1.0 Overview and Mission Statement

Commented [AB1]: Overall, the team is off to an okay start in terms of what your ideas are. However, pieces of the document were in the wrong place and much more detail is necessary. You need to mention how you will control the CO2 cartridge and whether or not it is even necessary, for example. Each section needs a thorough explanation and details on each component of your system should be explained. Be sure to reference past documents to see what will provide sufficient material.

Commented [AB2]: Needs much more detail and images describing your science.
1.1 Mission Statement:

Ascending through the various layers of Earth's atmosphere, our balloon satellite will demonstrate the ability to disperse micron sized particles in an attempt to promote ice growth and condensation. Our satellite will also attempt to establish a link with ground communications in real time in order to prove the feasibility of balloon satellites as a communications network.

1.2 Purpose of this mission:

Our team would like to explore cloud seeding as it is a popular method used by ski resorts to accumulate snow. Further research into this process could be advantageous. Additionally, the quality and effectiveness of using transmitters to maintain a constant connection with our balloon satellite will be tested. A connection made using this method could help give less fortunate areas access to the internet.

1.3 What is to be found:

The plan is to discover if balloon satellites could be an effective and cheaper means of seeding clouds to produce more condensation. Additionally, the team wants to find out the reliability of making a communication link with the balloon satellite in mid-flight. This idea has been proposed as a new way to get internet in extreme locations as well as less fortunate areas around the world.

Sources:
https://www.scientificamerican.com/article/how-dust-could-solve-california-s-drought/
https://science.howstuffworks.com/nature/climate-weather/meteorologists/cloud-seeding1.htm
https://x.company/loon/

2.0 Technical Overview:
The satellites cargo, dust, will be placed in a funnel on our balloon satellite with a CO$_2$ canister aimed at it. Once our pressure sensor reads (a certain value), indicating the balloon has reached the proper altitude, the servo motor will open a trapdoor and the CO$_2$ canister will spray the dust particles out of the balloon satellite and into the clouds.

2.1 Design

2.3 Design to date

Commented [AB10]: What kind of dust?
Commented [AB11]: Why is this necessary versus just dropping it?
Commented [AB12]: Aren’t the environmental sensors on the balloon shield?
Commented [AB13]: Good foundational solidworks model
Commented [AB14]: Capitalization
Commented [AB15]: Explain why the aluminum frame is necessary and better
2.3 Hardware:

The team will buy a servo motor which can be acquired from Adafruit Industries. Additionally, Adafruit Industries sells transmitter and receiver pairs that will be purchased. A basic funnel for the cloud seeder will be acquired from a local convenience store. Silver micron particles can be acquired at a highly reduced cost from a group member's work.

Must Include:
- 1 GoPro Hero4 Session digital camera w/ 2GB memory card
- 2 Arduino Unos with OpenLog microSD card shield
- 1 internal and 1 external temperature sensor
- 1 Pressure sensor
- 1 Three-axis accelerometer
- 1 Humidity sensor
- 1 Heater kit
- 5 Batteries (for flight); additional batteries will be needed for testing
- 5 in. of 1/4 in. PVC pipe

Additional Parts:
- Silver particles

Commented [AB16]: Put this in a table
Commented [AB17]: Grammar
Commented [AB18]: Grammar
Commented [AB19]: List where all of this will be obtained in a table
Commented [AB20]: Need metric units
3.0 From Design to Satellite:

The transition from conceptual ideas to manufacturing, calibration, and final assembly will create a solid team infrastructure. Following an organized timeframe will ensure this process results in a spacecraft that is tested, safe, and able to produce a data set by launch day. The process will proceed as follows, initial brainstorming, feasibility, required hardware, required software, final design, manufacturing, testing/calibration, final assembly, fully integrated testing, launch.

Initial brainstorming began with one important aspect, which lead to an overarching goal: going to space and how to capitalize on this unique feat to explore and produce a useful result. Two major objectives were voted on and became the intended instrumental payloads; weather modification by means of cloud seeding and balloon platform data transmission. As residents in a semi-arid desert, we see first hand the impact of drought, resulting in massive forest fires, ecological famine, reduced consumable water, and not to mention economic hardship.

