BEHEMOTH 4 ORNITHOPTER DESIGN NOTES

PATRICIA JONES – BOWMAN

February 15 2005

Behemoth 4 is the latest in my 'Behemoth' series of ornithopter experiments.

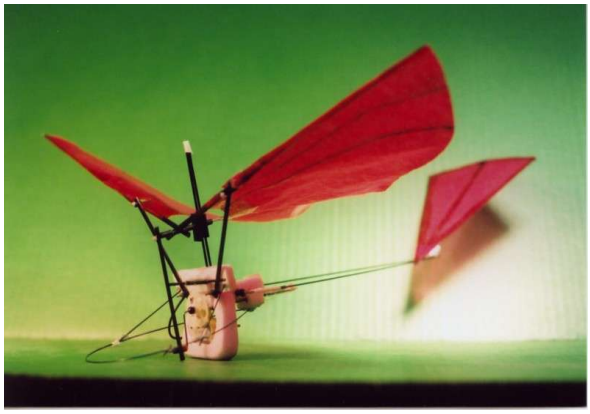

Fig 1
Behemoth 4 Ornithopter

OBJECTIVES

[1] To continue the 'floating' trailing edge' experiment that I started in Behemoth 3.

[2] Incorporate rotating fuselage/tailboom design to allow variable stoke plane angle in the wild hopes of hovering.

[3] Vastly improve the flapping mechanism design.

[4] Experiment with carbon fibre 'actinofibrils' in the wing membrane.

[5] Try permanently flexible silicone caulking compound as a flexible means of attaching the wing membrane to the spar and to the central shared wing root.

BEHEMOTH 4 DESIGN AND CONSTRUCTION

Behemoth 4 is an electric free-flight test model intended to test the above objectives before incorporating them into a radio-controlled test model [which will be Behemoth 5]

Wingspan 14 inches
Gross weight 15 grams

DESIGN AND CONSTRUCTION

FUSELAGE AND TAILBOOM

The forward fuselage was fabricated from pink wall foam, carved and sanded to shape. The aft fuselage [tailboom] is composed of 2 carbon rods joined together with a flattened U-shaped wire . This wire runs through the forward fuselage from left side to right side in a brass bearing tube and forms a pivot allowing the forward fuselage to rotate around the pivot with a pitching movement. The purpose of this is to allow the stroke plane angle to be varied to nearly horizontal in the optimistic hope of achieving VTOL and hovering flight !!

