The University of Florida has extensive experience in developing reliable and durable mission capable micro air vehicles (MAVs). Applying the design philosophies which have proven both efficient and successful in the past, UF has developed a 31 cm autonomous MAV which is capable of completing the mission objectives required at the 2nd US-European MAV Competition. In order to best employ the limited volume available in a MAV of this size, the Gator A MAV utilizes multifunctional airframe components. A hybrid aramid/carbon fiber construction was developed to maximize the signal strength of airborne transmitters and receivers. The MAV is capable of fully autonomous or stability augmented flight control, GPS waypoint navigation, return to home functionality, autonomous sensor deployment, and autonomous launching/landing. In addition, the MAV features a gimbaled camera capable of any viewing angle within a complete hemisphere in order to increase the surveillance capability. An autonomous MAV launcher and corresponding software was developed in conjunction with the MAV to increase the degree of autonomy of the system.

**Introduction**

In recent years, micro air vehicles (MAVs) have received significant attention for practical applications such as reconnaissance and sensor deployment. MAVs are ideally suited for such missions due to their low observability and quiet electric operation.

The team at the University of Florida has specialized in small mission capable UAV and MAV design and development through multiple contracts. The UF team has also competed in multiple MAV competitions on the international level, including the 1st US-European MAV Competition. In addition, the UF team has competed in the International MAV Competition (IMAVC) for the past ten years, winning first place overall the last eight consecutive years. Figure 1 shows the UF Gator A MAV developed for the 2nd US-European MAV Competition.

Through experience, the UF MAV team has developed a successful design methodology for mission capable MAVs. This methodology is based largely on the reliability and durability of the airframe, subsystems, and components. In addition, consistent success with low Reynolds number (Re) MAVs has been achieved through an extensive testing and modification process. Figure 2 shows an example of a successful 10 cm vehicle developed at UF for the International MAV Competition.

**Figure 1  Gator A MAV.**

The 2nd US-European MAV Competition consists of a single mission with multiple
objectives, each with unique challenges. The mission profile consists of launching, and then navigating to three surveillance targets. Each is oriented differently and must be positively identified. The fourth target requires accurate sensor deployment, followed by a landing within a specified region. Greater degrees of autonomy increase the score of each flight, as do smaller vehicle dimensions and shorter mission completion times.

Figure 2. 10 cm MAV for the IMAVC.

In order to successfully compete at the 2nd US-European MAV Competition, the UF team has developed an autonomous 31 cm MAV which has proven to be mission capable, reliable, and durable. Autonomous systems and maximized signal strength were focal points in the design of the Gator A MAV.

I. Aircraft Design

The University of Florida team has had success with previous MAV designs, both for competitions, as well as grants and contracts. Therefore, complete ground-up designs are unnecessary and inefficient. New designs for unique mission profiles are based heavily on previous successful designs, and iterative modifications are performed to meet their respective objectives. Due to the unpredictable nature of low-Re flow, this approach has proven more reliable and less time consuming than iterative computational methods.

Similar to previous designs, the UF Gator A MAV design is based around thorough utilization of a sphere, wherein the diameter is chosen as the maximum linear dimension of the aircraft. Due to the propeller protrusion, a circular planform is not permissible without exceeding the maximum dimension. The design approach then leads to an elliptical wing planform. A maximum linear dimension of 31cm was chosen, and the design is shown in Fig. 3.

Figure 3. Planform design sketch.

The utilized airfoil is also based upon previous designs. The primary constraint on the airfoil design is a zero pitching moment, negating the need for a horizontal stabilizer. The Gator A MAV utilizes the airfoil designed for the 2004 IMAVC, which was based on both panel method and thin airfoil theory. Wings with airfoil camber values of 4, 6, and 8% were tested.