Weather modification, by means of cloud seeding is a feasible process which has been conducted for decades using rockets and planes. The goal is to show a balloon platform can also produce results. This process entails injection of dust particles at certain levels in the atmosphere. These dust particles act as nuclei for water vapor to condense, creating a raindrop or a snowflake depending on the local temperature. This relatively simple process is quite feasible, as its mission critical components are: get the dust payload to the correct altitude and release the payload. As the balloon ascends through most of Earth's atmosphere, it will be in the correct place, the pressure triggered servo trapdoor has limited moving parts and dust ejection is powered by gravity which may be assisted by a CO2 cartridge if space permits. This equates to a quite feasible cloud seeding mission objective that is achievable. As a secondary science payload, the team will be testing the data collection and transmission from the ground to spacecraft. The balloon mounted transponder will ping the ground based receiver showing a data transmission as the satellite ascends. This proof of concept will show that balloon mounted transmission targets can act as mobile assets in a world of growing dependency on data and connectivity. As the receivers and transponders have limited ranges, at some point signal will be lost. To determine maximum transmission distance, calibrated timestamps and pressure measurements will be used. This working transmission distance will be a main science goal, this communication will not trigger cloud seeding activities, resulting in a low risk and feasible stand alone science payload.

For success, reliable hardware is paramount. A list of required hardware and timeframe for ordering is as follows:

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Order Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacecraft chassis (weight relieved aluminum)</td>
<td>Completed</td>
</tr>
<tr>
<td>Arduino 1 &amp; 2</td>
<td>Completed</td>
</tr>
</tbody>
</table>
- Temp/humidity/pressure gauges Completed
- Heater 2/13
- Power bus (Lithium ion) 2/13-2/20
- Transmitter/Receiver 2/13-2/20
- Dust chamber/funnel Machining Started
- Servo 2/13-2/20
- Laser pointer 2/13-2/20
- Camera System 2/20-2/29
- Data storage (SD cards) Completed
- Dust (1 μm sized silver of iron nanopowder) Completed

    Arduino Software will drive the ability for our hardware instrumental package to produce and save data along with achieve mission operations. Our code and functionality is on track. An overview of software integration is as follows:

    | Software Functions          | Status/Time frame |
    |-----------------------------|-------------------|
    | Temperature Sensor          | Completed         |
    | Humidity Sensor             | Completed         |
    | Pressure Sensor             | Completed         |
    | Power Bank                  | 2/15-2/20         |
    | Servo Control               | 2/15-2/20         |
    | Data Collection (SD interface) | 2/20-2/29      |
    | Heater Control              | 2/20-2/29         |
    | LED Functionality           | Completed         |
    | Data-set Analyzation Software | 3/10-3/20   |
    | Transmission Interface/Functionality | 3/1-3/15 |
    | Ground Data Receiver        | 3/1-3/15         |

    Final design will incorporate the functionality for the satellite to communicate with the ground, expel a dust payload, take data, and survive the harsh conditions of low space. Spacecraft bus (Arduinos) will take temperature, pressure, and humidity measurements, correlating with the satellite to know what section of the atmosphere it is in. At this point our communication systems will send the measurements to a computer on the ground. After getting the measurements ideal to seed the cloud, we will send a command from the ground to deploy the particles. However, if the communication fails, we have set an altitude of 40,000 feet to create a targeted trigger for dust deployment. When a desired altitude is reached, or the command received, the software will send for motion in to the servo. The rotational servo motion will be transferred to a linear motion, pulling a rigid arm, opening or closing a trapdoor styled mechanism, releasing the dust payload once, or at multiple altitudes depending on the local cloud level or moisture content. The final design will localize the spacecraft bus, power bank, servo, camera, and heater. These will be encapsulated in foam for thermal and shock abatement. This foam vault will be secured to an aluminum chassis. The dust chamber and trap will remain exposed.
Once final design is completed, there will be a built in hold to check for conceptual functionality, weight, mission safety, risk management, and cost structure analysis. Only if these requirements are achieved will final manufacturing, testing, and calibration be moved forward.

Testing and calibration is a mandatory procedure that will take weeks to achieve. Each mission sub-system will be tested separately to assure localized performance. Known calibration methods, such as low temperature calibration with dry ice as a standard, will be used. The team will test for pressure in a vacuum chamber, down to 50 millitorr, using tank mounted convectron gauges to confirm pressures. Structural testing will consist of drop tests, high-g rotational whip tests, debris contamination testing, low temperature stress, and a shake test. Once these tests are performed and passed, final assembly will start. ESD precautions will be implemented for final assembly. Testing and Calibration will be repeated after final assembly to ensure functionality and flight readiness. This fully integrated testing will replicate the conditions and functionality desired during flight. Apollo 18 will save data, extract, and produce a calibrated data set to confirm the scientific packages will perform as designed and produce the expected data set.

Following this rigid development to production to testing scheduling structure will facilitate the needed checks to make sure time is not wasted and a viable robust balloon satellite is the result. Modifications inevitably will arise, though, with careful planning, built in design reviews, functionality calibration, risk management, and cost structures, Apollo 18 will arrive with a flight ready vehicle.