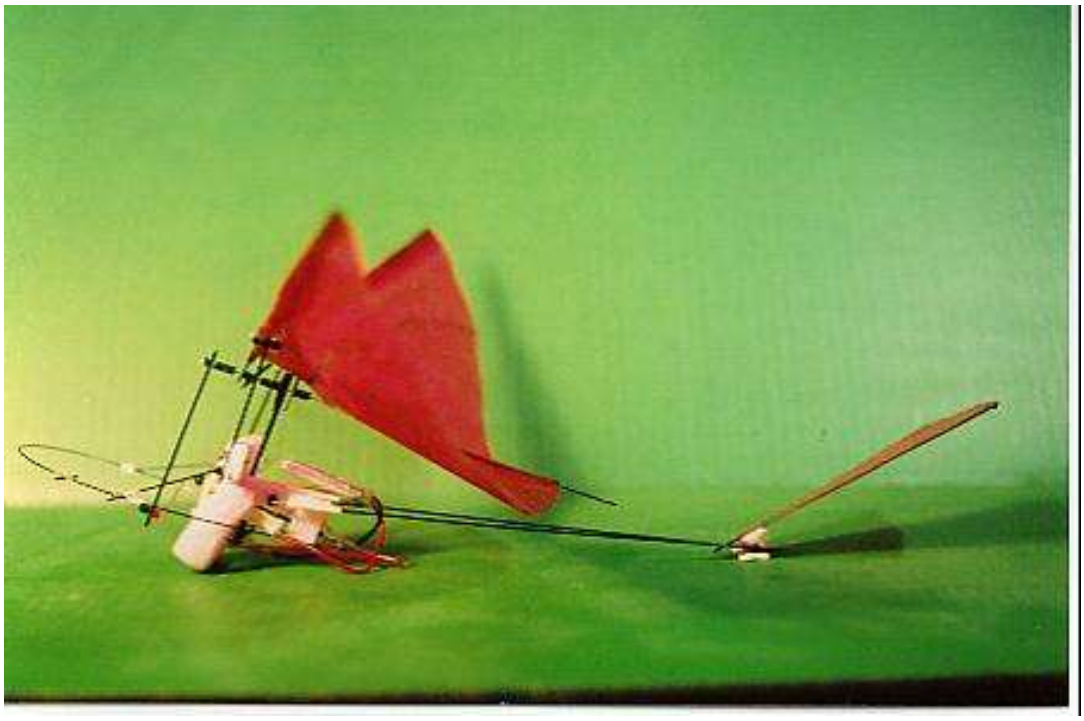

Fig 2
Fuselage and tailboom in normal cruise position.

A protective carbon rod loop or cage is attached to the forward fuselage and extends forward to protect the gears and flapping mechanism from impact damage. The gearbox is also protected by a foam shroud.