The component selection for the MAV was focused around reliability and durability, a proven design philosophy. The criteria for selection of components were ranked and are listed below. A table of the components are given in Table 1:

1. Reliability / Durability
2. Size / Form Factor
The design of the fuselage is a direct function of the components’ size, shape, and mass, as well as CG location (for static stability). A depiction of the fuselage design with housed components is shown in Fig. 3.

Table 1. UF Gator A MAV components.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Qty.</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>MR-012-030-5300</td>
<td>1</td>
<td>15.0</td>
</tr>
<tr>
<td>ESC</td>
<td>PHX-10</td>
<td>1</td>
<td>6.0</td>
</tr>
<tr>
<td>Autopilot</td>
<td>Procerus 2.1</td>
<td>1</td>
<td>17.0</td>
</tr>
<tr>
<td>Modem</td>
<td>Aerocomm AC4790</td>
<td>1</td>
<td>9.6</td>
</tr>
<tr>
<td>GPS</td>
<td>Furuno</td>
<td>1</td>
<td>19.2</td>
</tr>
<tr>
<td>Servos</td>
<td>BA-TS-4.3</td>
<td>2</td>
<td>8.6</td>
</tr>
<tr>
<td>Battery</td>
<td>TP 910mAh</td>
<td>2</td>
<td>46.0</td>
</tr>
<tr>
<td>Camera</td>
<td>Color CCD</td>
<td>1</td>
<td>35.1</td>
</tr>
<tr>
<td>Video Tx</td>
<td>2.4GHz 200mW</td>
<td>1</td>
<td>12.5</td>
</tr>
<tr>
<td>Misc.</td>
<td>Drop Mechanism</td>
<td>1</td>
<td>5.0</td>
</tr>
</tbody>
</table>

In order to provide the functionality required for the mission profile, multi-purpose components were implemented to minimize weight and fuselage volume.

To increase the GPS receiver sensitivity, the aircraft’s hatch was embedded with a thin copper plate. This plate acts as a ground plane for the GPS receiver (located at the center of the hatch). The multi-functional hatch can be seen in Fig. 4.

Figure 4. Multi-functional hatch/GPS receiver ground plane.

Figure 5 shows another multifunctional aspect of the MAV. The 2.4 GHz video transmitter antenna was embedded within the vertical stabilizer of the airplane. The stabilizer, which is constructed of a balsa core and fiberglass covering, is non-conductive in nature. This allows the antenna to operate unobstructed outside of the fuselage. Placing the antenna inside the stabilizer provided the added benefit of decreasing the required fuselage volume.

Figure 5. Embedded video antenna.

II. Subsystems

A. Autopilot

The specifications of the US-European Competition require that an autonomous control system be capable of managing the altitude, airspeed, and attitude, as well as the bearing of the MAV. The Procerus Kestrel 2.1 autopilot, shown in Fig. 6, was chosen due to its small size/weight and its capability of meeting the mission requirements.
Furthermore, the University of Florida has many years of experience with this autopilot and has used it in several other applications.

Figure 6. Procerus Kestrel 2.1 autopilot.

The Kestrel 2.1 (35 x 52 x 15mm, 17 grams) uses an inertial measurement unit (IMU) that features a three axis accelerometer and three axis gyro. Static and dynamic pressure sensors are applied to measure airspeed and altitude. A GPS receiver determines the position of the aircraft for navigation purposes. The Kestrel 2.1 has several different adjustable fail-safe functions that will trigger in the event of a malfunction.

If a loss of communication exceeds 2 seconds, the MAV will auto-level. If the communication link is out for an additional 2 seconds, the MAV will fly itself toward home, until a link is re-established (for piloted control). If the MAV loses GPS reception for more then 1 second, the MAV will auto-level. If the GPS remains out for an additional 3 seconds, the plane will execute a 30 degree bank and loiter for 5 minutes. In the event that the GPS link is never re-established, the MAV will land itself. A drops of battery voltage below 9 V, prompts the MAV to automatically return home and land.

