

1 The Aircraft

1.1 Aircraft Overview

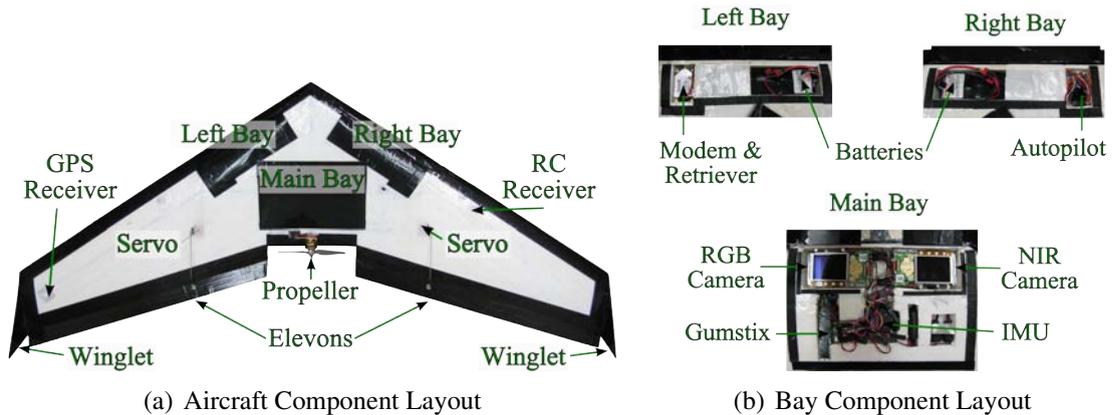


Figure 1: AggieAir Layout

AggieAir is a flying wing aircraft made entirely of a high density EPP foam and weighing approximately 8 pounds. The aircraft is propelled using an electric brushless motor (in a pusher configuration) and can roll and pitch by means of two elevons controlled by electric servos (Figure 1). Both the motor and the servos are controlled by the Paparazzi autopilot (Figure 2). Depending on the mode of operation, Paparazzi can control the movement of the aircraft based on the inertial sensors and a preprogrammed flight plan, or on the commands given to it by the RC receiver. The inertial sensors, which are used to navigate the aircraft, include a GPS module and an inertial measurement unit (IMU). The data from these sensors is preprocessed, logged and given to Paparazzi via the Gumstix embedded computer. After using the data to navigate the aircraft, the inertial data (along with other variables) is sent down to the Ground Control Station (GCS) using a 900MHz modem. Through this communication channel, the UAV can also receive commands from the GCS. In addition to preprocessing the inertial data, the Gumstix is also used to control the onboard cameras via the USB port.

Two 12v 8000mAh batteries are used to power the UAV. They have enough power to keep the UAV flying for about an hour. The only component not powered by these batteries is the retriever. The retriever has its own independent power source and aids in locating the UAV. Retriever reveals the location of the UAV by periodically emitting a strong beacon signal which can be heard using a receiver and a yagi antenna from 5 miles away. This beacon can then be used by pointing the yagi antenna in different directions and listening for the strongest signal from the receiver. The direction with the strongest signal is the direction of the UAV.

1.2 Launching and Landing

AggieAir uses a 20' bungee for takeoff. One end of the bungee is staked into the ground and the other end is attached to a hook underneath the UAV. Once the bungee is stretched about 40', the UAV is released and launched into the air. While accelerating and gaining

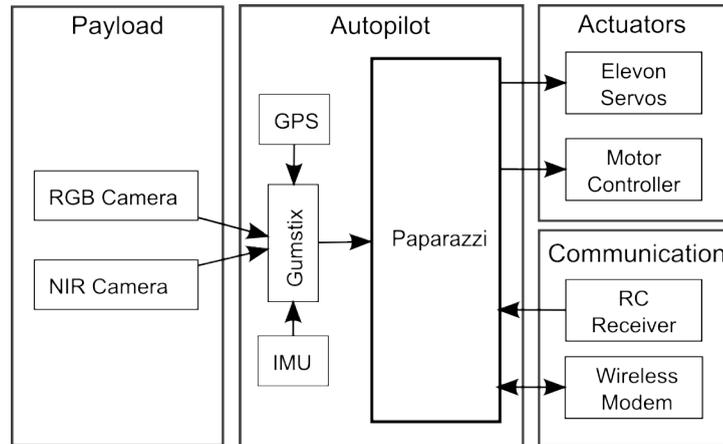


Figure 2: Aircraft Diagram

Table 1: AggieAir Aircraft Specifications

Wingspan	72"
Weight	8 lbs
Nominal Air Speed	30 miles/hour
Maximum flight time	1 hour

