Comments [AB1]: Overall pretty good. A few big things that stick out to me: I still don’t see the point in the 3D imaging (other than just to do it), but I like that you’ve come up with another, albeit unrelated experiment to do. In future documents, consider doing a spelling & grammar check. Regardless of the point, I’m excited to see how your video turns out!
I. **Overview and Mission Statement**

1.1 **Mission Statement**

Team Overbuilt and Underpaid intends to design, build, test, and launch a BalloonSat which will weigh under 800 grams and reach an altitude of 30 kilometers as part of the Colorado Space Grant student experience through the CU Boulder course ASEN 1400 (Gateway to Space). The project, Project Magnificence, will aim to take data on the Earth’s magnetic field using two magnetometers to compare measurements and increase accuracy, in order to better understand how the strength of magnetic currents increase with altitude/distance from launch point. Project Magnificence will also take three dimensional imaging in a near space environment using two GoPro cameras; these images will capture not only the main balloon burst, but also the fall back to the ground in order to clearly observe the process of descent.

1.2 **Mission Overview**

The space industry is exploding like never before, expected it to become an almost three trillion dollar industry within thirty years through the rise of privatized companies and an increased interest in the industry. A crucial aspect of the space industry are satellites, which are mainly used to observe the current condition of the Earth. Captivating three dimensional images is a way to give the young population a taste of near-space flight, and evoke thoughts about what the space industry has to offer. Team Overbuilt and Underpaid hopes to bring the realistic images of near-space down to Earth in order to educate young students about the edge of the atmosphere and show them what they have the potential to participate in.

Furthermore, Team Overbuilt and Underpaid will take magnetic field readings in order to study the Earth's magnetosphere. The magnetosphere is vital to today's society and life on Earth, as the magnetosphere protects the Earth from charged solar particles. Geologic data have hinted that the magnetosphere may be weakening and a polarity shift is possible in the future. In addition, there is a theory that fluxes in the magnetosphere have prompted periods of advanced rates of evolution. Geologic samples from the Atlantic tectonic plate have shown that the polarity of Earth's magnetic field has switched, with corresponding periods of higher solar radiation, theoretically prompting higher rates of evolutionary changes. Because of this, studying and understanding the state of the magnetosphere could lead to highly advanced scientific discoveries.

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Commented [AB2]: I liked this for the most part. There were a couple silly mistakes that could have been caught with a quick once-over but overall pretty good. Your overview read more like a business pitch in parts, but it did give a solid WHY, so I didn't take off points.

Commented [AB3]: This is good. Nice and concise.

Commented [AB4]: …decrease?

Commented [AB5]: Three-dimensional

Commented [AB6]: I think this might be a stretch

Commented [AB7]: Grammar

Commented [AB8]: …
Project Magnificence

Project Magnificence is aimed at educating people about the scientific method and human innovation in space. This mission is incredibly important, especially at a time when people are questioning scientific results.

1.3 Hypothesis
The team expects the magnetic field to weaken as the BalloonSat gains elevation due to the fact that magnetic field strength dissipates at farther distances from the magnetic body. This relationship can be described by the following equation, where \( r \) is the distance from the magnetic body and \( A \) is the magnetic field strength.

\[
A(r) = \frac{\mu_0}{4\pi} \frac{m \times \hat{r}}{r^2}
\]

II. Technical Overview

2.1 Design Summary
The data from the magnetometers will be used in conjunction with data from the pressure sensor to model the way the strength of Earth’s magnetic field changes with altitude. The images from the dual GoPro cameras will be colored and overlaid to create an image that can be viewed with 3D glasses. With the 94 degree vertical field of view on the camera, positioning the BalloonSat ~6m below the balloon will provide an ideal shot of the pop. This will require frame sync software to keep the GoPros firing simultaneously.

Commented [AB9]: I would have liked a little more here to sell me on how you’re going to do all of this. Your summary and testing sections (discussed below) are what cost you the bulk of your points for this section.
2.2 Structure
The BalloonSat will be built as a cuboid shape with length and width of .17 m, and height of .075 m. The satellite will be made of .01 m thick foam core and strengthened by aluminum tape and hot glue. There will be a cylindrical hole through the top and bottom of the BalloonSat that allows it to hook up to the flight string and balloon. Two Arduino Unos are used as commanding units and sit vertically on the left side of the box. The Arduino without the shield will be connected to the magnetometers, and the one with the shield will run the various sensors provided to the team. Two GoPro cameras will be mounted in the top-back corners of the structure. There will also be a heater and four 2 Ah Lithium Ion batteries to power the BalloonSat.