The Kestrel 2.1 provides 4 servo ports, as well as an extra configurable serial output. This output was used to control the camera gimbal unit. A wiring diagram for the Kestrel 2.1 is shown in Fig. 7.

Figure 7. Kestrel 2.1 wiring diagram.

The autopilot uses a series of PID control loops to adjust the roll, pitch, altitude, and trajectory tracking. The MAV is tuned using traditional PID techniques while airborne. Figure 8 shows an example altitude hold control loop.

Figure 8. Altitude hold control loop.

The Kestrel 2.1 autopilot uses a 900 MHz transceiver to communicate with the ground station. This digital link allows for real-time data logging, as well as on-the-fly mission changes. Typically, the Kestrel 2.1 uses a 1000mW Aerocomm 4490 modem, which has a large form factor and consumes excessive current. To this end, the University of Florida has designed a communication board featuring the Aerocomm 4490 1x1 10mW modem, shown in Fig. 9.

The modem (also shown in Fig. 9), is approximately 25% of the size, less then half
the mass of the original Aerocomm 4490, and draws only 80 mA. This board also integrates a 1.5 A, 5 V high-efficiency switching regulator to provide the correct voltage to the camera, servos, and video transmitter. The board occupies less volume (51 x 29 x 10mm) and has a mass of 9.6 grams. UF’s communication and power regulation board Altium PCB design is shown in Fig. 10.

Figure 9. UF designed Aerocomm communication and power regulation board.

The ground station is comprised of all the components needed to control the airplane and view on-board video. The components were combined and housed in a Pelican® laptop case. A schematic for the ground station is shown in Figure 11.

Figure 10. Altium daughter board.

The antennas for video reception and vehicle control are mounted to the top of the case. The large antenna is a 900MHz patch antenna linked to the autopilot ground station box with a 10 mile download and upload radius. A manual remote controller is attached to allow for piloted controls in the event of an autopilot failure. The other two antennas mounted to the top of the case are 2.4 GHz patch antennas used for the video receiver. This combination allows for a greater reception angle, with a 3 mile range. Both the video receiver box and the autopilot ground station are networked to the laptop for one simple interface. The housing meets military standard C-4150J for durability and reliability, and is well suited for field use.

Figure 11. Ground station schematic.

The ground station for the Kestrel 2.1 includes specialized hardware with a 1000mW Aerocomm 4490, for serial communication with a laptop computer and Kestrel’s Virtual Cockpit software. This setup is shown in Fig. 12.

Figure 12. Ground station.
PID constants, mission attributes, and fail safes can be modified in the software, which displays real time information about airplane location, mission parameters, and control mode status. A screen shot of the Virtual Cockpit software is shown in Fig. 13.

![Figure 13. Screen shot of Virtual Cockpit.](image)

**B. Camera Gimbal**

In an attempt to improve surveillance capabilities, UF has developed a camera gimbal (Fig. 14) which is compatible with the Kestrel 2.1’s hardware.

![Figure 14. Camera gimbal mechanism.](image)

A modified KX141 CCD camera was mounted within the gimbal. The heavy aluminum lens casing was lathed down to reduce the weight. The camera was chosen for its high resolution, and low light handling ability. While smaller CMOS cameras were readily available, the need for high quality video more than justified the camera’s weight of 13g. In the azimuth, the camera’s range of movement is +/- 180°. In the elevation plane, the camera moves 90° downward from the horizontal.

The 360° azimuth travel is accomplished by gearing a Futaba 3110 servo down to a 3:1 ratio. Position feedback is given to the servo by a 5 kΩ B type potentiometer, located at the last stage of the gear reduction. The camera elevation is controlled by a micro servo, mounted within the half-sphere case right behind the camera circuit board. The servo arm is fixed to a bracket and moves the case from 0°-90°. The entire gimbal has a mass of 35.1 grams, and is calibrated such that the camera is always looking at a set GPS waypoint.

