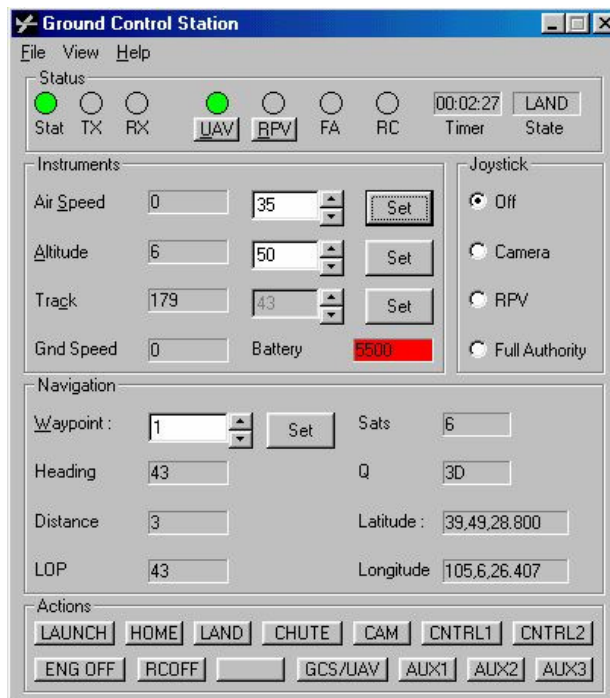


AP1 Autopilot, Flight Control and GCS System

The AP1 autopilot is a full function, low cost UAV control system. The AP1 can fly the mission autonomously or under the GCS supervision of a pilot while augmenting the stability of the airframe allowing the pilot direct command of the nature of the flight but secure in knowing that the stability of the airframe will not be compromised.

- Small, lightweight and low cost
- Autonomous navigation and mission control
- UAV, RPV, FA and RC operational modes
- Ground Control Station (GCS)
- Powerful 1 Watt spread spectrum RF link
- In-flight re-tasking and parametric selection
- Autopilot controls AETR&F servos
- Multi-state control
- Holding patterns
- Camera gimbals and on/off controls
- Multi-mode joystick
- Integrated sensors
- Real-time data analysis
- Flaperon, Elevon or V-Tail mixing

The GCS is a multi-window display is designed to be spread across as many monitors or as large a desktop as the physical layout allows. Each window be moved, minimized or closed during execution.



The Main Screen

The main screen is the central collection point for fundamental control of the UAV. The pilot can:

- Monitor RF link status
- Set airspeed, altitude and track
- Set next waypoint
- Monitor flight conditions, navigation and battery
- Assign joystick functions
- Activate controls

The pilot can control all aspects of flight from the main screen.

The joystick can be assigned to control the camera gimbals, as the Remotely Piloted Vehicle (RPV) command or as the Full Authority (FA) command where it will drive the control surfaces directly.

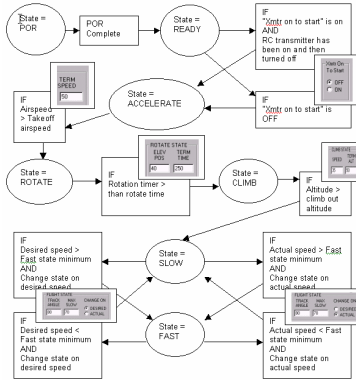
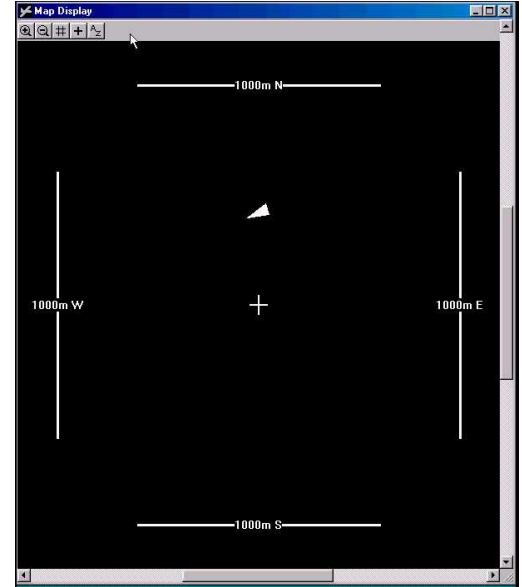
The pilot has pushbutton control over the following actions:

- Launch – the UAV waits for the launch button before entering the accelerate state
- Home – sends the UAV directly home
- Land – causes the UAV to land immediately
- Chute – deploy the parachute via servo
- Camera – turns the camera / video transmitter power in the airborne unit on/off
- Engine off – kills the engine
- GCS/UAV priority – selects mission priority
- Two additional digital control and two additional servos control (if no camera gimbals)

The Map

The map display shows the position of the UAV relative to the GCS. Mission planning is accomplished by setting waypoints, defining flight legs and mission actions using the mouse and drop down menus.