2.3 Special features
The camera lenses are 112mm apart which is just shy of twice the average human interpupillary distance. This should exaggerate the 3D effect beyond what a person attached to the balloon would perceive. This is important since the goal is to capture a bursting balloon that is roughly 30.5 meters across and over 30.5 meters away. Multiple accelerometers set to detect different short ranges of magnetic flux will be more accurate than one accelerometer set to detect a larger range of magnetic flux.

2.4 Hardware
Below is a list of necessary hardware and where it can be purchased.
- The MAG3110 Triple Axis Magnetometer by SparkFun can be purchased on their website for $14.95. It takes 1.95-3.6 V and has a range of -10 to 10 Gauss with accuracy up to 0.001G. The data outputs at up to 80 Hz.
  https://www.sparkfun.com/products/12670
- The 9DoF Sensor Stick by SparkFun can be purchased on their website for $14.95. The 3 axis accelerometer has a range of -16 to 16 g. The 3 axis magnetometer has a range of -16 to 16 Gauss. The 3 axis gyroscope has a range of -2000 to 2000 degrees per second. All of these ranges can be dialed down for increased accuracy. This chip takes 3.3 volts.
  https://www.sparkfun.com/products/13944
The documentation on these sensors includes instructions on how to breadboard them and interpret the signals they send to the Arduino.
- Four 2 Ah Lithium Ion batteries will power the satellite. These can be found on SparkFun’s website for $12.95. Each cell outputs 3.7V at 2Ah and has an operating temperature of -25 to 60C. They weigh in at 36 grams a piece.
  https://www.sparkfun.com/products/13855

2.5 Functional Block Diagram
The functional block diagram depicts the organizational flow of the three separate BalloonSat subsystems. Components include the temperature control subsystem, consisting of a heater and led indicator; the atmospheric instrument suite, consisting of a humidity sensor, pressure sensor, accelerometer, and a temperature sensor; the scientific data collection subsystem,
consisting of two separate magnetometers; and the 3D imaging subsystem, consisting of two self contained GoPros.

2.6 Testing
To ensure that the structure can handle challenges of near-space and protect the components within, the BalloonSat will be subjected testing to guarantee the BalloonSat operates as expected upon launch and that all team members, staff, spectators, and the environment are safe. The testing includes the Whip Test, Drop/Stair Test, Temperature Test, Mission Simulation Test, and Camera and Sensor Test.

Whip Test: The whip test simulates the violent acceleration due to free fall that the BalloonSat will face after burst. This test challenges the BalloonSat’s structure without damaging the inner components. For this test, the BalloonSat will be fixed to a length of rope, similar to the tether to be used on launch day, and will be spun at high speeds. This experiment will be performed in a secluded, but open space to avoid damaging any buildings or windows and not impede on any passing spectators.

Drop/Stair Test: On decent, the BalloonSat will experience extremely high velocities and ultimately a harsh landing, it must be proven that the structure can adequately protect the internal components so that data can be retrieved after landing. This test involves dropping the BalloonSat from the ITLL Bridge and tossing it down multiple flights of stairs. This test will be conducted with caution of and courtesy for passing students and staff.

Temperature Test: The near space environment can dip down to temperature below -80°C. Therefore, this test will expose the BalloonSat to these extreme temperatures to ensure that it can adequately maintain the internal temperature within the working range of all sensor and instruments. This test involves placing the BalloonSat in an insulated box with dry ice for 90 minutes. This test will be conducted with the proper safety equipment and in the correct testing environment.

Commented [AB13]: How will you prove this?
Commented [AB14]: What does this mean in terms of degrees? Quantification is important here
Mission Simulation Test: The scientific data collection instruments must be tested to ensure that they will operate correctly and measure the magnetic field strength as altitude increases. This means that the magnetometers will be subject to magnetic fields of known strength to test their data collection.

Camera and Sensor Test: The suite of sensors must be tested to ensure that they can handle the challenges of this flight and will collect accurate data for analysis. Each sensor will be tested individually to verify its functionality. Further, the 3D imaging system will be tested to ensure that the frames on each camera are taken in sync and that the data collected can then be compiled into a 3D image. To test this, the cameras will be placed into the BalloonSat and will record a balloon popping to simulate burst.

