SYNERGY

Hampton Roads

Technical Journal Paper

9th Annual Student Unmanned Aerial Systems (SUAS) Competition

2012 AUVSI Student Competition

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Document Change History			
Item	**Date**	**Change**	**Comment**
1	3/1/2012	Initial Creation of Document	Document Baseline
2	3/14/2012	Insertion of Device Pictures	Capture pictures of devices
3	4/2/2012	Add Graphics and System Diagrams	Remove large pictures/images
4	5/5/2012	Document Team Content Review	Team Review
5	5/12/2012	Document Format Review	Change formatting
6	5/19/2012	Document Baseline	Final revision
7	6/3/2012	Document revisions added.	Updated content.

Abstract

The Synergy Hampton Roads team has focused on a systems engineering approach to provide an aircraft that is capable to perform basic flight operations for the 2012 Student UAS Competition. This is the first year for this team and it has selected a Commercial-Off-The-Shelf (COTS) aircraft that proved to be an effective choice for performing the mission as well as provide an economical choice for replacement in case of an accident or loss of the airframe and it's Inertial Navigation System (INS).

Introduction

This paper presents a technical overview of the Unmanned Aerial System (UAS) designed by Synergy Hampton Roads student team. The system meets the requirements for entry in the Association for Unmanned System International (AUVSI) Student UAS Competition held at the Naval Air Station Patuxent River, MD (Webster Field).

The Unmanned Aerial System consists of the Unmanned Aerial Vehicle (UAV) and Ground Control Station (GCS). The UAV is a radio controlled aircraft capable of manual flight and is equipped with the necessary sensors to perform automatic flight navigation using Global Positioning Satellite (GPS) communication. The GCS is a PC-based software program used to interface the operator with the UAV by providing real-time data from the aircraft sensors.

Systems Engineering Approach

Overview

Mission Objectives

The following mission objectives have been defined as some of the Key Performance Parameters listed in the Statement Of Work (SOW):

- The system shall be capable of autonomous flight.
- The system shall be capable to identify ground targets with the characteristics of shape, background and foreground color, and an alphanumeric symbol.
- The system shall provide the basic GPS coordinates of the targets found.
- The system shall complete its mission in less than 40 minutes time.
- The system shall be capable of safe operation and demonstrate safe procedures.

Avionics and Instrumentation

Overview

The Avionics and Instrumentation team was responsible for all electronic and software systems need for the unmanned aircraft. This included an autopilot, an inertial measurement unit (IMU), airspeed and altitude sensors, Global Positioning System (GPS), and telemetry radio system. These systems are outlined in the following sections.

Flight Control System

The autopilot is the core device of the unmanned system and in the source of all autonomous operations. This device is defines the UAV’s ability to perform in an autonomous mode by using the algorithms to interact with the on-board sensors. The autopilot polls all the right sensors for information about the status and orientation, makes any necessary control and navigation decisions, then adjusts the right control surfaces accordingly.

The GPS is an external sensor used for navigating to both static and dynamic waypoints. Static waypoints are pre-loaded onto the autopilot and are used to control to flight path of the UAV. Dynamic waypoints can be uploaded from the secured GCS to allow changes pre-authorized to alter pre-loaded missions.

The manual mode allows for an authorized pilot to take over and fly the aircraft when needed. The control system for flying the UAV in manual mode is made up a standard onboard control system made up of the following components:

Receiver

Responsible for receiving control input from the pilot’s transmitter to operate the servos on the aircraft as well as switch the autopilot between the manual and autonomous modes.

Battery

The flight battery pack is used to control the flight control system only. A lithium polymer (LiPo) battery pack was chosen to be separate from the other sensors for safety and to ensure complete flight operations of the aircraft were distinct from the sensors.

