StoRC: Search to Rescue Craft
Autonomous Flight and Payload Release Vehicle

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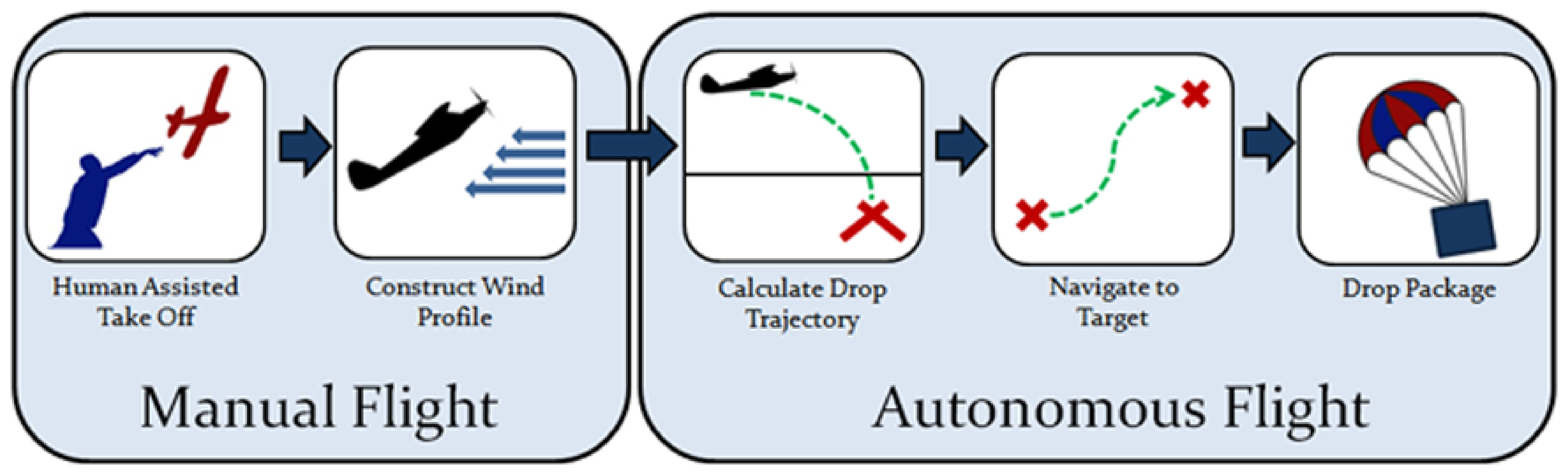
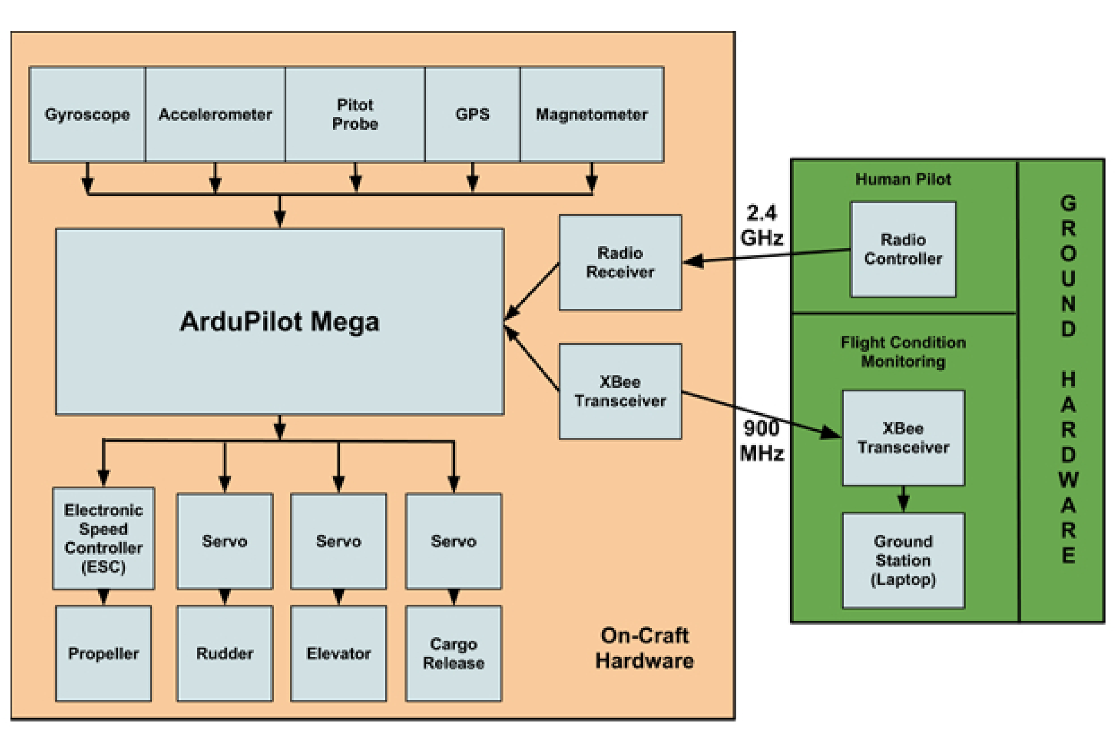
Motivation