2.7 Safety
Team Overbuilt and Underpaid will ensure that all safety precautions are taken and will prioritize safe BalloonSat testing for both bystanders and team members. The team will perform all testing a safe distance away from others and windows. All safety guidelines will be followed when using equipment such as soldering irons, drills and saws. All members will act responsibly and professionally throughout the entire project, conducting themselves with respect for others, the equipment, and the workspace.

2.8 Data Retrieval
The data gather from the atmospheric sensors, 3D imaging equipment, and both magnetometers will be written onto 4 separate 2GB SD cards: one from the atmospheric sensor suite, one for both magnetometers, and one for each GoPro. After retrieval, this data will be analyzed and cataloged. The pressure and magnetometer data will be compiled to display the variation in magnetic field strength as the balloon ascended and descended. The humidity and temperature data will be organized to display the weather data on launch day and the internal BalloonSat temperature. The accelerometer data will be used to display the stability throughout flight, and the GoPro image data will be compiled to create 3D images from the flight using the 3D system in the GoPro Studio Program.

2.9 General Mission Requirements
In addition to the sensors provided to the team, the BalloonSat design includes two additional experiments: collecting magnetic field data, and the attempt at 3D imaging. The magnetometer is the additional sensor that will serve to collect the former set of data. The structure will be built to ensure the BalloonSat is able to complete additional flights, and the inclusion of the flight string interface is referred to in section 2.2 (Structure), as well as the use of foam core for the exterior and the protection of all switches and wires within the foam core. Temperature testing and the incorporation of the heater kit will ensure that the internal temperature remains above -10°C during the flight. The total weight is below the requirement of 800 grams. The two Arduinos are incorporated into the design as well as the provided external temperature sensor. Two GoPros are being flown to capture 3D images. The budget includes cost of spare parts and all hardware will be returned at the end of the course. The payload includes no living organisms, and the power system includes Li Ion batteries rather than 9V batteries. Visual indicators and LEDs from the shield are included in the BalloonSat and in the diagram.
### Management and Cost Overview

#### 3.1 Schedule

Below is a detailed schedule that covers course requirements and a BalloonSat construction timeline.

<table>
<thead>
<tr>
<th>Week</th>
<th>Schedule</th>
</tr>
</thead>
</table>
| **Week 1 2/4 - 2/10** | - Wire and solder breadboard and Arduinos.  
- Hands-on Arduino II and III.  
- Conceptual Design Review completion and presentation.  
- Finalize proposal for submission.  
- Begin structural construction |
| **Week 2 2/11 - 2/17** | - Complete homework 6 (due 2/15)  
- Complete Authority to Proceed Meeting with Chris  
- Order hardware: GoPros, magnetometer 1, magnetometer 2, lithium ion batteries,  
- Complete Structure Construction: foam core exo-structure assembled and ready for component integration  
- Complete heater subsystem construction |
| **Week 3 2/18 - 2/24** | - Complete and submit homework 8 (due 2/22)  
- Begin hardware assembly: atmospheric instrument hardware integration (power supply, data storage)  
- Begin structural testing: conduct kick test, drop test, whip test and collect data on necessary improvements  
- Begin subsystem programing: GoPro 3D imaging programing and image processing system, atmospheric data collection programing, scientific experiment data collection programing |
| **Week 4 2/25 - 3/3** | - Complete and submit homework 7 (due 3/1)  
- Begin Preliminary Design Review (due 3/6)  
- Test 3D imaging system: ensure the system can collect data and that all data processing programs are operational  
- Test scientific data collection system: ensure that both magnetometers accurately collect and store data |
| **Week 5 3/4 - 3/10** | - Complete and submit Preliminary Design Review (due 3/6)  
- Complete and submit DD Rev A/B (due 3/8)  
- Start DD Rev C (due 4/5)  
- Start Mid-Semester Team Evaluations (due 3/15)  
- Complete hardware setup and start subsystems integration to the structure |
| **Week 6 3/11 - 3/17** | - Complete and submit Mid-Semester Team Evaluations (due 3/15)  
- Complete and submit Service Approval (due 3/20)  
- Complete BalloonSat temperature testing with integrated subsystems |

*Commented [AB18]: This section was well done.*
Week 3/18 - 3/24
- Complete and submit homework 9 (due 3/22)
- Start RFF Cards (due 4/6)
- Final BalloonSat structural testing with all systems
- Complete all BalloonSat systems: final BalloonSat ready for launch

Week 8 3/25 - 3/31
- Prepare for Launch Readiness Review
- Maintain group communication
- Enjoy academic break

