

Flying Fish Phase II Vehicle Specifications

University of Michigan

The Flying Fish Phase II vehicle is currently under construction and will be ready to fly within the next 30-60 days (likely before the CoA is approved). A design schematic is shown in Figure 1. The airframe is a lightweight unmanned seaplane with a dual-pontoon, twin-tail, twin-electric design. The wing surface will be covered with solar cells to enable energy balance throughout daytime deployment. The airframe is constructed primarily of Kevlar and carbon fiber composite materials. The wing and pontoons are constructed of foam covered by composite material. As shown in Figure 2, the wing is constructed as a central section and two wingtips of roughly equal spanwise length that securely join at the spar, with a composite aft tab joiner assisting in the support of torsion and shear loads. This joining method has been previously used in numerous giant-scale R/C models thus is a flight-proven design. The central wing section is permanently attached to the full tail and pontoon assemblies. A capped carbon-fiber shear web runs the length of the wing at the 30% chord station. Dual central channels facilitate internal wire routing, and encapsulated solar cell panels are smoothly embedded in the top wing surface with minimal water-tight wire penetrations into the wing. Batteries are housed in the pontoons with top hatch access. The maximum power point trackers for the solar energy harvesting system are mounted inside the carbon fiber stanchions connecting the pontoons and wings with side access hatches. The motor controllers and motors are mounted and sealed inside the carbon-fiber booms with fins providing conductive cooling. Control surfaces are actuated with high-torque waterproof R/C servos mounted adjacent to each surface. A central waterproof cylindrical pod houses the avionics. Physical design characteristics of this airframe are provided below. Specifications for the onboard avionics system are also provided. Note that although construction is still in progress, most components and materials, including the motors, batteries, encapsulated solar cells, and electronics have been possessed by the University of Michigan since late 2008.

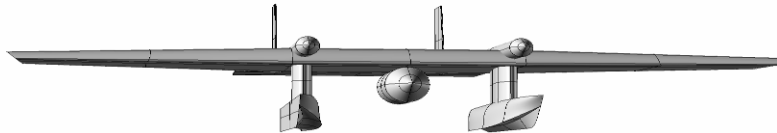


Figure 1: Flying Fish Phase II Design (Solid Model; construction is in-progress)

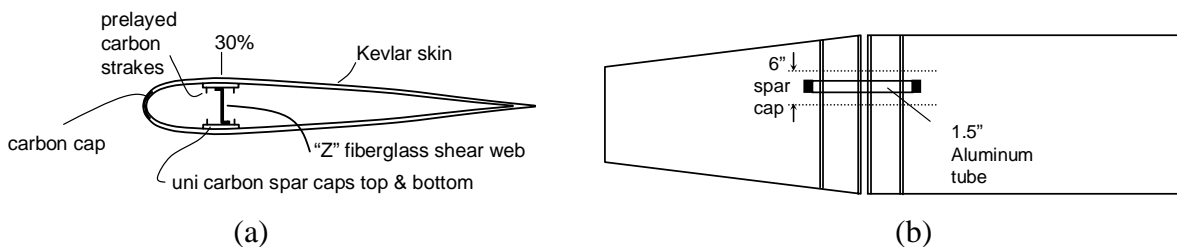


Figure 2: Wing Cross Section (a) and Wingtip Interface (b) Design.

Physical Design Specifications:

Flight Weight: 15.5kg

Cruise Speed: 56kph (15.6m/s) (*Max Speed:* 80kph (22.4m/s))

Estimated Endurance: 12 minutes (full throttle), 22 minutes (cruise)

Estimated Range: 21 km

Propulsion:

Configuration: Twin, Counter-rotating, Tractor

Motors: AstroFlight, 860M-4T (brushless in-runner, direct-drive)

Speed Control: Castle, Phoenix-80 (80A brushless)

Propellers: APC 16x8, carbon reinforced nylon

Thrust: 44.5N (10lbf) (per motor)

Thrust/Weight: 0.66

Battery Type: 5-cell Lithium-Polymer, 18.5V (average), 21V (peak)

Battery Capacity (nominal): 5000mAh (ea), 4 packs: 20Ah (total)

Main Wing:

Airfoil: NACA2414

Span: 3.76m

Chord: 0.61m (root), 0.46m (tip)

Washout: -2deg

Dihedral: 3deg (effective, from taper)

Wing Area: 1.88m²

Wing Loading: 8.25kg/m²

Aileron Length: 79cm (25cm inboard from tip)

Aileron Chord: 10cm (average)

Wing Configuration Notes: Modified-Hoerner tips, Outer sections removable from center span

Horizontal Tail:

Airfoil: Flat plate

Span: 1.07m

Chord: 45.7cm

Area: 0.487m²

Tail/Wing Separation: 1.18m

Elevator Chord: 14cm

Elevator Configuration Notes: Full span, Independent sections split on center, Ends cut to clear rudder

Vertical Tails:

Airfoil: Flat plate

Height: 0.48m

Chord: 0.46m (root), 0.30 (tip)

Area: 0.18m² (stabilizer), 0.36m² (total)