The user may select between two user-defined holding patterns stored in UAV memory. These holding patterns may be re-written in flight via the GCS.



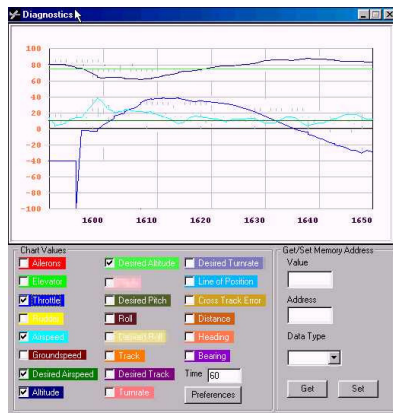
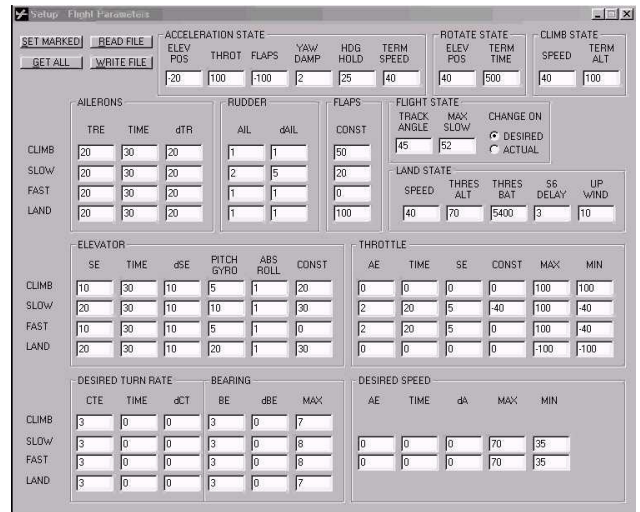
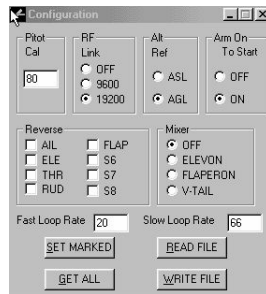
Flight States

The AP1 supports multiple flight states to facilitate control under a variety of conditions. The state diagram shows that the AP1 allows full control during launch, rotation and initial climb. These flight parameters are set by the user in each state according to the flight profile and stability of the airframe.

Parametric Selection

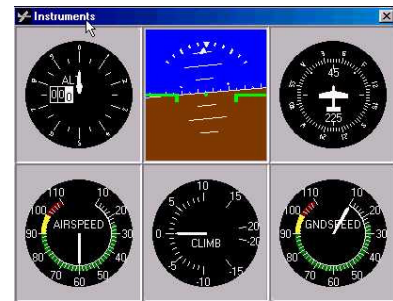
Parameters can be changed in flight thus facilitating a formerly time-consuming that that used to take days into a couple of hours.

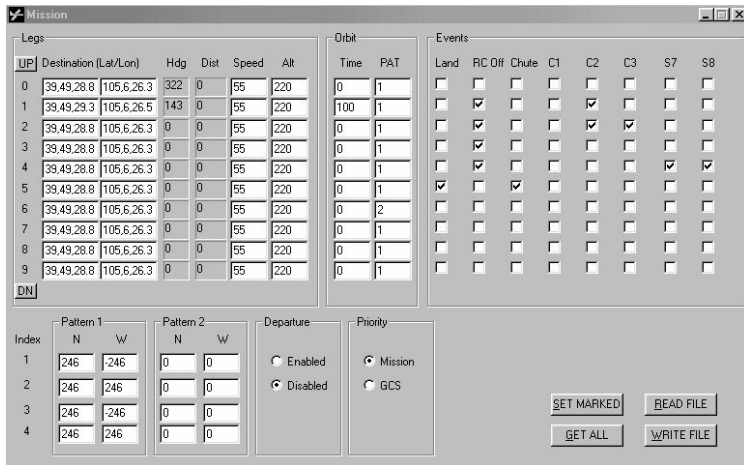
Parameters can be stored as files and sent to the UAV with a single button click.



Parametric selection is no longer a trial and error process. A real-time data analysis tool is provided to assist in the selection and effect of parametric changes.

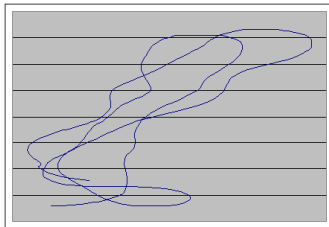
A set of flight instruments completes the GCS operator interface.