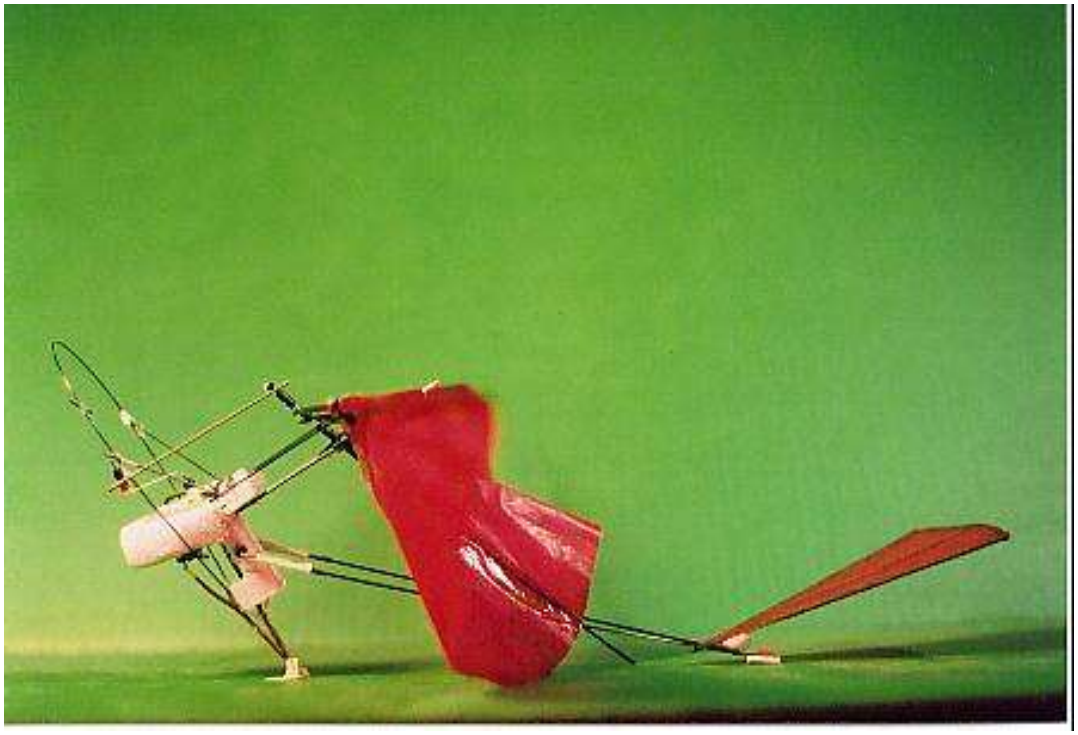

Fig 3
Fuselage in maximum pitch up position

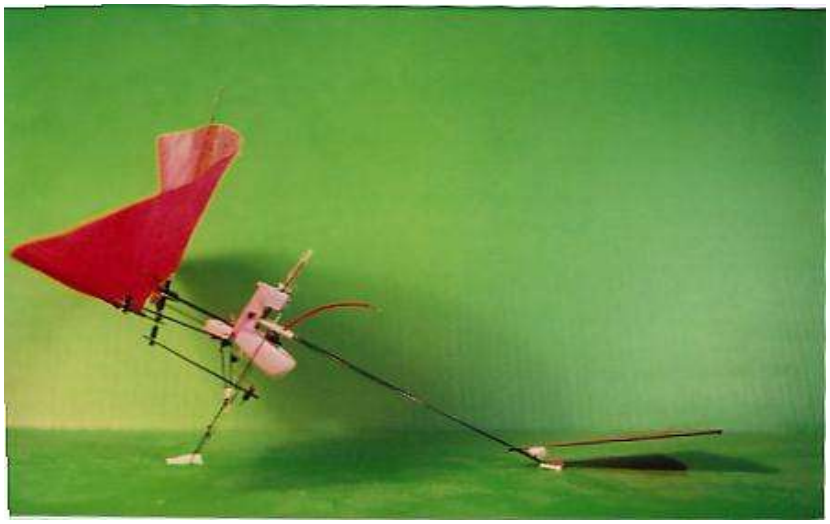

Fig 4
Fuselage in maximum pitch down position

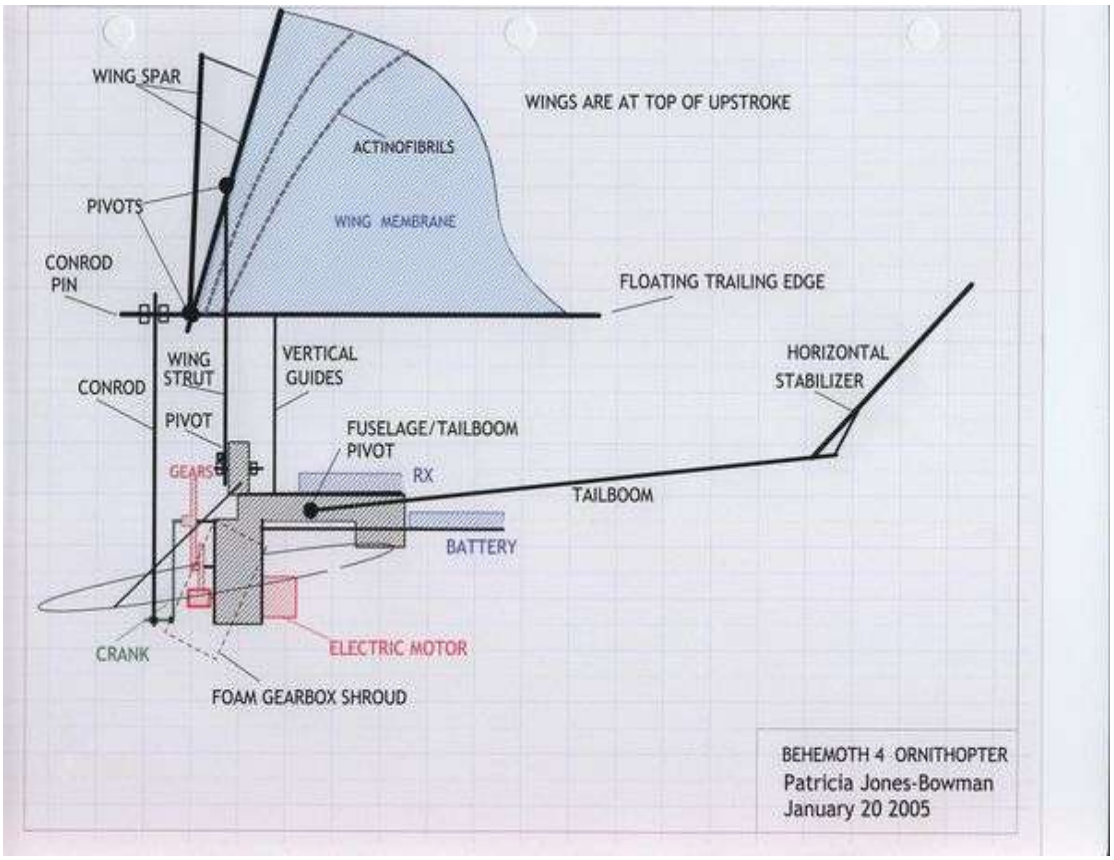

Fig 5
Behemoth 4 Ornithopter Test Model
[drawing is not to scale]

WINGS [Membrane wings]

The spars are carbon rods glued to the flap bars with epoxy .The joint was then wrapped with epoxy soaked thread for strength.