Stabilizer Separation: 1.04m

Rudder Chord: 14cm

Rudder Configuration Notes: Full Height, Independently actuated rudders

Floats:

Length: 1.15m

Depth: 15.2cm

Beam: 12.9cm

Draft: ~10.8cm

Separation: 1.04m (on center)

Distance Below Wing: 19.8cm (wing bottom to float top)

RF Equipment:

Radio Control System:

- Rx: Futaba, R149DP, 9-channel PCM dual-conversion receiver
- Frequency: 72.970 (Ch. 59)

Computer Uplink:

- Tx/Rx: Digi, XTend XT09-PKI, serial radio modem
- Frequency: 900MHz
- Power: less than 1.0W

Vehicle Avionics System:

The onboard avionics system design for Flying Fish Phase II is illustrated below in Figure 3. A Microbotics MIDG-II inertial navigation system (INS) provides 6-DOF filtered state estimate from a set of three-axis gyros, accelerometers, and magnetometers in combination with GPS. The sensor system also includes two pressure transducers for redundant airspeed measurements and a waterproof ultrasonic altimeter for low altitude surface ranging. Dual embedded Linux Gumstix Overo computer boards mounted on Tobi expansion boards are locally networked to provide onboard computational power and data acquisition capability. The integrated system provides analog-to-digital conversion, multi-port serial communications, 802.11b Wi-Fi (active only in the lab for high-speed data transfer), and large-volume data storage via onboard Compact Flash. A Microbotics Servo Switch Controller provides a fail-safe switch between computer and radio-controlled pilot servo commands as well as a means for the computer to log pilot inputs. Long-range communication and ground station telemetry are enabled with a Digi XTend 900MHz radio modem. The solar energy harvesting system includes 28% efficiency encapsulated solar cells mounted over most of the wing surface (center and wingtip sections). These cells are connected to Maximum PowerPoint Tracker (MPPT) boards developed and tested at the University of Michigan using technology shared with the University's Solar Car team. Flying Fish Phase II hosts two MPPT boards per wing, connecting in turn two the battery packs and networked via converted RS/485 link to the Gumstix Overo boards. The Overo boards monitor battery energy and rate of change in battery energy over time. All embedded software is written in C.

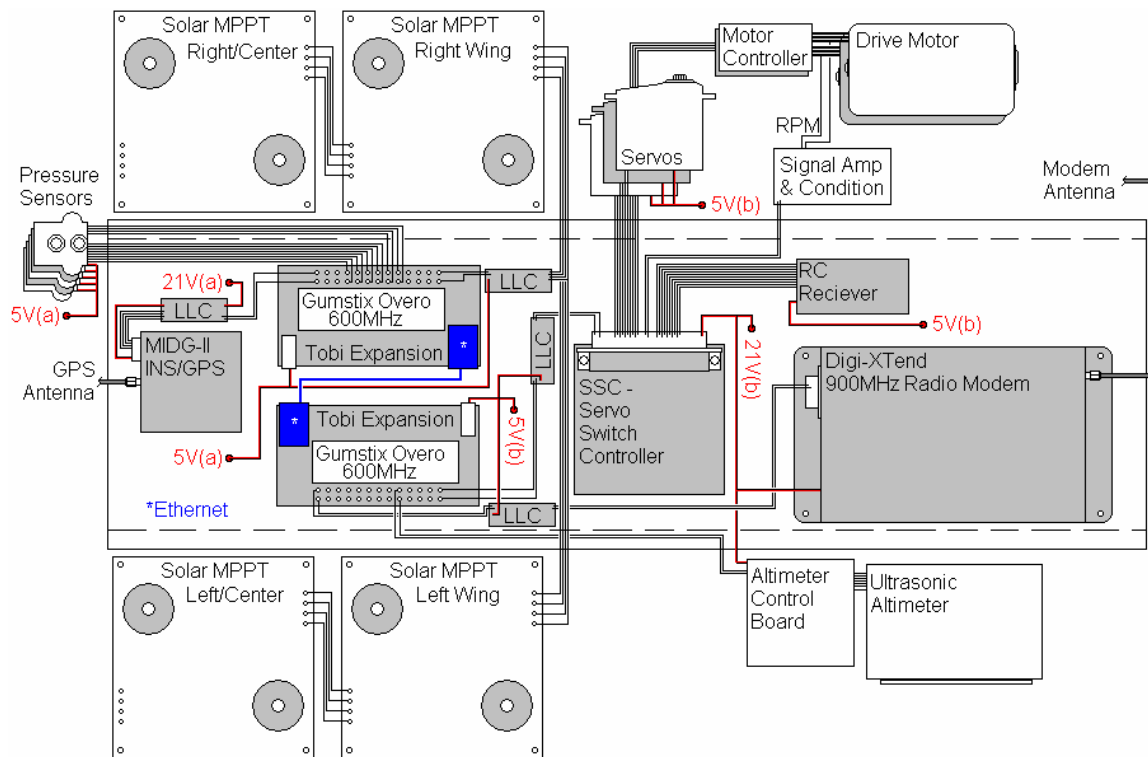


Figure 3: Flying Fish Phase II Avionics System