

ECE 4011/ECE 4012 Project Summary

Project Title	MITLL High Ball
Team Members (names and majors)	Mathew Manning (CmpE)
	Brandon Redder (EE)
	David Richardson (EE)
	David Sanchez (EE)
	Kristine Scott (EE)
	Kyle Watters (EE)
Advisor / Section	Morris Cohen, Witt Smith – A05
Semester	Summer 2018 – ECE 4011
Project Abstract (250-300 words)	<p>High Altitude Balloons (HABs) are primarily used for capturing aerial imagery, observing atmospheric conditions, and conducting test in near-space conditions. HABs are a low cost alternative to other high altitude vehicles such as drones, HABs with payloads under six pounds are lightly regulated in the United States, and operating an HAB requires less training than other unmanned aircraft suitable for aerial surveillance. The largest drawbacks to latex HABs are the limited flight times and lack of control over flight path. Normally during ascension the gas filling the balloon expands as atmospheric pressure drops causing the balloon to burst and ending the flight. The balloon's path is reliant on wind currents, and the flight time is limited by rate of ascension and the burst altitude of the system. Teams across the country have designed altitude control systems for HABs that alternatively release gas or ballast from the system to keep the balloon within operating altitudes, increasing flight duration. This project developed a method of controlling altitude with future goals of implementing a position control system. Future work will utilize wind speed and direction variation with altitude to allow the balloon to navigate to a specified location.</p> <p>The importance of directing the course of the HAB is tied to the intended use of the system. The project focused on designing an HAB system which will capture aerial images during and after natural disasters to help disaster relief teams track evolving situations. Current high altitude balloons are impractical for this purpose because they cannot remain over the target area for long enough, and high altitude planes or drones are cost prohibitive. The project has the potential to improve the effectiveness of disaster relief teams when they are needed most.</p>

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List codes and standards that significantly affect your project. Briefly describe how they influenced your design.	<p>Federal Codes (FAA Regulations)</p> <p>(Title 14 CFR 101.1) General Applicability This part prescribes rules governing the operation in the United States, of the following:</p> <p>4) Except as provided for in § 101.7, any unmanned free balloon that -</p> <ul style="list-style-type: none"> (i) Carries a payload package that weighs more than four pounds and has a weight/size ratio of more than three ounces per square inch on any surface of the package, determined by dividing the total weight in ounces of the payload package by the area in square inches of its smallest surface; (ii) Carries a payload package that weighs more than six pounds; (iii) Carries a payload, of two or more packages, that weighs more than 12 pounds; or (iv) Uses a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon. <p>(Title 14 CFR 101.33) Operating Limitations The balloon may not operate within: Class B, C, D, or E airspace, below 2,000 feet, clouds below 60,000 feet, above a populated area while below 1,000 feet, or in any manner which may cause hard to person(s) or property below.</p> <p>(Title 14 CFR 101.35) Equipment and Marking Requirements The balloon must be equipped with two independent cutdown systems, radar reflective devices (or surfaces which echo radar operating in the 200 MHz. to 2700 MHz. frequency range). The balloon must be cutdown should conditions drop below minimums specified in 14 CFR 101.33. The balloon must be equipped with lights which are visible for at least 5 miles and have a flashing frequency between (40 and 100 cycles per minute) to operate below 60,000 feet between sunset and sunrise.</p> <p>(Title 14 CFR 101.37) Notice Requirements Between 6 and 24 hours before launch, the balloon's operator must notify FAA ATC of balloon identification, estimated date/time of launch (+/- 30 minutes accuracy), location of launch site, cruising altitude, forecast trajectory, estimated time to cruising altitude, length and diameter of balloon, length of suspension device, weight of payload, duration of flight, forecast time and location of impact with surface of earth. FAA ATC must be notified of cancelation. FAA ATC must be notified immediately after launch.</p> <p>(Title 14 CFR 101.39) Balloon Position Reports The course of the balloon must be monitored with each position being recorded (at minimum) every 2 hours. Balloon position reports must forward to FAA ATC at request. One (1) hour before beginning descent the operator must notify FAA ATC of current geographic position, altitude, forecast time of penetration of 60,000 feet, forecast trajectory for balance of flight, forecast time and location of impact with surface of earth. If a balloon position report is not recorded for any 2 hour time period, the operator shall immediately notify FAA ATC with the last recorded position and any revisions to the forecast trajectory. Upon re-establishment of tracking FAA ATC shall be notified.</p>

