Human Powered Helicopters Take Off

By Mike Hirschberg, Executive Director

Over the past three years, tremendous progress has been made in pursuit of the AHS Igor I. Sikorsky Human Powered Helicopter (HPH) Competition, with a half dozen official registrants for the Competition. Recent progress has been made by several teams, with three related here.

On June 21, the University of Maryland established a (currently uncertified) world record of 50 seconds – more than 2.5 times the previous maximum demonstrated duration. In addition, the NTSWorks Upturn made its first flight on June 24 and another team, AeroVelo, hopes to fly its Atlas HPH in August.

A Little History

In 1977, the Gossamer Condor human-powered aircraft won the first Kremer Prize for flying a figure 8 around two marker ½ mile apart. Inspired by this accomplishment, AHS looked into the feasibility of a human powered helicopter. Based on at least six attempts that had already been made and studies published in England in the 1960s that indicated that an HPH was perhaps possible, an ad hoc AHS committee found that it must be feasible. Since a figure 8 was thought too difficult initially, the first step was set to be just hovering.

In 1980, the AHS Board of Directors approved the initiation of the Igor I. Sikorsky HPH Competition, initially with an award of just $10,000 pledged to the first successful controlled flight of a human powered helicopter that meets all of the conditions of the rules (the prize was soon raised to $20,000 and much later to $25,000). The key requirements are to demonstrate a one minute hovering time and a momentary achievement of 3 m altitude, while staying within a 10 meter square (see **www.vtol.org/hph** for the full rules).

In the first dozen years, about 17 HPH machines were built. California State Polytechnic University at San Luis Obispo students built a series of machines, culminating in their "Da Vinci IV" with a 100 ft (30.5 m) diameter rotor machine in 1989. It established a record by flying for 8.6 seconds and reaching a height of 8 inches. The design used a 100 ft (30.5 m) diameter two-bladed rotor driven by propellers at the tips. The Cal Poly reaction-drive rotor aircraft weighed 96 lb (43.5 kg).

In Japan, Professor Akira Naito of Nihon University was responsible for five attempts at an HPH between 1985 and 1994. The final version, Yuri-1, achieved an altitude of 0.2 m (8 inches) and a flight duration of 19.46 seconds. The quadrotor had a 10 m (33 ft) diameter rotor on each arm of the cruciform structure and weighed 38 kg (83 lb). (Apparently neither the Da Vinci and Yuri successes were certified by the Fédération Aéronautique Internationale (FAI), the world record-keeping body for aviation.)

After these two breakthroughs, later HPH attempts failed to get off the ground and the competition lay stagnant.

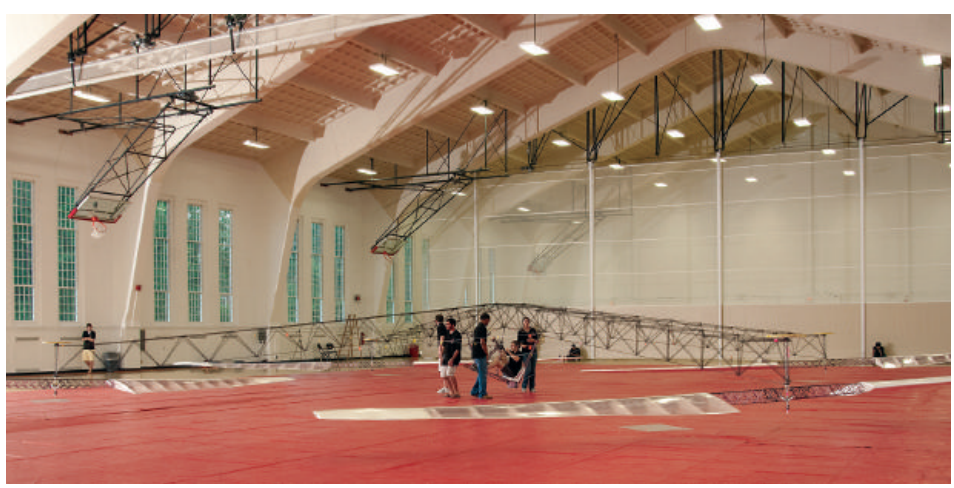
In 2009, the AHS HPH coordinator, Matt Tarascio, secured from Sikorsky Aircraft Corporation a pledge of $250,000 as the prize for the AHS Igor I. Sikorsky Human Powered Helicopter Competition, which Sikorsky President Jeff Pino announced at the AHS Annual Forum 65. With the deluge of sudden interest in the AHS Sikorsky prize, Tarascio formed the HPH Committee, now headed by Ben Hein.