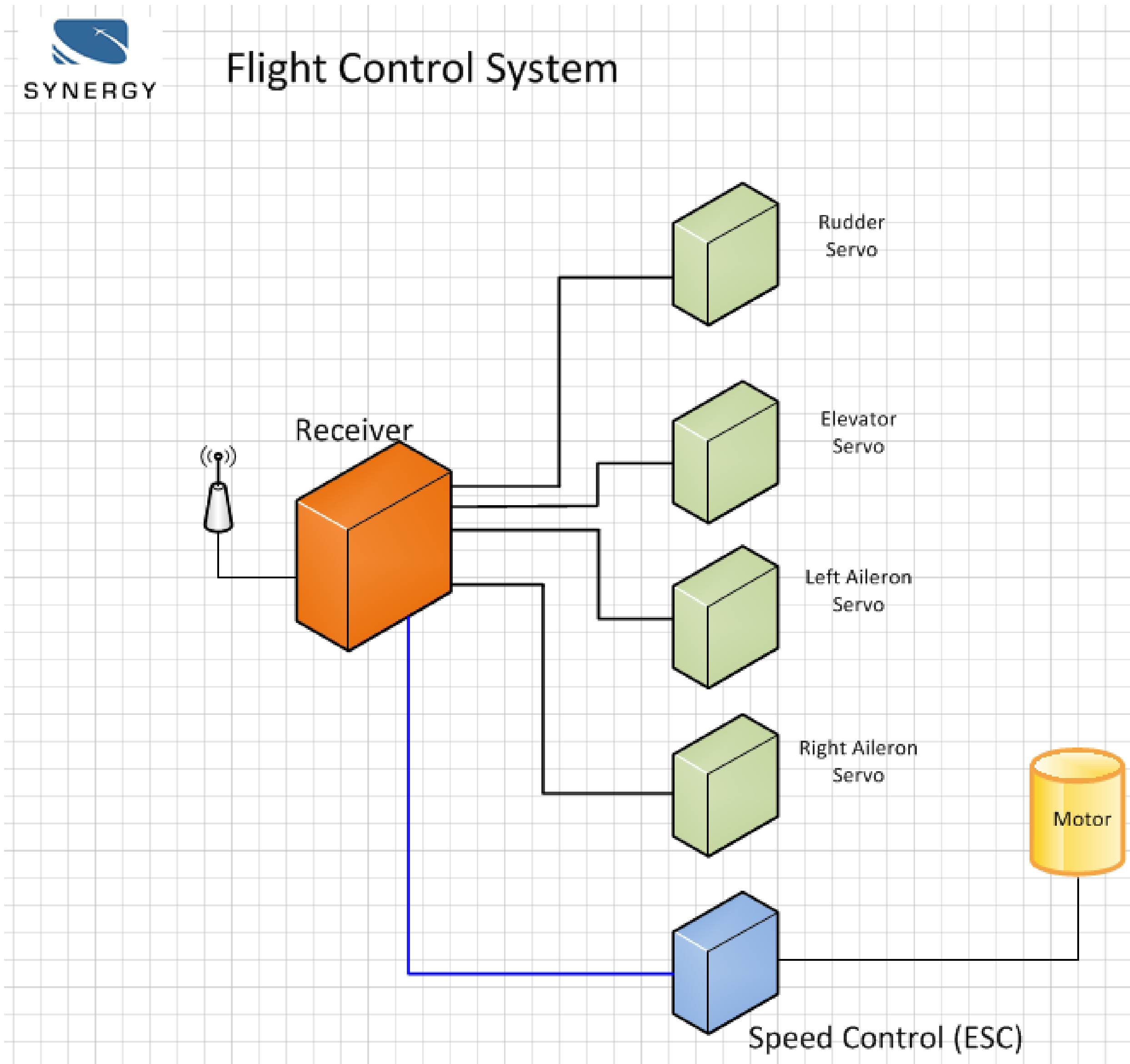
Servos

The servos are used to operate the control surfaces of the aircraft for all flight operations.

Electronic Speed Control (ESC)

The ESC is used to control the operation of the electric motor. This device operates to control the speed of the motor from input of the pilot in manual mode or from the autopilot in autonomous mode.

The following graphical representation shows the layout of the flight control system.

