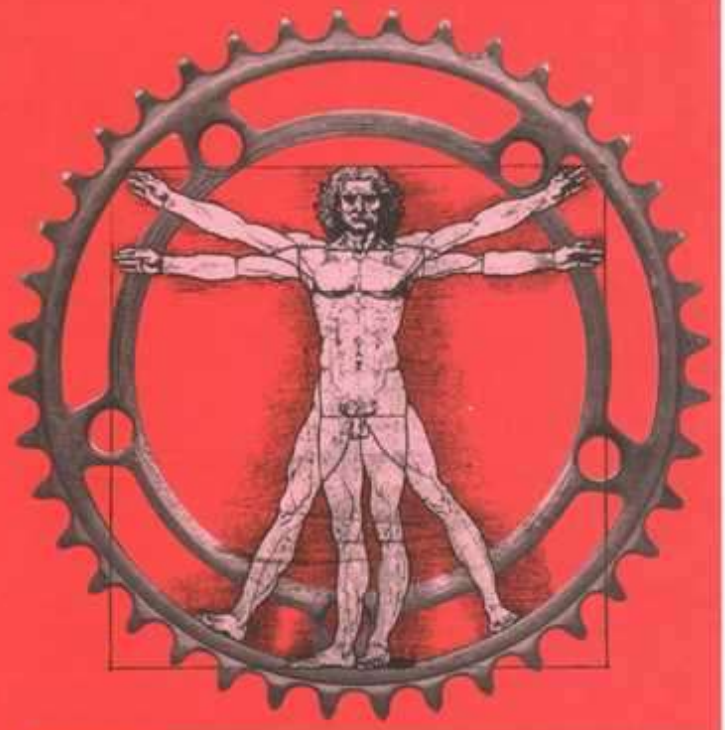

HUMAN POWER

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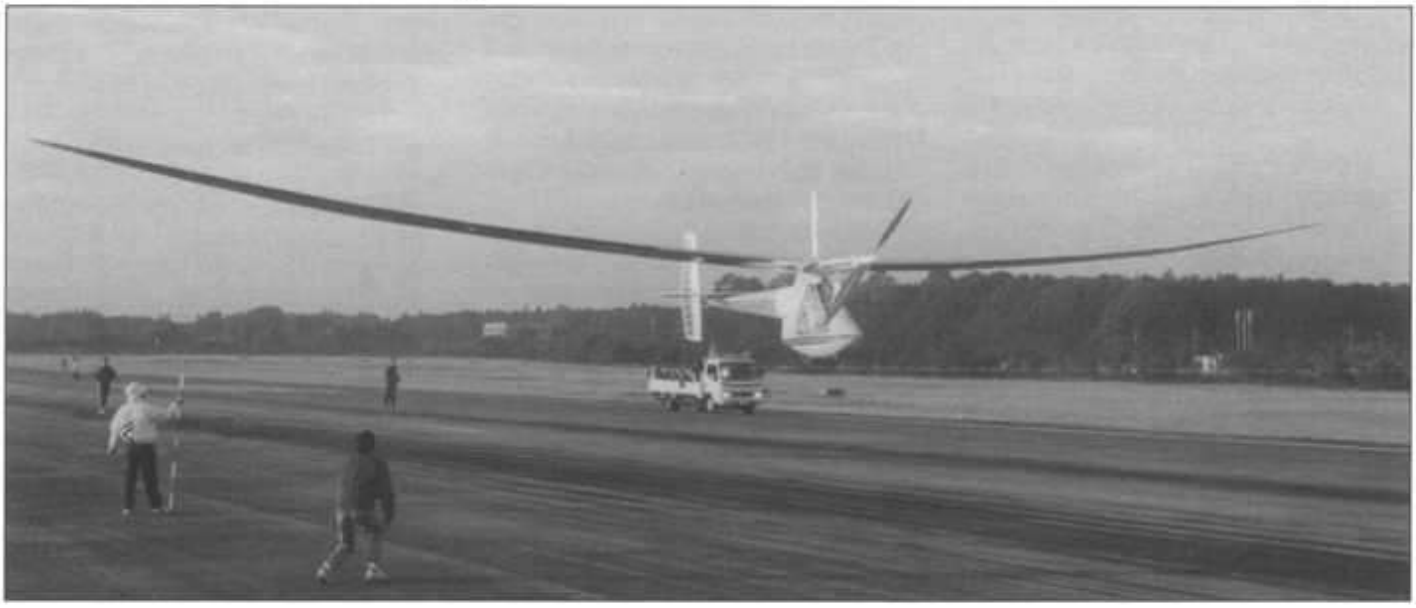
PROJECT REVIEW