Gamera

In 2008, students at the University of Maryland's Alfred Gessow Rotorcraft Center began considering the AHS HPH Competition. Inspired by the success of the Yuri-1, they extrapolated the design to an even larger cruciform quadrotor, with 13 ft (42.6 ft) diameter rotors and a total weight of 48.6 kg (107 lb). The HPH was named "Gamera" after the giant flying turtle of Japanese monster movies, in homage to the University of Maryland's Terrapin mascot and to Nihon University in Japan.

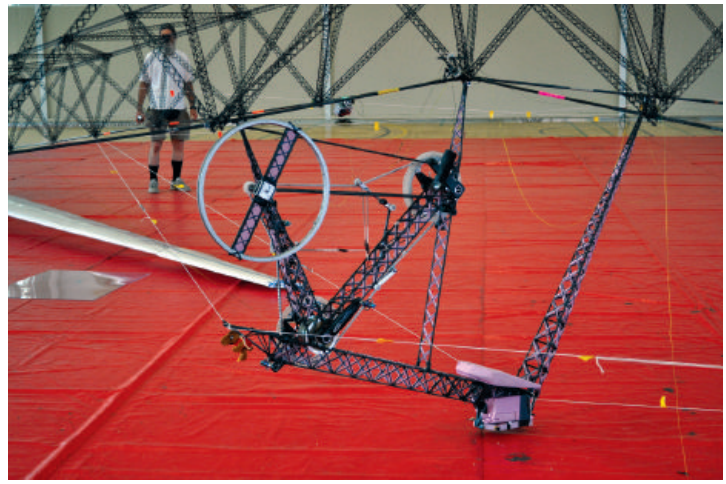
On July 13, 2011, the Gamera set an FAI-recognized hover duration record of 11.4 seconds, driven by biology student Judy Wexler. (See *Vertiflite* Fall 2010 for more details on Gamera I.)

Over the past year, the University of Maryland has publicized much of its research in a number of conference proceedings and established a website with their papers, videos and other details on their efforts (**www.agrc.umd.edu/gamera**), adding to the body of knowledge of human powered helicopter science and engineering.



University of Maryland has established what should soon be an official world record of around 50 seconds with its Gamera II, shown here during its record flight on June 21. (Photo by Earl Zubkoff.)

University of Maryland team of students and faculty advisors pose with Gamera II. (Photo by John Consoli.)



The Gamera cockpit was improved. Miniature trusses comprise the macro truss structure. (AHS photo.)

Maryland students have now developed a new aircraft, Gamera II, which is 30% lighter and capable of flights over 60 seconds – one of the key pillars of the AHS Igor Sikorsky HPH Competition. The Gamera II had significant improvements in structural approach, cockpit, transmission and rotor design. The cruciform structure of the new vehicle is a trusswork of trussworks, further reducing the weight and increasing the stiffness. Although the rotors are the same diameter, taper was introduced, as well as a sixfold increase in root stiffness. Each blade was reduced from 3.3 kg (7.3 lb) to 2.0 kg (4.4 lb) – a 40% reduction.

