Document:	**Functional Analysis**
Project:	**Weather Balloon Altitude Control System**
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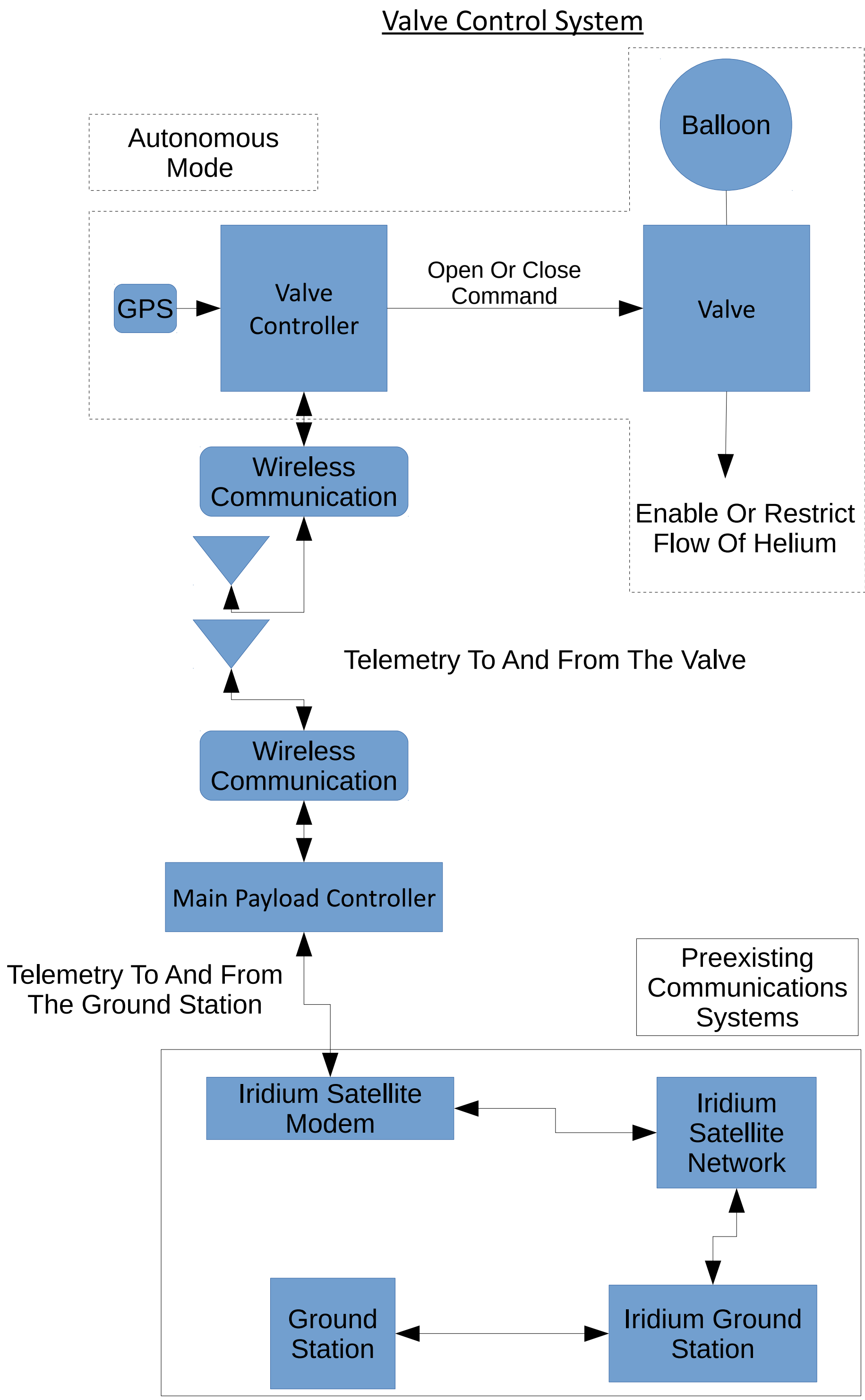
Date:	**9/15/2014**

Introduction

The following functional specification overviews the high level requirements of the valve control system. Very few if any technical details will be provided however the overall function of the system will be detailed. The functional specification starts with a black box model which describes what each individual subsystem does along with a high-level look at how the systems are connected together. The next section is functional specifications. The functional specifications provides a granular look at what each subsystem must do to accomplish the overall goal of the project. Each high level function is broken down into smaller sub functions as needed. Finally the design metrics for the project will be presented. The design metrics are the overall design goals that the end product will be weighed against to determine if the project was successful or not.

Black Box Model

This project consists of four main subsystems, the preexisting long range communication system, an Iridium satellite modem, a controller in the main payload to interface to the Iridium satellite modem, a controller up on the valve with a GPS unit, and the a valve to vent helium. Currently the MSGC BOREALIS program is using an Iridium satellite modem to communicate with the balloon payload other ballooning groups commonly use amateur radio DTMF. This project will entail designing a main payload controller that can interface to an existing communications system be that a satellite or amateur radio DTMF. This controller will then via a wireless connection communicate with a controller up on a valve closer to the balloon. This valve controller will then directly control a valve that is inserted into the neck of a balloon which will open and close enabling or restricting the flow of helium out of the balloon to achieve neutral buoyance. The valve controller will also have the functionality to operate autonomously, venting helium to achieve neutral buoyance at a preprogrammed attitude. It will do this be implementing an algorithm to interpret GPS data and determine when and for how long the valve should be opened to achieve the user selected altitude.


