High Altitude Imaging Platform Testing and Integration

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Abstract

The High Altitude Imaging Platform (HAIP) began as a University of Texas student design project whose goal was to create a useful payload for the Fredericksburg High School Rocket. After several unsuccessful launches attempted by Fredericksburg High School, the project transferred to the supervision of Applied Research Laboratories (ARL) at the University of Texas at Austin. ARL proposed that an imaging platform launched via amateur rockets could be used for drug interdiction and disaster relief. Previous work on this project has included the system design, material acquisition, ejection testing, and payload design. The resulting flight profile will be as follows: a Montgolfier balloon will inflate upon ejection from the rocket, heating as it falls until it reaches neutral buoyancy and will hold the payload, a self-contained video transmission system with a GPS receiver and associated electrical components, at a high altitude. After the objective has been met, a small drogue chute will return the canister and balloon safely to ground. Initech Consulting has been contracted by ARL to construct, test, and integrate the payload package for the HAIP project. During the Spring 2002 semester, Initech realized six key goals. Initech rebuilt the payload canister with structural integrity, vibration isolation, airtight sealing, and temperature control in mind. A rigid mounting structure for the internal electrical components was also built to provide protection for the avionics equipment. Furthermore, Initech conducted payload ejection tests, determining the amount of charge required to safety push out the HAIP from the rocket. The drogue chute was redesigned and remade. Both neutral buoyancy tests of the Montgolfier balloon and range testing of the transmitter were attempted. Some suggestions are made to future groups to encourage success. A complete flight test of the HAIP project is scheduled for the summer of 2002.
Acknowledgements

Initech would like to acknowledge the people involved with the High Altitude Imaging Platform (HAIP) project. Dr. Martin Barlett of Applied Research Laboratories has provided sponsorship and guidance for the project. Danny Linehan imparted his knowledge of airtight sealing and rocket ejections. Daniel Parcher has also been extremely valuable in helping Initech accomplish this semester’s goals. The above-mentioned employees of ARL were also gracious enough to offer their time for meetings and for testing. Initech would also like to recognize Rick VanVoorhis, he was the rocket specialist for the summer launch and regularly offered the team his erudition on a wide array of issues. Of course, we would like to show appreciation to Dr. Ronald Stearman, our ASE 463Q professor, as well as Dr. Jennifer Lehman and Lixin Gong for their time and patience.
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1.0 Introduction

1.1 Project Overview

The University of Texas at Austin’s Applied Research Labs (ARL) has selected Initech Consulting to design, test and integrate the High Altitude Imaging Platform (HAIP) into their rocket. The HAIP payload consists of a drogue chute, a Montgolfier balloon, and an avionics canister. The avionics canister contains a camera, a GPS receiver, an accelerometer, a transmitter, and batteries. ARL is expecting to launch the rocket in the summer of 2002.

1.2 Project History

The current project stems from a joint project between University of Texas at Austin and Fredericksburg High School. The Fredericksburg High School started creating large sounding rockets in 1996. In 1999, the Fredericksburg High School Aeronautics instructor, Brett Williams, contacted the University of Texas at Austin’s Department of Aerospace Engineering and Engineering Mechanics (ASE-EM). Mr. Williams wanted the ASE-EM department to develop a payload for the sounding rocket. The HAIP payload was developed in summer of 2000 for that particular application. However, the HAIP payload was not able to fly on the rocket due to problems involving reliability of the rocket, and the UT-Fredericksburg High School collaboration ended.

In the fall of 2000, ARL decided to investigate the use of a rocket-launched telecommunications platform suspended on a balloon. This system has some unique advantages over other platforms for applications in drug interdiction. Sponsorship for the
HAIP then shifted to ARL in 2001, and consequently the research began to focus on the development and testing of the HAIP payload.

Previous design groups in the ASE 463Q class have completed limited analysis of various ejection systems, selected and bought instruments for the avionics canisters, constructed a canister for the avionics, and tested different aspects of the HAIP payload deployment. The SABER and the LOST group investigated mechanical, pneumatic, and pyrotechnic systems to eject the payload from the rocket. Throughout the semesters, many components have been researched, purchased, and used. The canister housing the avionics was redesigned by LOST, but never built. The SOL group tested the drogue chute deployment and Montgolfier balloon inflation. The LOST group tested the pyrotechnic ejection system. [Mauldin, 2001]

1.3 Rocket Flight Profile

The figure below shows the flight profile of ARL’s rocket.

Figure 1: Flight Profile of the Rocket-Balloon Project
The rocket ejects the payload at its apogee, which is expected to be approximately 8000 ft. The rocket then falls and deploys its parachute 400 feet above the ground to minimize distance traveled to retrieve the rocket. The payload continues falling until the drogue chute exerts enough force to deploy the Montgolfier balloon. The Montgolfier balloon automatically inflates. The balloon starts collecting heat from the sun and heats the air inside the balloon, causing buoyant lift. At the completion of the mission, a timer in the avionics canister severs the connection to the balloon, causing the whole system to return to earth.

1.4 Team Goals

The five major goals of Initech Consulting are:

1) Design a method to eject payload from rocket
2) Make the HAIP package ready for flight
3) Determine optimal size for drogue chute
4) Predict the behavior of the balloon after deployment
5) Design a structure to house all electronic components

1. A system to eject the payload from the balloon needs to be developed. This system needs to be safe and reliable. Different ejection systems must be compared to find the ejection system best suited for the job. A theoretical model of the ejection must be developed and tested.