Testing began in mid-June and a media event was held on June 20. Regular flights were made beyond 40 seconds, but often the lack of control would require aborting the flight to avoid impacting the walls of the armory where it was being tested. The longest flight was approximately 50 seconds on June 21, driven by Kyle Gluesenkamp, a mechanical engineering Ph.D. candidate. This was witnessed by an observer of the National Aeronautic Association (NAA), the U.S. affiliate of FAI. The NAA will review the evidence to determine the exact duration of flight and certify this as a new official record, which will be recognized as a world record by FAI.

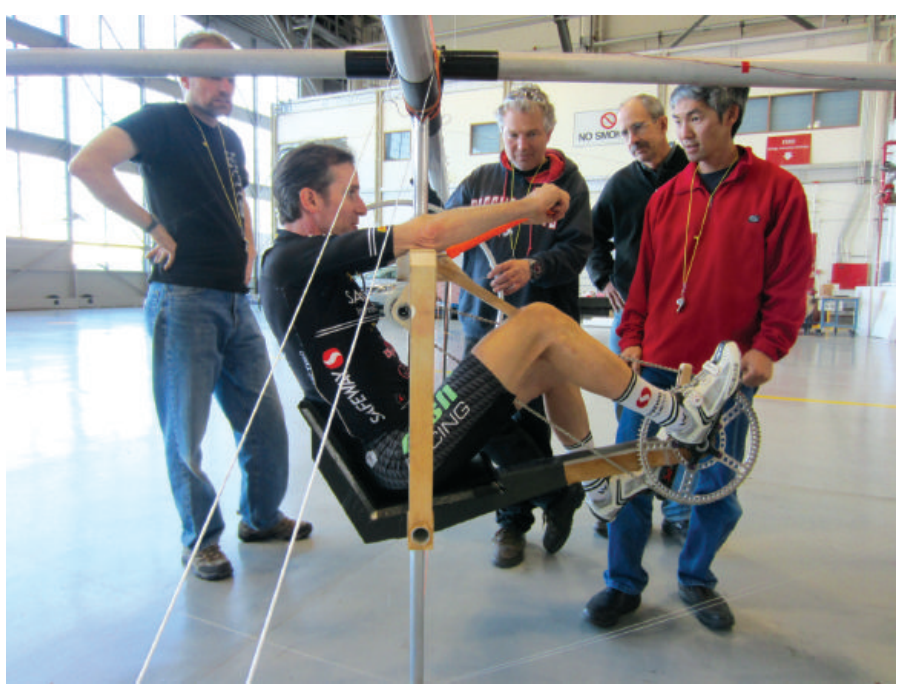
Additional testing is planned for later this summer. The other student power plants who flew Gamera II were Colin Gore and Dennis Bodewits, each with similar results. Judy Wexler's world record for flight duration by a female pilot still stands.

The University of Maryland team is continuing to refine Gamera II and studying approaches to accomplish the altitude and control requirement of the AHS Sikorsky Prize.

Upturn

Neal T. Saiki was the leader of Cal Poly's Da Vinci team, the first record holder for a human powered helicopter. After graduating, Saiki privately built a coaxial HPH in 1994 called the Penguin, but it suffered from intra-rotor aerodynamic interference due to the extreme closeness of the two pairs of rotors. It was destroyed in a California wildfire. After working at NASA, Saiki developed lightweight mountain bikes and then zero emissions electric motorcycles. In 2011, he and his wife Lisa formed NTSWorks (**www.ntsworks.com**), based in Santa Cruz, California, and have developed a new battery breakthrough suitable for electric motorcycles and electric cars.

The Upturn design, also based on the reaction driven rotor principle of Da Vinci, was originally conceived nearly 15 years ago. Construction began two years ago. (See *Vertiflite* Winter 2010 for more details on NTSWorks and Upturn.)



Members of the NTSWorks Upturn team from left to right: Scott Larwood, Robert Pasco (pilot), Stephen Buchter, Chuck Tremper and Neal Saiki. (Photo by Kyle Naydo.)

Upturn made its first flight on June 24, achieving 10 second and a record 2 ft of altitude, in Santa Cruz, California. (Photo courtesy of NTSWorks.)