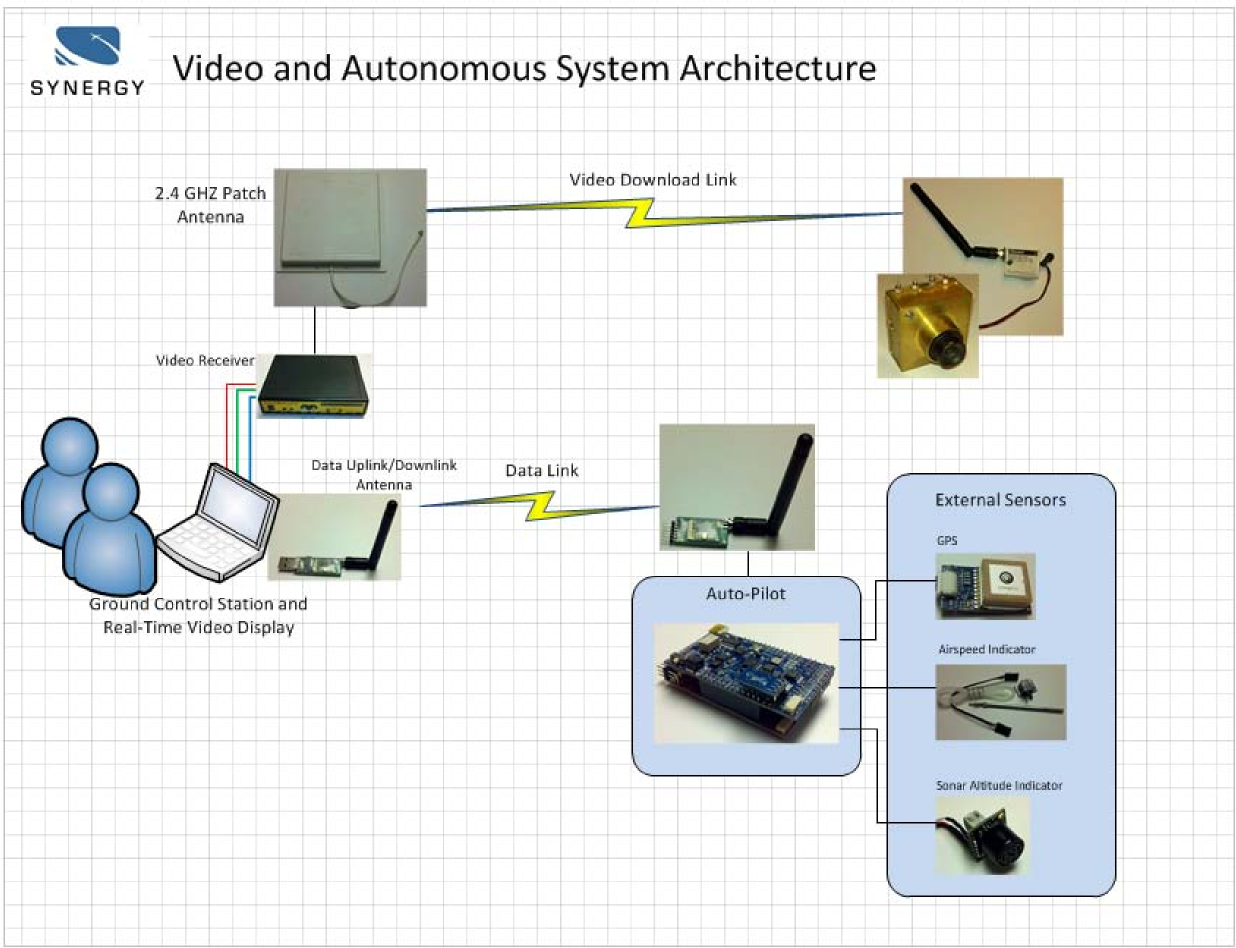


Video and Autonomous System Architecture

Overview

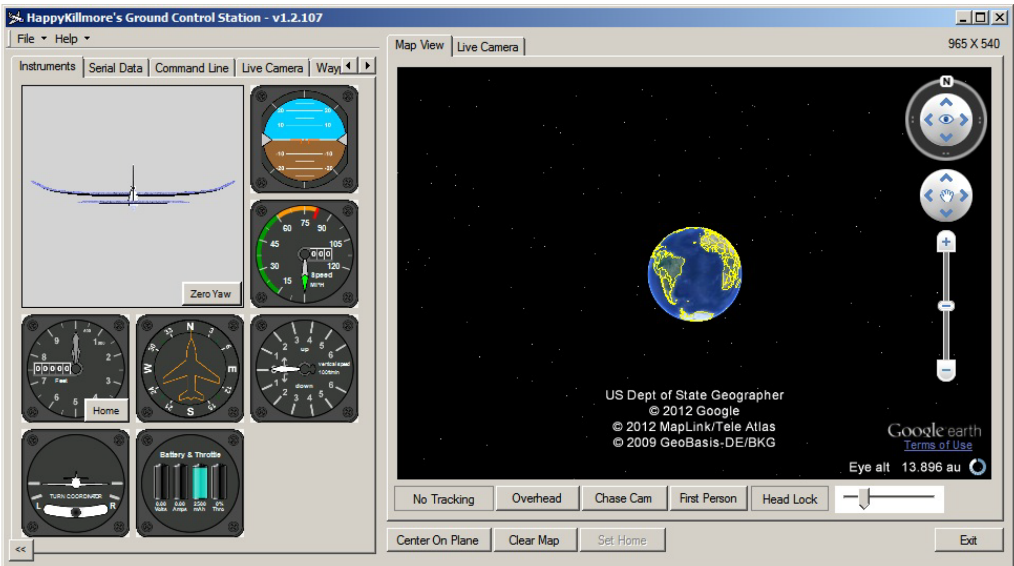
The system architecture is made up of many sub-systems including the flight sensors which are used to obtain information about the aircraft's state. This sensor information includes altitude, airspeed, pitch, roll, yaw, position and heading. This information allows for the creation of a total picture of the aircrafts state. With this picture control and navigation decisions can be made. The flight sensors defined below are global positioning, airspeed, barometric pressure, inertial measurement unit, and altitude using sonar. All of these sensors are required to make the autopilot function.

