It has long been believed that above a certain tip-speed ratio, somewhere below 1, a rotor will become unstable. The highest tip-speed ratio ever achieved by a helicopter was 0.8 on the Lockheed Cheyenne compound attack helicopter prototype. The McDonnell XV-1 SR/C autogyro was μ champion and achieved a μ of 0.95 during flight tests, until passed 49 years later by the CarterCopter, another SR/C autogiro, which achieved a μ of 1.0 during routine flight tests on June 17th, 2005.

Rod Anderson