altitude, the UAV follows a line beginning from the point at which it was released and extending to the known GPS location of where the bungee is staked into the ground. Once the UAV flies past the bungee location, the throttle turns on and the plane continues flying straight until it reaches a preset altitude and ground speed. At this point, the UAV moves on to the next command in the flight plan.

To land, the UAV first circles around a given waypoint until it reaches a specific altitude (usually about 65ft AGL). Once this altitude is reached and the UAV is pointed in the right direction, the UAV glides down toward another waypoint at ground level and about 150 - 200 yards away from the first waypoint. When the UAV reaches ground level, it has scrubbed off most of its speed and safely lands on its belly.

A 50x100 yard strip of clear land is needed for successful autonomous takeoff and landing with a larger 100x200 yard strip clear of anything over 50ft high. Manual RC operation can be used to takeoff and landing in smaller areas. Since it is easier on the UAV, it is preferred to have a grassy field for takeoff and landing. However the UAV could also use a dirt field or road.

1.3 Paparazzi Autopilot

The Paparazzi Autopilot has three modes of operation: manual, semi-autonomous and fully-autonomous. The pilot can switch between these modes using a switch on the RC transmitter. If Paparazzi doesn't detect the RC transmitter, the default mode of operation is fully-autonomous.

In manual mode, the UAV is flown manually by a pilot at the ground station with the RC transmitter. The RC Receiver on the UAV receives the command signals from the transmitter and passes them on to the Paparazzi board. The Paparazzi board then

actuates the motor and servos according to these control signals. Even though the actuators are controlled through the Paparazzi board, the pilot is in complete control of the aircraft.

The semi-autonomous mode adds some autonomy by interpreting the elevator control signals from the RC transmitter as roll and pitch angles; the throttle is still manually controlled. For example, if the pilot pulls the stick to the right, Paparazzi will interpret this as a specific positive roll value and will try to hold the UAV in that orientation. If the pilot lets go of the stick, Paparazzi will hold the UAV at zero roll and zero pitch. The semi-autonomous mode is used to help trim and tune the aircraft.

When in fully autonomous mode, Paparazzi flies the UAV according to a preprogrammed flight plan. The flight plan contains waypoints and blocks which are used to tell the aircraft where to go. A waypoint is a point of interest on the map defined by its location (GPS and altitude). The blocks use the waypoints to give specific commands to the UAV. An example of a block is the Goto Block. The Goto Block simply tells the UAV to go to a given waypoint. Another example is the Circle Block, which tells the UAV to circle around a given waypoint at a given radius. Blocks can be set up to simply move to the next block when finished, to move to a different block somewhere else in the flight plan or to repeat until the operator directs it to a different block. Exceptions can also be used in the flight plan to detect specific conditions and to redirect the UAV accordingly. For example, an exception could be used to tell the UAV to come home if it gets too far away.

1.4 Payload

The payload on AggieAir includes two cameras. One camera takes pictures in the visual band of the spectrum and the other takes pictures in the near infrared band of the spectrum. They are both controlled through USB by the Gumstix. The Gumstix tells the cameras when to take a picture, and records the position and orientation of the UAV when the picture is taken. The pictures are taken at equal time increments that are dependent on the altitude of UAV over the area of interest. To avoid damaging the cameras while the UAV is being launched, the Gumstix will extend the lens and start taking pictures at a specified altitude. Similarly, for landing, the Gumstix will stop taking pictures and retract the camera lens once the UAV descends below another specified altitude.