The membrane is tissue with 2 carbon roving 'actinofibrils' attached to the lower surface with permanently flexible silicone caulking compound. These actinofibrils run diagonally spanwise from root to tip and are curved slightly aft at the outboard end.
Flexible silicone caulking compound was also used to attach the tissue membrane to the carbon spar and to the extended top conrod pin [which also forms a single, shared wing root for both wings.]

The wings have a slight average dihedral angle.

Fig 6
Wings at top of upstroke

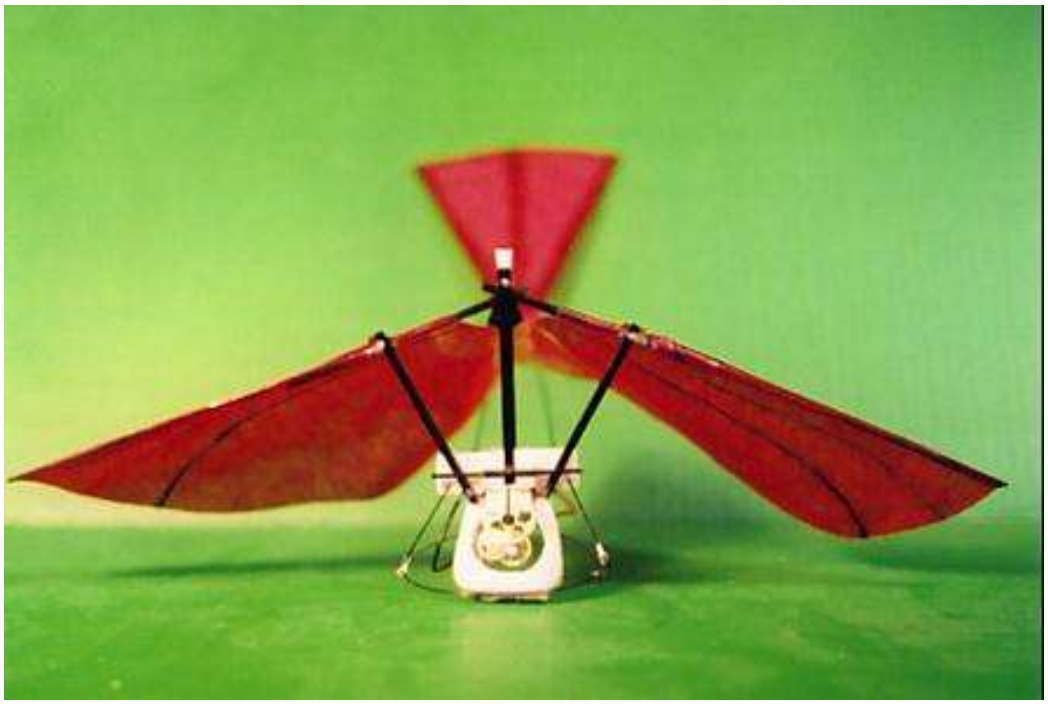

Fig 7
Wings at bottom of downstroke

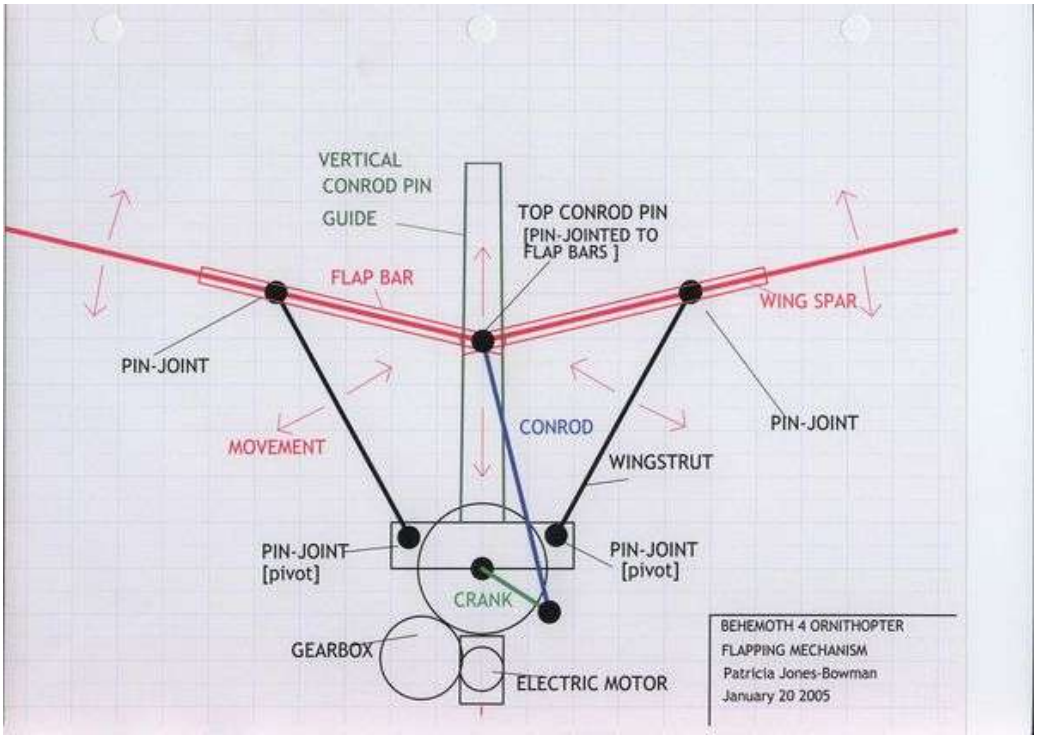

Fig 8
Flapping Mechanism

FLAPPING MECHANISM

The flapping mechanism produces symmetrical flapping and is composed of a wire crank, a single carbon [flat, rectangular rod] conrod, 2 carbon rectangular rod wing struts, 2 flap bars [the extended inboard ends of the wing spars] , the top conrod pin which is extended to the trailing edge of the wing membrane and a vertical guide for this conrod pin/ wing root.

The wing struts are pivoted at both ends ie: at the lower end where they attach to the fuselage and the upper end where they attach to the spars. The flap bars [inboard end of spars] are pivoted together where they meet above the centre of the fuselage by the top conrod pin which extends aft to the trailing edge of the wings, the wing membrane is attached to the top conrod pin aft of the flap bars where it [the pin] forms a communal wing root for the wings.

When the crank is turned, the top conrod pin moves vertically in the vertical guide. This is made possible because the wing struts rotate around their lower pivots which allows the top conrod pin pivot to move vertically eliminating the need for wing sliders at the inboard end of the flapbars.