The following system component diagram show the integration of the flight sensors and the autopilot along with the data links to the Ground Control Station.



Ground Control Station

The following image is a screen shot of the Ground Control Station software. It is a digital dashboard with real-time avionic controls to allow a pilot to view the position as well as the attitude of the aircraft.



Aircraft

Airframe

Several airframes were reviewed and tested prior to selecting the Hobby Lobby Senior Telemaster for the competition platform. The following key performance parameters were defined and used to determine the selection of this aircraft.

Key Parameter	Value	Comment
Large Wing	95”	Needed to carry payload efficiently.
Flat bottom Airfoil	Clark Y	Needed high lift airfoil to carry extra weight while still maintaining slow speed
Wide Chord	12”	Increased wing area provides the ability to fly slow while carry on-board sensors
Large fuselage	Large box-type fuselage	Lightweight and sturdy construction provides ability to carry sensors and also allows for inexpensive repairs if needed.

Aircraft Specifications	
Wingspan	95”
Wing Area	1330 Sq Inches
Radio	4 Channel
Motor	60 size electric motor

Power System

The motor and battery packs were selected based on the manufacturer’s recommendations with regard to the weight of the aircraft and mission key performance parameters defined by the requirements of the mission objectives.

The initial test flights of the aircraft determined that a 50% throttle setting on the RC controller would provide more than enough thrust to keep the aircraft aloft when powered by a single, 6-cell LiPo battery that contains 5000 mAh

Motor

The motor selected is a brushless motor with the following specifications:

AXI Gold 4120/18 Outrunner motor

Motor Specifications	
Kv	515Kv
Motor Diameter	2”
Shaft Diameter	6mm
Voltage Range	18.5V – 25.9V
Max Amperage	77 Amps
Propeller Size	14 x 8

The motor is turning a 14x8 propeller to produce enough thrust to carry the weight requirements at a slow speed. A higher pitched propeller was used but caused the aircraft to fly too fast and the video was too difficult to view.

Batteries

The batteries are a Lithium Polymer (LiPo) type system. A total of six cells are needs to produce 22.2 volts of power using either 2 x 3-cell packs or a single 6 cell pack. Each pack produces a nominal voltage of 22.2 volts with a total 5000 mAh.

Mission Safety

The safety of the mission is key and it is the responsibility of all team members and is recognized during each phase of the mission. The pre-flight checklists were performed by the ground crew team to ensure the aircraft was airworthy. Once the checklist was completed, the pilot and the flight operations team were briefed on the status of the ground check results.

Flight safety checklists were performed by the pilot and co-pilot to ensure the fail-safe system was enabled and ready in case of a data link failure.

Flight operations performed their data and video link checks and informed all teams the aircraft was a “go for launch”. After the flight, the ground control team performed an aircraft inspection to ensure the integrity of the battery packs as well as the airframe and would perform maintenance if needed.

Flight Testing

The primary objective of the UAV’s first flight test was to demonstrate flightworthiness and flight
control. Pre-flight included balancing at the UAV’s location of the center of gravity (CG) and inspecting the structural integrity prior to takeoff.

The initial flight test was performed without the video subsystem which was tested on later flights. All team members were present with assigned roles to plan, pre-flight, fly, and perform post-flight operations. Safety checklists were used to ensure ground and flight operations were as safe as planned.