Commands are sent serially from the autopilot to a servo control board that moves the servos to their desired positions in order to track a moving target.

**C. Sensor Deployment Assembly**

The paintball dropping device (Fig. 15) consists of a servo fixed to the inside of a semi-circular carbon fiber channel. A BMS-303 servo was used in the sensor deployment assembly. The servo arm moves 90° in the horizontal plane, allowing the paintball to be loaded or dropped. Flight testing has shown that mounting the servo within the channel increases durability during landing. The sensor deployment assembly weighs 5 g.

![Figure 15. Paintball dropping device.](image)
GPS waypoint and time-delay is programmed into the mission parameters. As the MAV flies over the pre-programmed waypoint, the servo is actuated and the paintball is released. The time delay allows for wind conditions and airplane velocity to be taken into account.

D. Antenna Design

In an aircraft of this size, volume in the fuselage is limited. In past designs, this has caused problems with close-proximity RF devices. As a solution, both airborne antennas have been traditionally designed with limited space, multi-functionality, and desired performance in mind.

Two RF frequencies are used on the MAV: a bidirectional digital autopilot link at 900 MHz and a unidirectional 2.4 GHz video downlink. The two antennas were designed around these two frequencies.

a) 2.4 GHz Antenna Design

The 200 mW Black Widow A/V transmitter operates on a fixed channel at 2.45 GHz. The antenna was designed as to be embedded into the vertical stabilizer of the MAV. A monopole microstrip PCB antenna was chosen for this application.

The antenna was designed in Ansoft Designer and simulated on a 30 mil FR4 PCB board with 1 oz copper and no ground plane. The absence of a ground plane ensures an omni-directional radiation pattern. The Altium laid-out antenna and the final manufactured antenna can be seen in Figure 16.

Figure 16. PCB antenna.

Ansoft Designer has the ability to plot many different performance characteristics of the antenna. A plot of input impedance versus frequency was used to iterate the length of the design until a desired match of 50 Ω is achieved. At 2.45 GHz, the impedance of the antenna is 49.63 + j102.10 Ω. The reactive portion of the impedance was cancelled out with the use of a series capacitor in order to reduce reflection losses. The desired capacitor was calculated to be 6.63 nF.

The 2.4 GHz monopole antenna is linearly polarized. Therefore, a polarized patch antenna was selected in order to reduce unexpected signal degradation due to polarization losses. The radiation pattern of the antenna in the azimuth is nearly 360 degrees, which allows video reception regardless of MAV orientation. This arrangement produces two significant dead spots on the antenna both along the vertical axis of the antenna, parallel to the face of the PCB, as shown in Fig. 17.

Figure 17. Simulated radiation pattern.

The physical antenna was laid out using Altium DPX and manufactured by Advanced Circuits on a 30 mil, two layer, 1 oz copper FR4 printed circuit board. AppCad was used to calculate the dimensions and clearances of the coplanar waveguide used to feed the antenna.

For placement of the stabilizer, the antenna was first cut out of the fiberglass FR4 board. A 6.8 nF capacitor and shielded coaxial were soldered into their respective pads.
The 2.4 GHz monopole antenna was verified with a network analyzer (used to measure the performance of a two-port network). For best power transfer and antenna radiation efficiency, the input impedance of the antenna should match the output impedance of the video transmitter (50 Ω). The 50 Ω network analyzer’s output could then be directly connected to simulate the video transmitter. The frequency was swept between 2.35 to 2.50 GHz to confirm the antenna’s resonant frequency. The 2.4 GHz antenna showed a resonant frequency at 2.45 GHz as its impedance was closest to 50 Ω. At this frequency, the antenna has an input impedance of 53.43 – j3.78 Ω. Fig. 18 shows the measurements taken during the frequency sweep.