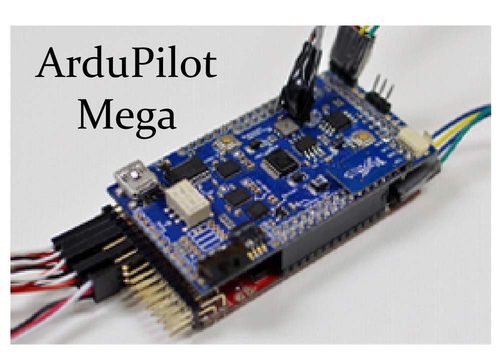
In the event of a natural disaster, communication and transportation networks are often disabled, rendering victims stranded and in need of supplies. Similarly, remote military outposts are hard to reach but frequently find themselves in need of resupply. The current solution to both of these problems is to deliver supplies by helicopter, exposing air crews to the potential for injury and death. This project explores the use of an aircraft to autonomously, accurately, and safely deliver a payload to a specified GPS location.

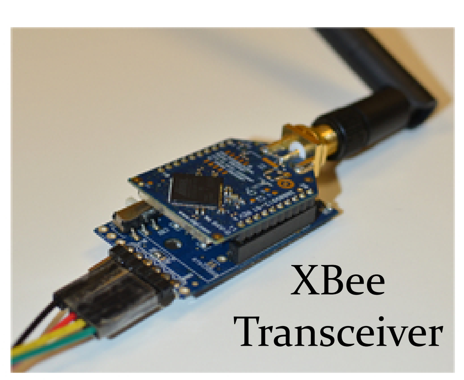


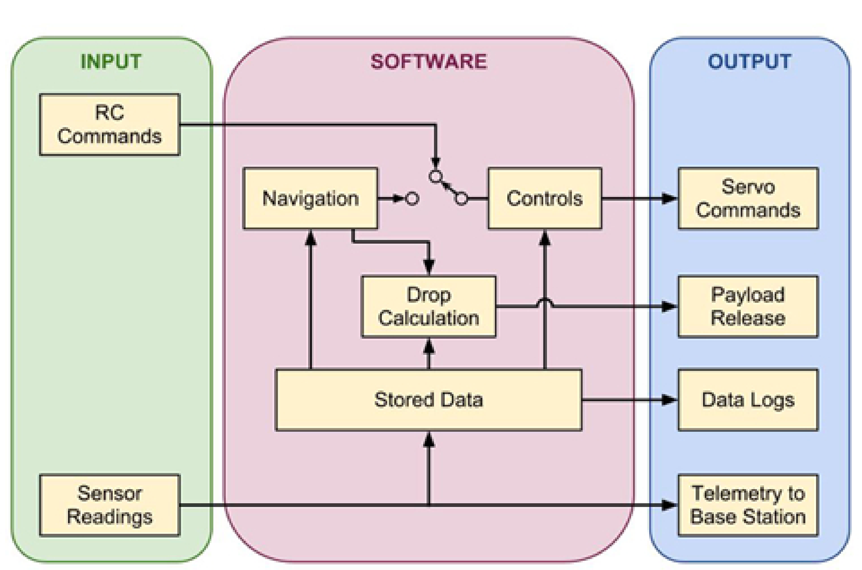
Hardware and Software

As shown in the schematic below, our sensor package consists of inertial measurement, weather condition, and GPS sensors. Data is logged and processed using an ArduPilot Mega microcontroller. For real-time flight condition monitoring, the system uses a master-slave telemetry unit to send data from the plane down to a laptop on the ground.