The Upturn weighs 95 lb and has two rotor blades with a diameter of 85 ft (25.9 m), plus two orthogonal 48 ft (14.6 m) diameter blades with two tip-mounted 6 ft (1.8 m) propellers. The pilot powers the propellers, which rotate the two rotors.

Amateur bicyclist Robert Pasco was the pilot for the successful June 24 flight, which lifted off the ground for 10 seconds, climbing to about 2 ft (0.6 m) off the ground.

In contrast to previous HPH concepts, Upturn uses a computer stabilization and control system for stability and safety aloft. This had previously been prohibited, but due to an inadvertently ambiguous clarification in the official HPH rules, this has been temporarily grandfathered in (see sidebar).

Several issues with the custom designed onboard control system had prevented successful flights over the past several months, with the inputs fighting the pilot's power output.

Saiki notes that the Upturn's rotors are mounted above the pilot, reducing the dependence on ground effect. The Upturn's blades are 5 ft (1.5 m) above the ground. He is bullish on the Upturn's progress: "With the additional power that a professional cyclist can provide, we should be able to win the [AHS] Sikorsky Prize."

Atlas

AeroVelo is a collection of students and professionals working on lightweight, efficient designs; core members of the team began in 2006 with the founding of the Human-Powered Vehicle Design Team at the University of Toronto. AeroVelo (**www.aerovelo.com**) is led by Dr. Todd Reichert and Cameron Robertson, both graduates of Toronto.

In August 2010, AeroVelo's first project made aviation history by achieving the age-old dream of bird-like flight – the world's first human-powered ornithopter, the Snowbird. The team then focused on the design of high-speed streamlined bicycles. In 2011, AeroVelo smashed the college land speed record by traveling 72.6 mph (116.9 km/hr) at the Human-Powered Speed Challenge in Battle Mountain, Nevada.

AeroVelo is now focused on the AHS HPH Competition. Dr. Reichert is the project manager and pilot, and Cameron Robertson is the chief structural designer. The project team has made extensive use of multi-disciplinary optimization, with the main design code written by Reichert and Robertson.

Their Atlas design is also a cruciform quadrotor design, based on Yuri-1. It is being designed and constructed at the Great Lakes Gliding Club in Tottenham, Ontario, just outside of Toronto. AeroVelo recently ran a successful fundraising campaign on Kickstarter.com, and has been primarily supported by corporate sponsors, research grants and individual donors.

Preliminary design and analysis for Atlas began in late 2011, with the focused design begun in January. Construction was begun in May – all the very large rotors are nearly complete, and the supporting structure fabrication has begun. The team expects to fly this August.

HPH Competition

The scientific breakthroughs, engineering innovations and inspiring accomplishments that have been engendered by the AHS Igor I. Sikorsky Human Powered Helicopter Competition are a testament to ability of the human spirit to tackle seemingly impossible challenges. The coming months could finally answer the question posed by AHS in 1980 – is a human powered helicopter possible?

AeroVelo in Toronto has begun fabrication of the major structural components and is completing construction of all rotor components. (Photo courtesy of AeroVelo.)

Electronic Controls

Since the HPH Competition was initiated, the use of energy storage devices has been prohibited. This has even been extended to the use of batteries for electronic controls. In his 1993 article, Jan Drees writes "Even if only a very small electric current is required – for instance, for moving a trim tab – then a small generator should be used, but not a battery." In an attempt to clarify the prohibition on energy storage (including batteries), the rules were updated in November, but inadvertently caused more confusion and left the Competition in an ambiguous dilemma that was reasonably interpreted as not disallowing batteries for control. As a result, the HPH Committee decided at their May 2012 meeting to strike the recently added rules (4.1.4.1 and 4.1.4.2).

All registered competitors were subsequently notified that they would be allowed to attempt the AHS HPH prize under the previous version of the regulations that included these two rules until July 1, 2013.