	<p>FCC Regulations for Cell Phone and Amateur Radio Communications</p> <p>(Title 47 CFR 22.925) Prohibition on airborne operation of cellular telephones. Cellular telephones installed in or carried aboard airplanes, balloons or any other type of aircraft must not be operated while such aircraft are airborne (not touching the ground). When any aircraft leaves the ground, all cellular telephones on board that aircraft must be turned off. The following notice must be posted on or near each cellular telephone installed in any aircraft:</p> <p>“The use of cellular telephones while this aircraft is airborne is prohibited by FCC rules, and the violation of this rule could result in suspension of service and/or a fine. The use of cellular telephones while this aircraft is on the ground is subject to FAA regulations.”</p> <p>(Title 47 CFR 97.113) Prohibited transmissions</p> <p>(a) No amateur station shall transmit</p> <ul style="list-style-type: none">(2) Communications for hire or for material compensation, direct or indirect, paid or promised, except as otherwise provided in these rules; <p>Page 4</p> <ul style="list-style-type: none">(3) Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer.(5) Communications, on a regular basis, which could reasonably be furnished alternatively through other radio services <p>Design Implications</p> <p>FAA regulations constrained the weight and weight per square inch of the design, and FCC regulations limited the form of communication. Assuming the altitude control system is functional and no hardware problems occur, a flight will be terminated when the battery dies or all of the ballast is used. The regulations relating to weight limit the size of the battery and the amount of ballast that can be used, which limit the maximum flight time. Our system will prioritize ballast over battery weight since the position control will use ballast more often than pure altitude control systems. The limits on the weight per square inch affect the shape of the system, eliminating any structure with a thin profile, increasing the internal volume. The larger volume is harder to heat, so our design will section off areas of the frame containing components sensitive to temperature, humidity, and shock. Communication between the balloon and the ground station is already limited by the distance and possible interference in the atmosphere, so regulations against cellular channels at high altitudes and amateur radio for commercial uses lead the team to utilizing satellite communications.</p>
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<p>List at least two significant realistic design constraints that applied to your project. Briefly describe how they affected your design.</p>	<ol style="list-style-type: none"> 1. The payload must weigh less than 6 lbs. This has to be considered when choosing the materials for the structure, and the hardware used in the payload. The weight of the ballast and battery will directly limit the maximum flight duration. 2. Battery must last for the duration of the flight. The size of the battery and the power consumption of the electronics must be taken into consideration because the weight of the battery must be as small as possible. 3. The system must be reliable at altitudes up to 100,000 feet. At this altitude the pressure is 0.162 PSI and the temperature can fall as low as -57 °C. To overcome these limitations our design utilizes an insulated frame, heating elements, and components rated for low temperature conditions.
<p>Briefly explain two significant trade-offs considered in your design, including options considered and the solution chosen.</p>	<p>Ballast weight and battery. Both are necessary for long flights but since weight is important there must be a good balance between the two. Battery must be efficiently used so that a larger battery is not needed.</p> <p>Insulation/waterproofing and weight. The payload has to have some kind of insulation and waterproofing to protect from cold temperatures and water damage but that would make the payload heavier. A styrofoam cooler seems like a good option to use.</p>
<p>Briefly describe the computing aspects of your projects, specifically identifying hardware-software tradeoffs, interfaces, and/or interactions.</p> <p><i>Complete if applicable; required if team includes CmpE majors.</i></p>	<p>Our project required extensively developed software to ensure proper automation of altitude control, communication between ground station and balloon, and proper operation of onboard equipment. Any missed edge case in any of the three categories could lead to a catastrophic failure. Due to the nature of buying off the shelf products, our team had to mesh the pre-existing subsystem frameworks in order to achieve our goal of an operational localized automated high altitude balloon.</p>

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<p>Leadership Roles (ECE4011 & Forecasted for ECE4012) (NOTE: ECE4012 requires definition of additional leadership roles including:</p> <ol style="list-style-type: none"> 1. Webmaster 2. Expo coordinator 3. Documentation 	<p>Mathew Manning</p> <ul style="list-style-type: none"> • Safety Officer <p>Brandon Redder</p> <ul style="list-style-type: none"> • Webmaster, and Hardware Assembly Lead <p>David Richardson</p> <ul style="list-style-type: none"> • Team Leader, and Expo Coordinator <p>David Sanchez</p> <ul style="list-style-type: none"> • Transportation and Cutdown System Lead <p>Kristine Scott</p> <ul style="list-style-type: none"> • Documentation Coordinator, Sensor Integration Lead <p>Kyle Watters</p> <ul style="list-style-type: none"> • Simulation and Communication Systems Lead
<p>International Program: Global Issues (Less than one page) (Only teams with one or more International Program participants need to complete this section)</p>	Not Applicable