4.0 Testing:

**Drop Test** - The structure of our balloon satellite will be completed by conducting a drop test to make sure the box can handle landing.

**Kick Test** - A kick test will further improve confidence in the structural stability of the balloon satellite.

**Whip Test** - A whip test will be performed to make sure the satellite can handle the harsh swinging while attached to the balloon.

**Cold Test** - Additionally, the team will conduct a cold test on our satellite to ensure all components can work as expected in the harsh environments found at 30 kilometers.

**Testing the Communication Systems**: We can test our communication systems by placing the satellite far from the computer we will use to send the commands and check if a stable communication can be established. To stimulate the motion of the balloon, we can carry the satellite in a moving car and set up the computer at the end of the street.

**Testing Cloud seeding**: To test the cloud seeding, we will yield our satellite to a weather balloon and stimulate the deployment of the cloud from an appreciable altitude. (One of our teammates can provide the balloon)
5.0 Safety:

In order to ensure safety, all team members will wear proper PPE (personal protective equipment) when operating power tools and heavy machinery. Team members will also only use machines they feel confident with and have been trained to use. For testing, a safe place will be found to conduct these tests and the area will be checked for pedestrians before each test.

6.0 Special Features:

This mission will include a funnel and small CO2 cartridge that will be used to push the dust out of the balloon satellite and into the clouds. We will also place a laser near the camera so that way when the dust particles are dispensed we can hopefully see its trajectory. Aluminum frame for additional structural support.

7.0 - Data Retrieval:

Preferably, a constant connection will be held with our satellite using transmitters so that data can be recorded in real time and not depend on retrieval. Also, in our satellite we will be positioning a laser in the direction we launch the cloud-seeding particles. Our GoPro Camera will also be oriented in the same direction. Once the precipitation occurs on the particles, a cloud will be formed and the path of the laser would become visible. This would show the success of our cloud seeding mission.

8.0 Functional Block Diagram:

Commented [AB36]: mention away from windows

Commented [AB37]: this isn’t a sentence

Commented [AB38]: this isn’t what is required for this section. Rather you need to describe how you will launch and retrieve the sat, where the data is kept, and what you will do with the data

Commented [AB39]: spelling

Commented [AB40]: Needs a paragraph thorough explanation of the FBD. 2GB memory is not the sensor attached. You should not have the servo on the Arduino with the balloon shield for environmental data. Also, have a key with color coding. Where is your CO2 cartridge? Where is your camera?
9.0 Schedule:

Commented [AB41]: Needs to be more thorough in terms of testing and an explanation at the beginning

III. Management and Cost Overview:

Apollo 18
1 - **Build Schedule**

<table>
<thead>
<tr>
<th>Date</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-11-18</td>
<td>Finalize proposal</td>
</tr>
<tr>
<td>02-08-18</td>
<td>Start Coding arduino &amp; finish soldering electronics</td>
</tr>
<tr>
<td>02-13-18</td>
<td>Start working with the servo for the trap door</td>
</tr>
<tr>
<td>02-20-18</td>
<td>Finish structure for Stress Testing</td>
</tr>
<tr>
<td>02-27-18</td>
<td>Final Software test</td>
</tr>
<tr>
<td>03-08-18</td>
<td>LR Communications test</td>
</tr>
<tr>
<td>3-20-18</td>
<td>Launch readiness</td>
</tr>
<tr>
<td>04-08-18</td>
<td>Analyze Data</td>
</tr>
<tr>
<td>04-08-18</td>
<td>Video and Expo</td>
</tr>
</tbody>
</table>

2 - **Team Chart**

3 - **Construction Plan**

Maxx is our team leader and will organize and coordinate our team’s progress. Our electronics team composed of Thomas, John, and Maxx will lead the effort on electronic development ranging from servo motor set up to setting up the gopro. Also, they will handle all

Commented [AB42]: Something like this should replace your Gantt chart with much more information listed. This is a good start

Commented [AB43]: Spelling

Commented [AB44]: No explanation

Commented [AB45]: This needs to be the introduction to your management chart
circuit boards. Additionally, our software team composed of Kunal, Jack, and Steve will tackle the programming of arduinos and other equipment. The manufacturing team will attack the physical structure of our balloon satellite. They will ultimately make decisions on how to meet the mass requirement, what to cut and what to keep. Our organization team will manage the budget and act in correspondence to the team leader in making sure work is divided equally and everyone is building on their weaknesses and applying their strengths. Finally, our CAD team will specify in computer imaging, allowing us to view and alter our design before physical construction.