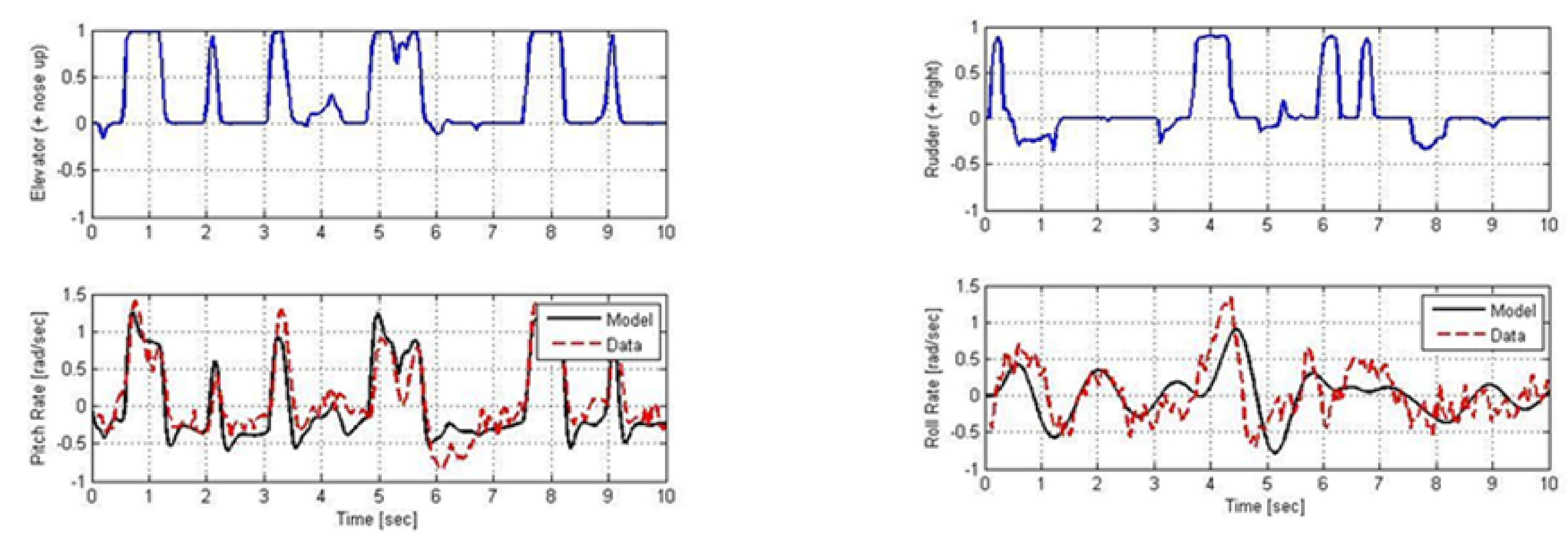


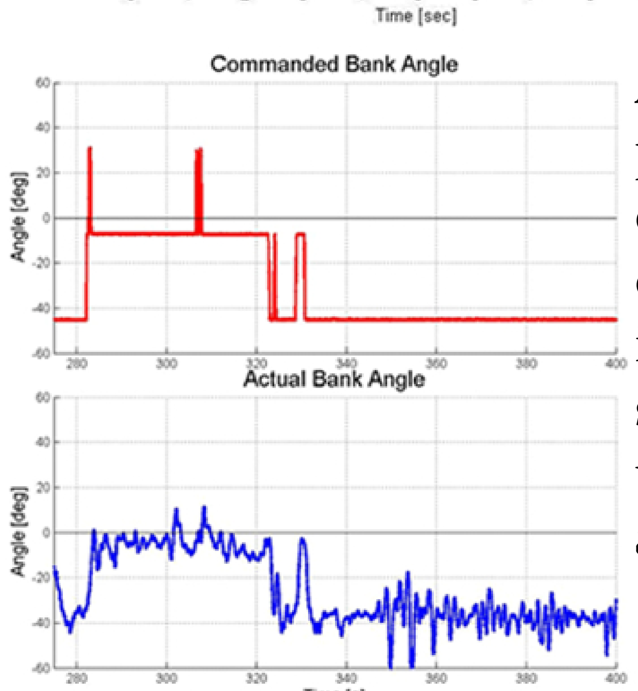
The microcontroller takes data from the sensors and uses the navigation and controls code to turn this data into flight commands. The code also determines when to release the payload and processes human pilot radio commands in manual flight. Data is logged in on-board flash memory and transmitted through the telemetry unit to our base station for real-time flight monitoring.