![Network analyzer sweep.](image)

**Figure 18. Network analyzer sweep.**

**b) 900 MHz Antenna Design**

The Aerocomm 4490 modem is a 900 MHz spread spectrum transceiver, which can operate in a given range. Therefore, the antenna must have a reasonable bandwidth in order to operate efficiently between 902–928 MHz. Furthermore, the size of the antenna is dictated by the limited size of the fuselage. A flexible monopole antenna was selected based on these requirements.

The 900 MHz antenna, shown in Fig. 19, is a custom fabricated monopole antenna constructed from shielded coaxial wire and small metal circular ground plane. The antenna is stripped back to leave the signal line exposed. A 5.5 mm circular ground plane was soldered to the shielding of the remaining wire. The remainder of the coaxial wire was used as a variable length transmission line.

![Custom monopole antenna.](image)

**Figure 19. Custom monopole antenna.**

A network analyzer was used to monitor the input impedance to the antenna at the feed point of the transmission line as the length changed. The transmission line length was reduced until a 50 Ω impedance was achieved. S parameter data (used in describing high frequency networks) was collected throughout the process. Fig. 20 shows the performance of the return loss of the 900 MHz antenna.

![Return loss vs. frequency.](image)

**Figure 20. Return loss vs. frequency.**

**E. MAV Launcher**

A MAV launcher was used to add a degree of autonomy to the system. The MAV launcher is computer controlled so as to minimize operator error. It is also very packable and portable for simple and efficient field operation.
a) MAV Launcher Design
The launching system was designed to propel the 250 g MAV at a velocity of 10 m/s. A picture of the launching system is shown below in Fig. 21. The system consists of a spring in compression that accelerates the MAV at a predetermined angle along parallel guide rails to maintain a level attitude. Testing was done with various springs and pull-back distances, until a reliable configuration was found.

Figure 21. Automated MAV launcher.

b) Manufacturing Process
The launcher components, which were designed in Pro-Engineering, were milled from aluminum by a computer numerical controlled (CNC) milling machine. A depiction of the CNC toolpath to produce the MAV launcher components is shown in Fig. 22.

Figure 22. Launcher component toolpath.

c) Computer Control Software
The MAV Launcher is triggered by a leverage lock controlled by a servo. Two options exist to initialize and trigger the MAV launcher: computer control through a custom graphical user interface, or a manual button located on the MAV launcher control box.

The MAV launcher’s GUI displays an option for either an instant launch, or a delayed launch (5 or 10 s). Launching status can be monitored in the GUI through bidirectional communication. For safety reasons, launching cannot be triggered prior to initialization.

LEDs on the MAV launcher control box indicate warning and power status. When launch is triggered, the system will start countdown and the warning LED will blink with increasing frequency to warn operators and bystanders of impending launch. Fig. 23 shows the inside of the control box.

Figure 23. MAV launcher control box.

III. Airframe Construction

A. Custom CAD/CAM Software
The migration of a design concept to a working model can be a complicated and time consuming procedure. In an attempt to increase productivity and reduce workload, the UF MAV team has developed a MATLAB-based program (MAVLAB). This program is specifically designed to turn simple planform shapes and basic parameters into a complex freeform wing model. Fig. 24 depicts the graphical user interface of MAVLAB.
MAVLAB has the capability to export tool path files a CNC milling machine. The advantage of this feature is the ability to mill wing molds that were exact representations of the CAD designs created in MAVLAB, reducing the likelihood of geometrical asymmetries in the airframe. Fig. 25 shows a wing mold being machined on a CNC milling machine.

The molds were machined from high density tooling board, whose main advantage is an increased material removal rate, thus reducing production time. This advantage allowed the UF MAV team to produce wing molds in as little as 30 minutes.

The choice of composite materials was influenced by the desire to maximize transmission and reception signal strength of airborne RF devices. To determine the maximum reception of the signal strength with a tuned antenna, a spectrum analyzer was used to test the reception strength within an entirely carbon fiber airframe, as well as a hybrid aramid/carbon fiber airframe. The results, seen in Fig. 26, were measured from a distance of 100 ft using the Aerocomm 4490 modem. The hybrid airframe provided significantly improved signal strength and was therefore selected for the Gator A MAV design.