4 - Team Information:

- John Fontanese: Studying Physics, works at LASP performing hypervelocity spacecraft calibrations for space based dust detection instruments. Operates, fixes, builds 3Mv linear electrostatic dust accelerators reaching speeds of 125 km/s. Familiarity with machining and design allows for structural manufacturing of our satellite and science payload construction.
- Jack O’Hara: Junior studying Astrophysics at the University of Colorado Boulder. Grew up in Golden, Colorado and worked at Vendettas in Vail, Colorado for the past three summers.
- Maxx Helfer: Junior studying Astrophysics at the University of Colorado Boulder. Works as a Lifeguard Instructor for the City of Boulder Parks and Recreation.
- Kunal Sinha: Freshman studying Aerospace engineering at University of Colorado Boulder. Grew up in Muscat, Oman.
- Stephen Ackerman: Sophomore studying Astrophysics at the University of Colorado Boulder. Grew up in St. Louis Missouri. Worked as a camp counselor and general contractor.
- Thomas Lynch: Freshman studying Aerospace Engineering at University of Colorado Boulder. He has worked as a soccer referee and a camp counselor, giving him problem solving skills and quick thinking.

5 - Document phone numbers, school, addresses, special skills, etc.:

- John Fontanese: 
  Phone: 303-880-7360
  Address: 960 Homestead Ct
  Skills: Machining, design, calibration, risk management.
- Jack O’Hara: 
  Phone: 303-817-5783
  Address: 950 28th street
- Maxx Helfer: 
  Phone: 719-271-0732
  Address: 2985 E Aurora Ave
- Kunal Sinha: 
  Phone: 303-619-5611
  Address: 3366 Willard, 2200 Willard Loop Drive
- Connor Cedzich-Grant: 
  Phone: 303-619-5611
  Address: 3366 Willard, 2200 Willard Loop Drive
  Skills: microcontroller programming, MIG welding, data analysis.
- Stephen Ackerman: 
  Phone: 314-957-8687
  Address: 2142 Canyon Blvd
- Thomas Lynch: 
  Phone: 708-717-7463
  Address: 026 Cockerell hall

6 - Budget:

| Budget: | Status: | Where: |

Commented [AB46]: This would look much better in a table

Commented [AB47]: Table

Commented [AB48]: This is supposed to be a cost estimation, not what you have delegated to spend. Need to show exactly what parts you think to use.
<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Purchased</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servo motor</td>
<td>$5.00</td>
<td>Not</td>
<td>adafruit.com</td>
</tr>
<tr>
<td>Power bank</td>
<td>$5.00</td>
<td>Not</td>
<td>phone battery</td>
</tr>
<tr>
<td>XBee transmitter &amp; receiver</td>
<td>$80.00</td>
<td>Not</td>
<td>adafruit.com</td>
</tr>
<tr>
<td>Funnel</td>
<td>$10.00</td>
<td>Not</td>
<td>Hardware store</td>
</tr>
<tr>
<td>Spacecraft Bus</td>
<td>$50.00</td>
<td>Not</td>
<td>Hardware store</td>
</tr>
<tr>
<td>Cloud Seeding Particles</td>
<td>$10.00</td>
<td>Not</td>
<td>LASP</td>
</tr>
<tr>
<td>Calibration Testing</td>
<td>$20.00</td>
<td>Not</td>
<td>LASP</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>$180.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Remaining Budget:</strong></td>
<td>$180.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**7- Budget Management:**

Maxx, the team leader, will keep track of the budget. Anything purchased will be directly added to the google spreadsheet document that keeps track of all our items, their cost, and the order status. The spreadsheet will also tell us exactly how much of our budget remains so we don't over spend.

**8- Requests to be at the Bottom:**

We need to be at the bottom of the line so that we can dispense the seeding particles into the atmosphere, being at the bottom will help us see the laser when the particles are dumped as well as see the formation of clouds with our GoPro after we have seeded. If we are at the middle of the line, our particles may fall on another satellite, distorting both our readings and the team’s whose satellite is below ours’.

**9- Request for Additional Weight:**

Our team is requesting additional weight for our satellite in the amount of 100 grams. We believe we will need it for two reasons; First, our structure will include a custom milled aluminium frame that already weighs roughly 100 grams. Secondly, the team is ambitiously taking on a ground mission in the hopes to make a communication link while the satellite is in mid flight to dispense the payload manually when the optimal conditions are met. This will likely

Commented [AB49]: Need to prove this with a detailed weight budget analysis

Commented [AB50]: spelling

Commented [AB51]: Is this heavier than what the foam core will be? Why do you want to use this?

Commented [AB52]: spelling
required additional hardware so we anticipate needing more weight to successfully achieve our missions goals.

Commented [AB53]: This will only require a few more grams