Week 9 4/1 - 4/7
- Complete and submit Launch Readiness Review (due 4/3)
- Complete and submit DD Rev C (1st draft due 4/5)
- Complete and submit RFF Cards (due 4/6)
- Final BalloonSat Weigh-In and Turn-In (due 4/6)

Week 10 4/8 - 4/14
- Start DD Rev D (due 4/28)
- Complete and submit Quick-Look Post Launch Presentation (due 4/12)

Week 11 4/15 - 4/21
- Prepare for design exposition (4/28)

Week 12 4/22 - 4/28
- Complete Design Exposition (4/28)
- Start Final Presentation (due 5/1)

Week 13 4/29 - 5/5
- Complete and submit Final Presentation (due 5/1)
- Complete and submit Final Team Evaluations (due 5/3)
- Complete and submit homework 10 (due 5/3)

Week 14 5/6 - 5/12
- Complete and submit Final DD Rev D (due 5/7)
- Complete and submit Community Service Activity Presentation (due 5/7)

3.2 Team Management
Responsibility Breakdown
Responsibilities have been broken down into four major subgroups, which are as follows:
Everyone is involved in at least two subgroups, excluding the Team Leader, whose primary responsibility is leading the team and therefore serves in only one other subgroup (Project Management).

3.3 Team Member Info
Name, followed by contact info and skills:
Kristina Dyson
Skills: public speaking, team management, conflict resolution
Ethan Burkley
Skills: meeting deadlines, planning, adaptability
Bailey Vigil
Skills: time management, problem solving, collaboration
Max Morgan
Skills: programming, prioritization, calm under pressure
Leah Selman
Skills: technical writing, attention to detail, analysis
Ben Gavin
Skills: CAD, electronics, critical thinking
Bob Loftis
Skills: budgeting, planning, goal-setting

3.4 Budget
The budget is one of the team’s main priorities. All members of Team Overbuilt and Underpaid will be responsible for updating any expenses for parts and associated cost. The ultimate budget responsibility belongs to team member Bob Loftis; Bob, along with the Project Management division, will responsible to ensure that the budget is not exceeded as well as allocating capital for project completion.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost</th>
<th>Weight</th>
<th>Purchase Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino Uno</td>
<td>2</td>
<td>N/A</td>
<td>50g</td>
<td>N/A</td>
</tr>
<tr>
<td>GoPro Hero 4 Session</td>
<td>2</td>
<td>N/A</td>
<td>148g</td>
<td>N/A</td>
</tr>
<tr>
<td>2GB SD Cards</td>
<td>4</td>
<td>N/A</td>
<td>4g</td>
<td>N/A</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td>2</td>
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<td>2g</td>
<td>N/A</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>1</td>
<td>N/A</td>
<td>1g</td>
<td>N/A</td>
</tr>
<tr>
<td>Humidity Sensor</td>
<td>1</td>
<td>N/A</td>
<td>1g</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Commented [AB20]: I noticed your org chart only had you in managerial roles. I would recommend getting into some of the meat of the engineering work too. You’ll get a lot more out of it than if you were just managing.

Commented [AB21]: Spares?
### Project Magnificence

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Weight</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Kit</td>
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<tr>
<td>Pressure Sensor</td>
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<td>5g</td>
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<tr>
<td>Foam Core Sheets</td>
<td>6</td>
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<tr>
<td>Foam Insulation</td>
<td>1</td>
<td>50g</td>
<td>N/A</td>
</tr>
<tr>
<td>Aluminum Tape</td>
<td>N/A</td>
<td>~25g</td>
<td>N/A</td>
</tr>
<tr>
<td>Switches/LEDs</td>
<td>~4</td>
<td>N/A</td>
<td>16g</td>
</tr>
<tr>
<td>MAG3110 Triple Axis Magnetometer</td>
<td>1</td>
<td>2g</td>
<td>14.95</td>
</tr>
<tr>
<td>2 Lithium Ion Batteries</td>
<td>4</td>
<td>144g</td>
<td>51.8</td>
</tr>
<tr>
<td>Mounting Bracket for 2 GoPro Cameras</td>
<td>2</td>
<td>15g</td>
<td>7.18</td>
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<tr>
<td>GoPro Wifi Remote</td>
<td>1</td>
<td>50g</td>
<td>19.99</td>
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<tr>
<td>Various Wiring, etc</td>
<td>N/A</td>
<td>~20g</td>
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</tr>
<tr>
<td>Testing with LI Ion Batteries</td>
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<tr>
<td><strong>Total</strong></td>
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