Valve Control System
Autonomous Mode
Balloon
GPS
Valve Controller
Open Or Close Command
Valve
Wireless Communication
Enable Or Restrict Flow Of Helium
Telemetry To And From The Valve
Wireless Communication
Main Payload Controller
Telemetry To And From The Ground Station
Preexisting Communications Systems
Iridium Satellite Modem
Iridium Satellite Network
Ground Station
Iridium Ground Station

Functional Specifications

The purpose of the valve system is to allow users of latex high altitude balloons to fly them at neutral buoyancy. This will be accomplished by venting a certain amount of helium out of the balloon during flight to affect the amount of lift produced by the displaced air. This will allow users to extend the duration of their flights, and allow them a degree of control in flight duration and altitude.

The electronics package will consist of two functional subsystems: a control subsystem and a valve subsystem. The control subsystem will reside within the main payload container that the end user supplies. The control subsystem is responsible for interfacing with the end user's tracking and command system (Iridium satellite modem, amateur radio, etc.) The interface protocol will need to be well documented for easy integration with the end user's existing payload. The interface will allow for remote control of the valve and its various functions. The control subsystem must wirelessly communicate with the valve subsystem. The control subsystem must have an endurance of 6 hours.

The valve subsystem interfaces directly with the valve mechanics and is responsible for actuating the valve as required. A wireless connection must be established between the control subsystem and the valve subsystem if required. The valve subsystem must also have a autonomous mode which works independently of the control subsystem if activated. The autonomous mode will use internal logic and various sensors to determine when to actuate the valve mechanics. In either mode the valve subsystem must be able to wirelessly send status updates and sensor readings to the control subsystem.

Specific design requirements for this project are as follows:

- The valve system will be required to have a sufficiently high flow rate to allow the user to bring the balloon to float (Neutral buoyancy) within 15 minutes of being open. Due to the ascent rate of the average high altitude balloon flight, the time window for venting is limited to a maximum of 15 minutes. If the vent time takes longer, the balloon may burst at high altitude due to excessive volume.
- The valve system will be required to achieve float at a pre-specified altitude to within a 10% degree of accuracy. This design requirement is aimed at making this product marketable to institutions that collect meteorological sounding data that will require altitude control that is acceptably accurate.
- The valve system will be required to operate inside the temperature range of -60 C to 40 C. This is the average operating temperature range from ground level to 100,000 ft.
- The valve system will be designed for use with 300 gram Kaymont brand balloons. Future designs may include a design that is compatible across other brands or sizes of balloons, but this project will be designed for a balloon commonly used for meteorological data collection.
- The total weight of the valve system cannot exceed 8 oz. The 300 gram balloons commonly lift a 2 lb. payload, and the addition of a valve system weighing more than 8 oz. becomes unreasonable compared to the average payload weight.
- Communication specification for interfacing the valve system with the end user's payload
    - The valve system is not required to control or track the end user's payload, however a data link protocol is provided to interface with the user's system if desired. The protocol specifies the method of communication the valve system expects from the external control system such as baud rate, serial protocol, timing, etc.

- Battery endurance of 6 hours
    - The complete valve system must operate for a minimum of 6 hours, however no particular power usage specification is required as long as the other functional specifications are still met (temperature range and weight would likely be most affected). The valve system design must determine how best to achieve this goal through efficiency of operation, battery capacity, DC/DC converter requirements, sleep states of the microprocessor, etc. The 6 hour requirement is based on the intended use of the end product.
- Cost per unit less than $100 for 100 units.
    - Due to the average cost of weather sounding packages, it would be unreasonable to expect a customer to pay more than $100 for the neutral buoyancy upgrade.
- The valve system will be required to provide flight termination for the balloon by venting a significant volume of Helium to cause the balloon to descend back to ground level.
- The valve will be required to have an in-line fill system that will allow the user to attach the balloon to the valve prior to fill, then inflate the balloon with Helium through the valve. This system will also require a fill station that will interface with the Helium tank regulator.
- This project will be required to be accomplished within 3 test flights and 1 demonstration flight due to budget and time requirements.

Design Metrics

The design metrics for the project are the most important project goals that must be met for the project to be a success. These specifications are the most important high level goals as they are the specifications given to the project group by the end user. If these design metrics are not met the end user will not only be displeased, they may proceed with another company's product.

The design metrics for the project are specified as follows:

- The valve mechanics must be simple to connect the latex weather balloon to and also hold onto the balloon so it does not disconnect in flight.
- The valve mechanics must allow for inline fill of the latex weather balloon.
    - Inline fill allows the end user to attach their latex weather balloons to the valve mechanics and then connect their helium supply to the valve. The valve system must not be cumbersome to connect or interface with.
- A float altitude between 30,000-60,000 feet within a 10% tolerance must be achievable with the system.
    - This altitude range encompasses the altitude regions in which the end user would typically utilize such a system, and an acceptable tolerance level at those altitudes.
- The valve must weigh no more than 1/2 pound.
    - If the valve system is heavier than that specified the end user will lose valuable payload weight for their experiments.
- The entire system must cost no more than $100 per unit in 100 unit quantities.

    - To be competitive or desirable with the intended market the entire valve system must not cost more than the cost of a typical weather balloon ($100).

- Up to three test flights and one final flight may be used to test the project design.