CHicK-2000 Project Team "Active Gals"



Remarkable achievement of ActiveGals HPA team in Japan
(from a communication from Toshiaki Yoshikawa)

This note gives some details of the human-powered aircraft "HYPER-Chick KoToNo Limited" built by the team "ActiveGals" in Japan, and sent by the team's leader Toshiaki Yoshikawa (letter, 26 March 2001). Mark Drela's review of the remarkable achievements of the team follow this note.

The technical data are shown in the drawing. The photographs show the plane itself and some of the team members, including the pilot Kotono Hori, who successfully made the first FAI I-C class human-powered flight in Japan in 1992.

On 4 and 5 November 2000, the team made the first flight of an HPA with stressed-skin construction.

Both the I-beam spars and the styrene paper mentioned in Mark Drela's review were reinforced with carbon fiber. The result was an aircraft that could fly (at a height of 2 meters) needing only 160 watts of power input to the pedals, a world minimum for an HPA.

Yoshikawa wrote, "It has a composite structure, CFRP on spar and GFRPed styrene paper on skin." He wrote also that the team is "working to realize a new circling method," described thusly: "The new circling method is by twisting the flexible wings during banking by applied aeroelasticity.

"The twist of the right wing is applied in the opposite direction of that of the left wing. This has been found to reduce power loss during the HPA's turn."

Circling flight is difficult because of the greatly increased power losses and the control difficulty in the turns. (The "inside" wing goes much slower than the outer wing and tends to lose lift.) Stressed-skin construction allows the use of wing-warping (in opposite directions) during the turn. It also greatly reduces wing deflection and permits the use of a very high aspect ratio, 43.7, further reducing the aerodynamic losses.

The aircraft is on display at the Kakamigahara Aerospace Museum.

—Dave Wilson

In flight, above, with pilot Kotono Hori (left).
Right: Project leader Toshiaki Yoshikawa
Opposite: Working on one of the wings of the craft—and the technical chart.

Photos and chart, CHicK-2000 team

Review by Mark Drela

The CHicK-2000 human-powered aircraft by the ActiveGals group has a number of notable features.

The wing structure employs a stressed skin which provides the necessary torsional stiffness in addition to its usual duties of forming the airfoil contour. The most common approach has been to rely on a tubular spar to provide all the bending and torsional stiffness, with secondary foam sheeting and a thin Mylar wing skin providing the airfoil shape.

Using the stressed skin for torsion instead allows the use of a full-depth I-beam spar to provide the bending stiffness. The I-beam spar is a far more efficient bending member than the tube spar, and hence provides a stiffer and stronger wing for a given weight.

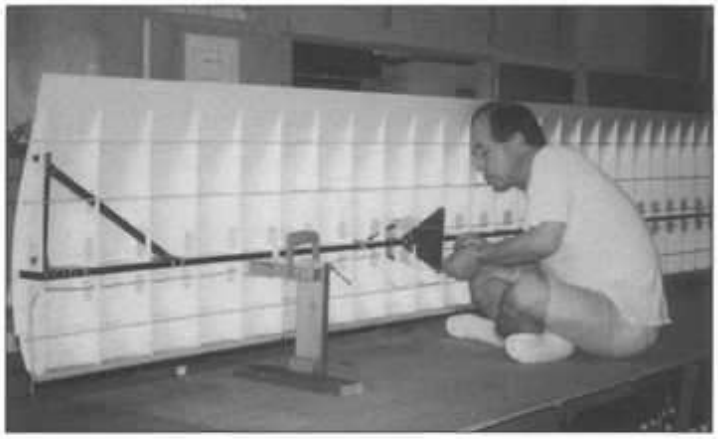
Not surprisingly, the wing-tip deflection of the CHicK-2000 under load is amazingly small considering its low empty weight of 31 kg and its immense wing aspect ratio of 44. The high aspect ratio obviously contributes to the modest specific flight power of 3.6 W/kg pilot mass, despite a fairly high wing loading of 46 Pa which gives a rather fast cruising speed of about 8 m/s. Low power coupled with high speed gives the potential for large range, and also gives the ability to handle windier conditions than more lightly-loaded HPAs.