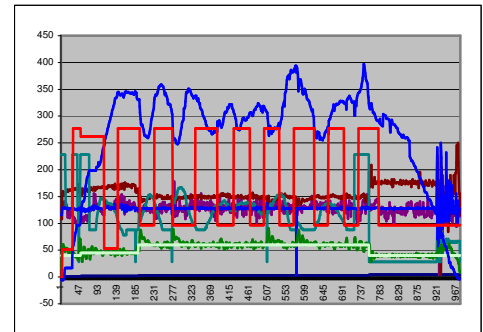


Mission Planning

The mission consists of a series of waypoints connected by flight legs. The mission planner can specify flight leg attributes and actions that will take place upon reaching the next waypoint. Up to 24 waypoints can be stored in the autopilot and additional waypoints can be loaded dynamically while in flight.



An extensive data log of all of the data downlinked to the GCS is maintained allowing detailed post flight analysis. Data is loaded into a spreadsheet program for graphical analysis

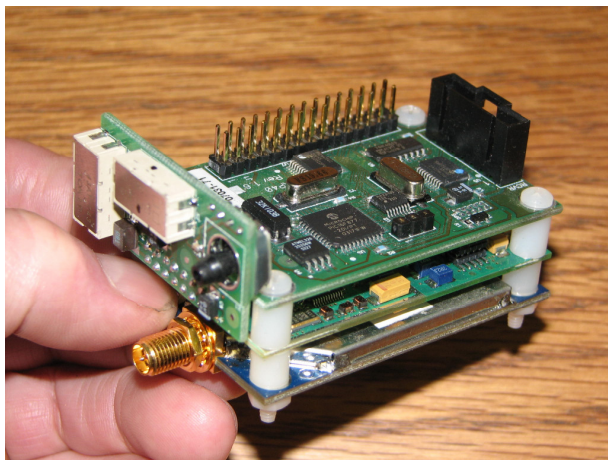


GCS System Requirements

The Ground Control Station is designed to run on a laptop or desktop PC running Windows 98 or later operating system. Connection to the RF MODEM requires a serial or USB port.

The Autopilot Hardware

The autopilot consists of 3 main components; the autopilot with onboard sensors, the GPS receiver and the GCS RF link.



The AP1 autopilot will stabilize most airframes. Control is achieved using augmented PID (Proportional, Integral, Derivative) control. Augmentation consists of a combination of feed-forward, coupling and fuzzy logic. Control is applied to ailerons, elevator, throttle, rudder and flaps. Three additional servos control parachute release and camera gimbals XY position.

Flight states are Ready, Acceleration, Rotation, Climb, Slow, Fast and Land. The Acceleration, Rotation and Climb states are tailored to enable takeoffs from catapults, runways, bungee, or hand launch. Landing under autonomous control consists of specifying an engine shutdown event upon arrival at the landing location and entering a holding pattern over the

selected landing site at minimum airspeed. Alternatively, a mission servo may activate a parachute recovery system.

The Multimode Joystick

The Joystick has 3 modes of operation:

- Camera gimbals control
- RPV flight control
- Direct control of flight servos

The joystick can point a two axis servo controlled camera gimbals, direct the UAV in PRV mode or take direct control over the flight surfaces. When used as a camera pointing control, the operator presses the trigger button, moves the camera to the desired position. When the operator releases the trigger button the camera remains pointed in the desired direction.

UAV, RPV, FA and RC Flight Modes

Normally the AP1 autopilot operates completely autonomously in the Unmanned Autonomous Vehicle (UAV) mode selecting waypoints, flight profiles and actions stored in the onboard mission memory. During autonomous flight the AP1 does not require any interaction with the ground support crew to carry out its mission.

The Remotely Piloted Vehicle (RPV) mode allows the ground-based pilot to control the track, altitude and airspeed of the airplane through the joystick attached to the Ground Control Station (GCS) or by entering the data in the GCS Main Window. Because the AP1 is still managing the flight control surfaces, the stability and safety of the vehicle is assured.

The Full Authority (FA) mode of operation is available at the Ground Control Station (GCS) for pilots to take over direct control of the flight servos using the attached joystick. In this mode, the safety protocols of the AP1 are disengaged and the pilot is responsible for the stability of the aircraft.

As an aide to the engineering development of the UAV system, the AP1 autopilot can interface to any standard, inexpensive, off-the-shelf PPM four-channel RC receiver, and control four servos (ailerons, elevator, throttle, rudder). In Remote Control (RC) mode, the RC pilot has direct control over the servos just like normal RC flying. The RC receiver will always override any action of the autopilot if the RC transmitter is turned on. UAV mode is invoked when the transmitter is turned off. The RC receiver may be switched off during flight from the GCS to prevent spoofing or other interference.

RF Link

The AP1 autopilot uses a modified MaxStream Xtend 1 Watt transceiver module. Range in line-of-sight conditions exceeds 14 miles. RF data rate ranges from 1M bits/sec to 9600 bits/sec depending on conditions.

Specifications

Weight	less than 100 grams including standard GPS and RF antennas
Size	2.9" x 1.6" x 2"
Power	5.4 to 8 Volts at 100 mA (receive), 600 ma (transmit)
PC Requirements	Windows 98SE or later
Sensors	Pitch rate, yaw rate, airspeed and GPS altitude