No viable process was available to automate construction of the airframe, so the UF MAV team developed a standard procedure. The following steps document the process.
1. After machining, the wing mold was not perfectly smooth due to the scalloping of the ball end-mill, and was lightly sanded to a smooth finish. Accuracy was achieved by first applying a light trace coat of black spray paint to the mold surface and then sanding until all painted regions were gone. The completed wing mold is shown in Fig. 27.

![Figure 27. Completed CNC wing mold.](image)

2. Teflon® release film was applied to the surface of the mold with spray adhesive to prevent the resin from bonding to the mold.

3. A single layer of pre-impregnated carbon fiber weave was placed on the release film, biased at a ±45º orientation, along the leading edge of the wing. Unidirectional pre-impregnated carbon fiber strips were cut and applied to construct the center section of the wing, and as reinforcement along the perimeter. The copper plate for the GPS ground plane was then set in the wing. Aramid weave was placed over the entire mold to form the wing skin. A final layer of carbon fiber weave was placed along the leading edge, sandwiching the aramid skin.

4. A high temperature epoxy resin was then spread over the aramid. Special care was taken to ensure even distribution, and any excess resin was removed. The entire wing was covered with porous Teflon® peel-ply, and placed in a vacuum bag.

5. The fuselage lay-up was completed in a two part process. First, carbon fiber weave was wrapped around a Teflon® lined male mold to produce the nose of the fuselage. Multiple layers were applied to the nose to provide adequate reinforcement for impacts.

6. The rear of the fuselage was constructed of multiple layers of aramid weave, which were pressed into a Teflon® lined female mold. Epoxy resin was applied to the aramid, taking care to reduce any wrinkles.

7. The fuselage parts were covered with Teflon® release film and placed in a vacuum bag with the wing, as shown in Fig. 28. The bag was sealed and a vacuum was drawn to a pressure of 0.01 atm absolute, as shown in Fig. 28. The vacuum bag was then cured in an oven at 130° C for 2 hours.

![Figure 28. Vacuum bagged wing.](image)

8. Once cured, excess material was trimmed away as shown in Fig. 29, and edges were sanded to remove splinters.
D. Assembly
1. The two fuselage pieces were mated together to ensure an acceptable fit. A small amount of glue was used to bond the pieces together.

2. A hole was bored into the nose of the fuselage for the motor. Glue is used to adhere the motor to the fuselage with the proper thrust angle.

3. The rudder and elevator were created by cutting sections out of the vertical stabilizer and wing, respectively, and then reattaching them with Tyvek® hinges and glue.

4. Servos were attached to the fuselage by double sided tape (Fig. 30), and lashed into place with aramid thread. Control rods were then installed, connecting the servos to the control surfaces. Special care was taken to minimize any clearance or play in these linkages.

5. The wing was then placed on the wing mold, and the fuselage is glued into place, a method that helps to reduce asymmetries in the MAV.

6. Electronic components such as the electronic speed controller, GPS receiver and autopilot were then installed.

7. The vertical stabilizer (Fig. 31) with the embedded antenna is attached to the top of the MAV with glue.

IV. Wind Tunnel Performance

Three distinct wings were tested within the University of Florida’s low speed, low turbulence closed loop wind tunnel. The square test section is 0.61 m on a side and 2.4 m long, and is capable of speeds approaching 100 m/s. All three of the wings contained identical planform areas, dihedrals, and root chord lengths. The wings were given varying cambers (4, 6, and 8% of the chord), to determine its affect upon performance.