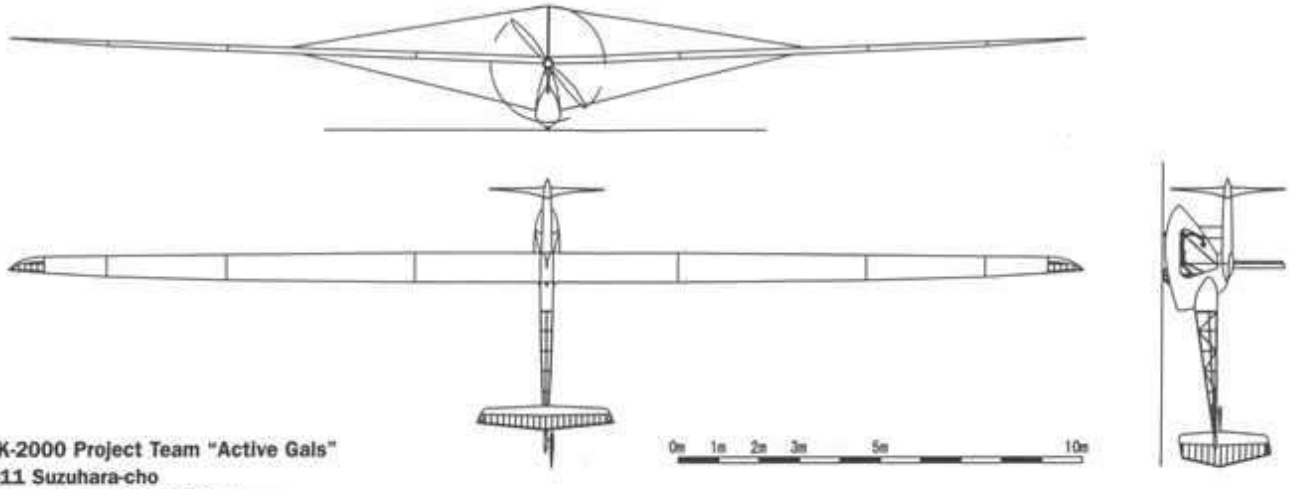
One practical disadvantage of a stressed-skin HPA structure is that common construction materials such as polystyrene foam do not have a sufficient shear modulus for the task. The ActiveGals group appears to have solved this problem with their fiberglass-reinforced styrene paper.

The stressed skin is also very demanding of design details and construction quality to preclude local buckling or failure. Again, these problems appear to have been surmounted as the aircraft is clearly structurally sound. Construction photos reveal meticulous craftsmanship.

Other reported innovations include the use of aeroelastic effects to twist the wings for roll control. Judging from the type of control yoke, the pilot appears to have full three-axis control of the aircraft, although it is not clear how the wings are twisted in practice.

—Mark Drela, MIT professor of aeronautics and astronautics, Massachusetts Institute of Technology (principal designer and constructor of several MIT HPAs).





CHicK-2000 Project Team "Active Gals"
6-36-11 Suzuhara-cho
Itami city, Hyogo 664-0882, Japan
(no e-mail address provided)

CHicK-2000 TECHNICAL DATA.				Pilot : KoToNo HoRi	
Span	26.6 m	Length	7.12 m	Height	3.04 m
Wing area	16.2 sq.m.	Aspect ratio	43.7	Propeller	2.85 m dia.
Empty weight	31.0 kg	Flying weight	75.0 kg	Wing loding	46.3 N/sq.m.
Min.flying speed	7.2 m/s	Min.power at speed	160W @ 8.0m/s	Max. glide ratio	1:48
Airfoil	Wortman FX76 MP-160 ~ DAE-21 ~ DAE-31 ~ DAE-51				

Above: A closer view of the cockpit and propeller of the CHicK-2000 aircraft. Right, Takashi Hattori, right-wing runner; below, Kouta Sata, left-wing runner.