Simulation and Controls

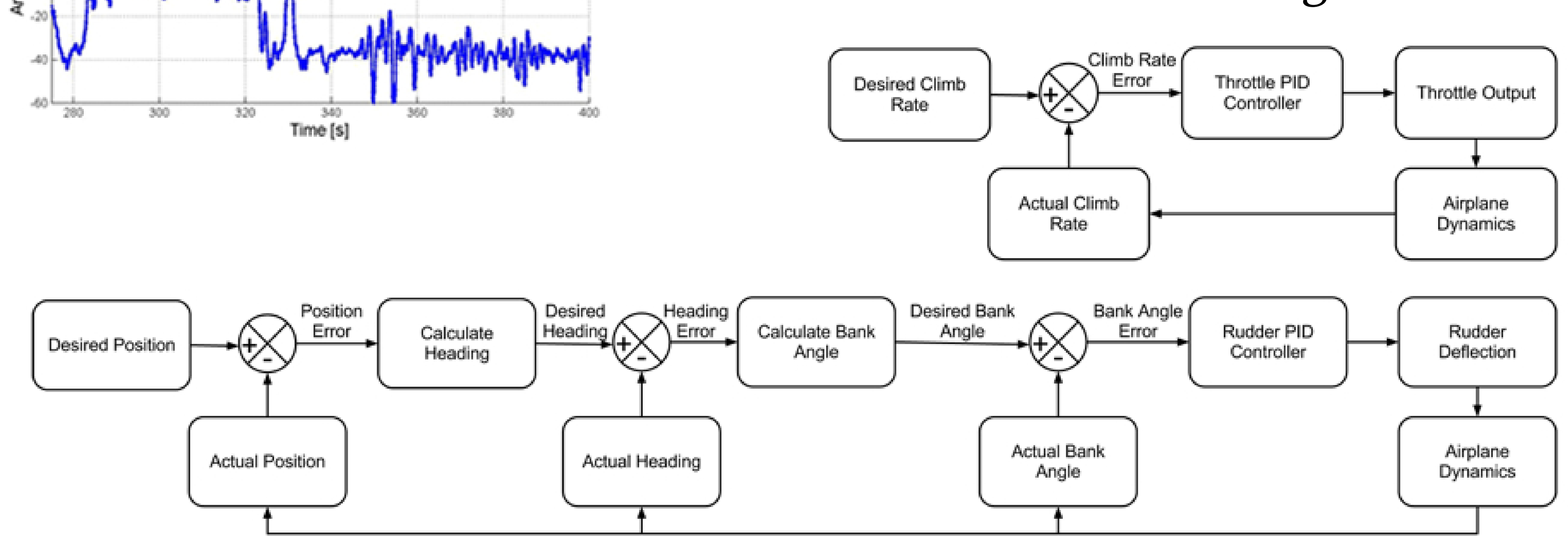
Autonomous rudder and throttle control is achieved with proportional, integral, and derivative (PID) control. A MATLAB/Simulink model is used to identify optimal nominal control gains. These gains can then be adjusted in real time during test flights to be anywhere between 10-200% of their nominal value derived in the model.

The control gain values are derived from a MATLAB/Simulink model that mimics real-life airplane behavior. In order to create an accurate model of airplane behavior, model parameters were adjusted until pilot inputs of elevator and rudder forced the model dynamics to match the actual dynamics, as shown below.





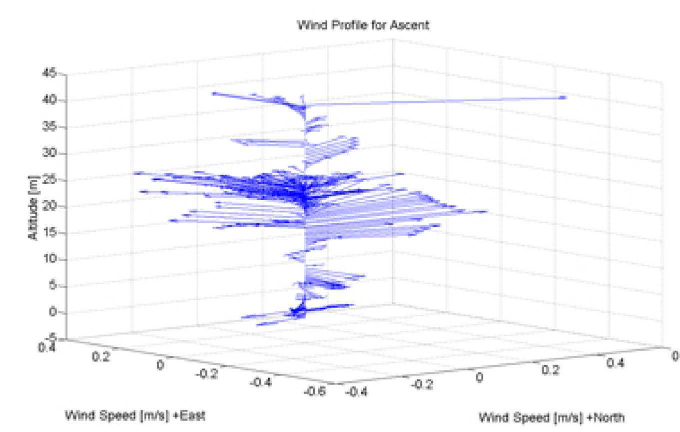
As seen on the left, rudder PID control provides satisfactory results in flight, by closely matching the actual bank angle to the comanded bank angle. This rudder control is implemented in the complete controls scheme shown below. This complete scheme uses throttle PID control to maintain altitude and rudder PID control for navigation.