ELECTRIC FREE-FLIGHT EQUIPMENT

KP00 Electric Motor
Didel gearbox with 20:1 ratio
Kokam 145 mah Lithium Polymer battery

The stage 2 gear shaft wire was extended forward of the gear and bent 90 degrees twice to form a crank.

FLIGHT TESTING

Static flapping tests started well, ran smoothly and ended with everything still in one piece.
The battery had to be moved forward to bring the CG to approximately 25 % aft of the leading edge [it now resides where the proposed RX is in the drawing on page 4.]

3 flight tests were then conducted. Since it has no radio control, this meant hooking up the battery and tossing it into the air to seek it's own destiny.

All the flight tests so far have been conducted indoors in very restricted space .

FLIGHT TEST # 1
Following hand launch, the model appeared to actually gain altitude very briefly then maintained straight and level flight until it flew into the wall. There was no tendency to pitch down.

FLIGHT TEST # 2
Maintained altitude briefly, turned slightly to the right then hit the wall.

FLIGHT TEST # 3
Maintained altitude briefly then turned and descended gradually before hitting the wall. The wings stopped flapping and a high pitched ' WHEEEE sound was heard. The stage 1 gear and gear shaft had dropped off and were eventually found on the floor nearby, 2 days later. They weren't damaged though the gearshaft is rather loose and I re-installed them.

There was no other damage and Behemoth is being fitted with a jettisonable landing gear for the next series of tests which will include 'Rise Off Ground' tests.

Feb 25 2005 To be continued.....Patricia Jones-Bowman