2. According to the rocket flight profile, the rocket is supposed to deploy the payload at 5000 ft (or roughly a mile). This means that the HAIP payload must transmit images over a minimum distance of 1 mile to a ground station. The current wireless camera system is designed for a 5-mile transmission range, although the system has not
been successfully tested over this range. A triggering mechanism needs to be designed to activate the payload after it ejects from the rocket. A timed mechanism needs to be designed to sever connections between the avionics canister and the Montgolfier balloon.  

3. The drogue chute designed by the SOL group was too big. During the balloon deployment test conducted by SOL group, the enormous weight of this chute caused the Montgolfier balloon to fall to the ground sideways. The LOST group discovered that the drogue chute half the current size could easily deploy the balloon. Minimizing the size of the drogue chute will also minimize the tilt of the Montgolfier balloon. Minimizing the tilt of the Montgolfier balloon will decrease the amount of heated air escaped and therefore increase the performance of the balloon. However, if the drogue chute is too small, it will fail to deploy the Montgolfier balloon. Therefore the drogue chute needs to be properly sized.  

4. Another major goal of Initech is to predict the behavior of the Montgolfier balloon after deployment. Inflating the balloon on the ground and allowing the sun to heat the balloon will test the buoyant properties of the balloon. Initech will also model ARL’s summer rocket test using computer programs written by SOL. [Gist 2001]  

5. Finally, the electronic components are expected to experience roughly 12g accelerations. The equipment needs to be mounted properly to withstand these accelerations. The Avionics canister also needs to be sealed and purged with nitrogen to avoid fogging of the camera lens.
1.5 Team Structure

Initech Consulting’s team structure is shown in the figure below. Dr. Stearman and the ARL group provide team oversight. The ARL group consists of Dr. Martin Barlett, Danny Linehan, Daniel Parcher, and Rick Van Voorhis. Apoorva Bhopale, team leader of Initech, was responsible for communicating with the sponsors of the project. Initech Consulting is divided into 5 sub-teams, to accomplish each of the major goals of the project.

1.5.1 Payload Ejection

The payload ejection team is led by Initech Consulting’s team leader Apoorva Bhopale and supported by Rob Wingo. This group has the responsibility of determining the proper amount of black powder to use to eject the HAIP payload out of the rocket.
1.5.2 Electronics Testing

The electronics testing team is led by Initech Consulting’s systems engineer Rob Wingo and supported by Apoorva Bhopale. This team has the responsibility of determining the range of the video transmitter and testing the performance of all electronic equipment. The team also will be responsible for designing the mechanism to cut the cords between the Montgolfier balloon and the avionics canister.

1.5.3 Drogue Chute Sizing

The Drogue Chute sizing team is led by Initech’s Consulting’s Aerodynamics Engineer, Brian Love and supported by Susan Schmidt. This team has the responsibility of determining the optimal size of the Drogue Chute.

1.5.4 Montgolfier Balloon

The Montgolfier balloon team is lead by Brian Love and supported by Apoorva Bhopale. This team will be responsible for conducting the neutral buoyancy test and to model the balloon deployment using computer programs written by the SOL team and verify the results with analytical calculations.

1.5.5 Payload Structural Design

The payload structure team is led by Initech Consulting’s structural engineer Susan Schmidt and supported by Brian Love. This team has the responsibility of designing the interior structure of the avionics canister. This structure should be able to survive a 12g loading and be completely sealed from the outside atmosphere.
1.6 Schedule

The schedule for this semester’s work is shown below.

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Project Assignment</td>
<td>Fri 1/25/02</td>
<td>Fri 1/25/02</td>
</tr>
<tr>
<td>2  Background Project Research</td>
<td>Mon 1/28/02</td>
<td>Fri 2/8/02</td>
</tr>
<tr>
<td>3  Meeting with Sponsors</td>
<td>Thu 2/7/02</td>
<td>Thu 2/7/02</td>
</tr>
<tr>
<td>4  Research and Development</td>
<td>Fri 2/8/02</td>
<td>Fri 3/1/02</td>
</tr>
<tr>
<td>5  Electronics Testing</td>
<td>Mon 3/11/02</td>
<td>Fri 3/15/02</td>
</tr>
<tr>
<td>6  Range Test</td>
<td>Sun 3/3/02</td>
<td>Sun 3/3/02</td>
</tr>
<tr>
<td>7  Midterm Presentation</td>
<td>Wed 3/8/02</td>
<td>Wed 3/8/02</td>
</tr>
<tr>
<td>8  Midterm Report</td>
<td>Fri 3/8/02</td>
<td>Fri 3/8/02</td>
</tr>
<tr>
<td>9  Spring Break</td>
<td>Mon 3/11/02</td>
<td>Fri 3/15/02</td>
</tr>
<tr>
<td>10 Canister Design</td>
<td>Mon 3/18/02</td>
<td>Fri 3/22/02</td>
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<td>11  More Range Tests</td>
<td>Fri 3/22/02</td>
<td>Mon 4/1/02</td>
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<tr>
<td>12  Buoyancy Test</td>
<td>Fri 3/29/02</td>
<td>Fri 4/5/02</td>
</tr>
<tr>
<td>13  APL Facilities Not Available</td>
<td>Mon 4/15/02</td>
<td>Wed 5/1/02</td>
</tr>
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<td>14  Final Presentation</td>
<td>Wed 5/1/02</td>
<td>Wed 5/1/02</td>
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<tr>
<td>15  Final Paper</td>
<td>Fri 5/3/02</td>
<td>Fri 5/3/02</td>
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</table>

Figure 3: Schedule