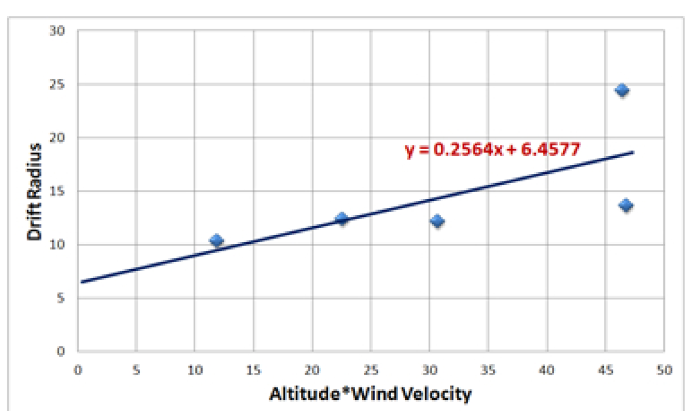


Payload Release Model

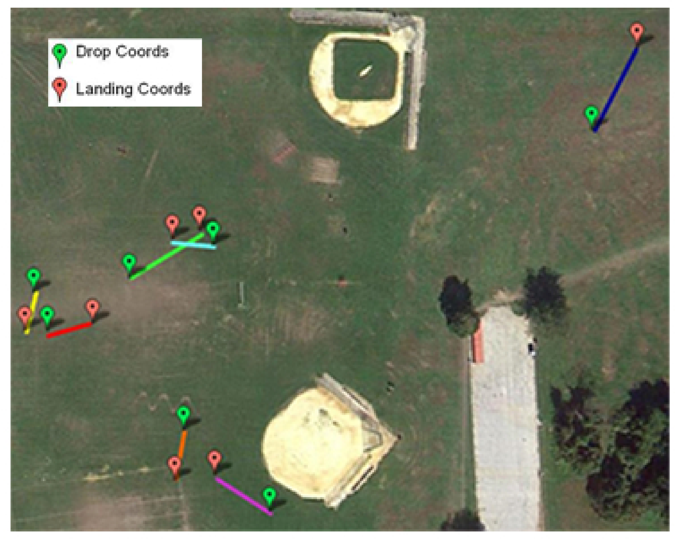
When deploying cargo from the plane, drift caused by wind carries the payload package away from the release location. Because we want our payload to land at a specific GPS location, a model was created to predict the drift based on wind data collected during the ascent. The plane then navigates to the release point that has the highest probability of resulting in an accurate landing.

As the plane ascends to its constant cruise altitude, it records wind speed and heading measurements to create a three-dimensional wind profile, shown below left. These measurements are then averaged to provide average north-south and east-west wind velocities.





The drop model uses altitude, the average wind speeds, and an experimentally determined drift constant, K, that incorporates parachute geometry and weight. In the above right graph, a linear relationship between drift and the product of altitude and wind speed is found as expected. Our experiments show an average K value of 0.2564.



Drop Color	Altitude (m)	NS Wind (m/s)	EW Wind (m/s)
Blue	21.25	-1.441	-0.0983
Yellow	22.33	-0.2256	-0.4812
Red	29.5	-0.5121	0.5686
Navy	35.51	-0.606	-1.1591
Orange	25.49	-1.1525	1.4288
Purple	32.78	No pitot	No pitot
Green	21.74	No pitot	No pitot

Conclusion

Key elements of our project can be implemented on larger scale UAV with only minor adjustments. The dynamics model simulates how the plane will react to an updated controls scheme, reducing the need for risky test flights. The controls scheme uses an appropriate combination of throttle and rudder control to maintain level flight and coordinated turns toward our drop location. Finally, the drop location model uses wind data collected during the ascent, parachute characteristics, and the physical release delay to determine when the payload release mechanism should be deployed. By changing only plane-specific parameters, these models can be used in real life UAV applications.