Aerodynamic forces and moments were measured using a 6 degree of freedom strain gage sting balance, capable of resolving forces down to 0.01 N. A standard run consisted of testing each wing at three different flight speeds (8, 10, and 13 m/s: all admissible candidates for MAV flight) and through a range of pre-stall angles of attack. In the interest of space, only the longitudinal force coefficients at 13 m/s are shown here.
The normalized lift can be seen in Figure 32. As all three wings have the same planform area, any variation in data at a given angle of attack is a direct result of the differences in camber. A well known result can be seen: the highest camber (8%) provides the highest lift. Large camber speeds the flow over the upper surface, increasing the maximum suction pressure and the lift. The wing with 4% camber also shows signs of stall at 16º, whereas the data from the higher camber wings remain linear.

The normalized drag of Figure 33 provides a more surprising result: at low angles, the wing with 6% camber has significantly lower drag than the 4 or 8%. This is thought to be a result of offsetting factors. The exaggerated shape of the 8% cambered wing is not streamlined enough to provide low drag, whereas the flat shape of the lower cambered wing (4%) is more susceptible to flow separation over the upper surface (as demonstrated by the decrease in lift slope at 15º). Figure 34 shows that the L/D is highest for the 6% cambered wing, predominately due to its superior drag performance.

V. Flight Testing

Flight testing was an integral aspect to the development and refinement of the Gator A MAV. Flight testing provided the opportunity to verify wind tunnel and theoretical data, configure autopilot control gain settings, and examine mission capability.

In order to refine the handling characteristics and performance, qualitative open-loop flight testing was performed. Control deflections, CG location, and thrust angle were initially based upon prior experience with similar vehicles. After initial launch, the aircraft was trimmed for straight and level flight with the control surfaces. Through an iterative process, the CG position was varied by altering component locations. The final location provided sufficient stability, yet still retained maneuverability for mission requirements. In addition, maximum control deflections were determined, which permitted the maximum desirable maneuvering capability.
To achieve the desired CG location without substantial component redistribution (or violating the design maximum linear dimensions), a modification was made to the wing planform. The leading edge of the wing was moved aft, resulting in a slightly decreased wing area. It was determined that this sacrifice in wing area was acceptable, as the modification permitted a more favorable component distribution towards achieving the desired stability characteristics.

In order to improve turning coordination, the addition of an upper vertical stabilizer was explored. It was found that this inclusion provided more coordinated turns with only rudder and elevator controls. In addition, the inclusion of the upper vertical stabilizer eliminated the requirement for any thrust offset.

VI. Subsystem Verification

On October 1, 2006, a mission profile similar to the competition mission was flown at Archer Field in Gainesville, FL using the Gator A MAV. The practice mission flown had three waypoints specified by the GPS. The first two waypoints represented picture targets, and the third represented the sensor deployment location. The MAV launcher was utilized for takeoff, and the entire mission was flown at an altitude of 100 m. Fig. 35 shows the mission profile, which is followed by a sample comparison of actual roll vs. desired roll in Fig. 36.

![Simulated mission profile](image)

**Figure 35. Simulated mission profile.**

![Desired and actual roll](image)

**Figure 36. Desired and actual roll.**

The simulated mission was a success. The MAV flew around both targets, clearly identified each, and deployed the sensor at the desired waypoint. This successful trial validated the design philosophies employed and verified the Gator A MAV’s mission capability.

VII. Conclusion

The UF Gator A MAV Team has successfully developed an autonomous Micro Air Vehicle capable of completing the mission objectives for the 2nd US-European MAV Competition. The Gator A MAV has a maximum linear dimension of 31 cm and is constructed of aramid and carbon fiber to improve transmission and reception signal strength. In addition, multifunctional airframe components were developed in order to efficiently utilize the available volume.

Features of the Gator A MAV include an autopilot with 900 MHz up/down link, GPS receiver, two-axis gimbaled CCD camera with 2.4 GHz downlink, autonomous sensor deployment, and autonomous landing capability. In addition, a MAV launcher and supporting software was developed, which permits reliable autonomous launching of the Gator A MAV.
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