Concept of operations

The stratospheric balloon mission GELIOSTAT-1

Team #1

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1. Introduction:

The objective of this document is to define the operations concepts for the various phases of the mission, covering both the air segment and the ground segment.

2. Mission operations requirements and constraints

2.1 General

- Weather: temp , humidity , fog, cloud, snow, wind.

1. Weather here poses a huge constraints on the planning and execution of the mission. With an altitude of about 15:30 km, the expected temperature at this height is around -56:-70 degree celsius. This temperature affects the electronic components, their accuracies and their function as most of the electronic components have a higher temperature working range.

- Payload : Working (FSS programmetry).

2. The mission has two payloads each has its working conditions that pose constraints. For the FSS experiment, operation conditions are voltage (5 volts), current (around 900 mA) and temperature in a range from 0:50 degrees celsius. Also,The different elements like fog, cloud snow and wind could also affect data acquisition process and data value along with data transmission

For the photogrammetry part of the mission, the conditions are the instrument position as it should always point towards the ground, power consumption of around 10 W, Temperature working range of 0:40 degrees celsius and humidity of less than 85% .

2.2 Mission Description

The stratospheric balloon mission is dedicated to design, assembly, integration, and flying of a stratospheric balloon to safely test and return with the data for high-definition imaging (for point cloud modeling) and experimental payload for FSS (Federated Satellite System). This mission is for the problem of a network of satellites that suffers from inefficiently allocated and unused resources such as downlink bandwidth, storage, processing power, and instrument time. Using this Federated Satellite System (FSS) payload, we’d be able to test its enhanced performance,

cost-effectiveness, and reliability of space missions for the future of a network of satellites.

A necessary condition of this mission is to ensure the safety of both the payloads, have unobstructed inter-balloon communication and data transmission along with maintained connectivity with the ground station. Also it is required to have a smooth and fast recovery of the payloads following the descent phase of the mission.

2.3 End – Users

The mission's direct end user is the Nano-Sat Lab who would be delivered the raw data from the mission to further analyze the idea of Federated Satellite Systems (FSS). Another direct user is a PhD Researcher from Skoltech who would be using the raw pictorial data from our mission for photogrammetry analysis.

The indirect end users include; scientific community with research interest based on the data, several industrial groups and meteorological department.

2.4 Programmatic & Operational Constraints

We have many pre-defined constraints for this mission.We will discuss those constraints in this section.

The first and foremost is the type of Stratospheric Balloon we are provided with and its specifications required like fuel per meter, maximum load to carry.

Then we need to keep in mind the physical characteristics of the payload we are being provided with. Their dimensions, sensitivity to the cold environment at high altitude and their safety.

We also need to check the availability of different electronic components to be used in the power, communications, and other control modules to make our mission a success.

Since our mission is stratospheric in nature we also need to account for humidity and low temperatures meddling with different components along with the lens of camera (for photogrammetry). Therefore, we need to come up with fail safe for our mission keeping these constraints in mind.

Furthermore, we need to keep in mind the availability of the field we will use for the launch. We need to stay in contact with the authorities to make sure the availability of the space so that our mission is not jeopardized.

Last but not the least, as per the requirements of the customer we'd be operating in the radio Frequency. Therefore, we need to work out a solution for effective communications and downlink using this frequency interval.

2.5 Relationship with other mission programs

- Relation with the other teams: importance.

Looking at the bigger picture we see that the success of all the three balloons (missions) is vital to the success of the individual mission. This includes consulting them with communications related problem and other issues that might prevent inter-balloon communications. Such as on the matter of executing the Federated Satellite System payload's inter-balloon communications and its systenance.Therefore, we need to have a high coordination with other teams working along with us having the same objective.

2.6 External dependencies or interfaces with other organizations

This section is to describe the mission`s interactions with outside entities and organizations. These are limited to:

- Skoltech: Representing the entity supporting the students configuring and operating the mission with the needed tools, labs along with the course providing the necessary knowledge and help for a successful mission.
- Military and civil airfields.

The launch need to be performed in a dedicated field for mission launch (airfields) which requires interaction with all the possible civilian and military airfields to choose the best fit for the mission based on field distance from Skoltech and means of equipment transport to it along with field width and availability of navigation through it.

- Meteorological services.

The mission balloons represent a constraint in terms of its high interaction with weather disturbances like wind and snow. That makes it necessary to insure a

day with minimum weather interferences which can be insured through help from the meteorological services.

- Air traffic control.

The mission includes a part where it might interact with other aerial vehicles. For that, coordination with air traffic control is necessary to guarantee the success of the mission.

- Federal security services, Military services: The mission includes photography and data collection from a great height in the airfield of the russian country. For this height and this payload, the mission becomes highly sensitive in terms of security and requires permission from the Russian government, the federal security services and the military services.

3. Air segment Characteristics

The air segment platform should have the capabilities to maintain the work of the main components of the system. There are camera Nikon P900 and FSSExp transmitter. All requirements and characteristics are described in this part.

3.1 On-board autonomous functions

The platform will obtain several functions. It should retrieve information from the FSSExp module, save, and transceive it to the ground station. Besides, a platform must gather sensor information that includes internal and environmental temperature, position and altitude of the balloon, and battery state of charge. After the end of the mission, it should open the parachute at the predefined height. From that point, the beaconing system must start working during a specific amount of time.

During ascending, the platform should take several photos of the surface to make photogrammetry by pressing the camera button.

3.2 The mechanisms for on - board generation, storage, and downlink of mission data products

All autonomous functions will be controlled with the NanoPi microcomputer. This computer will gather data from FSS through USART (universal synchronous/asynchronous receiver/transmitter) interface. Storage will be saved in NanoPi microSD memory. The LoRa radio interface will provide a downlink of the data product to the ground station. It will be provided by the microcontroller that will connect to the computer through the second USART.

Photogrammetry data will be held in the internal storage of the camera and used and analyzed after the end of the balloon mission.

3.3 The end-user services

During the flight mission, the platform will communicate with balloons from other teams by using a federation communicating protocol. This protocol is provided by Radio Frequency Inter Satellite Link, Nanosat lab.

Skoltech will provide the camera for the second part of the mission.

End-users will receive all gathered data from the platform in text or image format with a final report of the mission and their equipment.

4. Mission Operations Concepts

4.1 General

The mission operation concepts describe the main processes for each phase:

- Initiation
- Planning
- Execution
- Evaluation
- Exploitation

Initiation phase includes identification of the project objectives and creation of the necessary description documentation. An appropriate

response to the need is documented with recommended solution options. A feasibility study is conducted to investigate whether each option addresses the project objective and a final recommended solution is determined. Issues of feasibility and justification are addressed.

Planning process describes the development of the project solution in as much detail as possible and the steps necessary to meet the project's objectives are planned. In this step, the team identifies all of the work to be done and prepares all project documentation like project and work breakdown structures, concept of operations, and interface development.

The execution phase includes all steps and requirements of the mission that must have been done.

After execution of the mission evaluation and result exploitation phase will be started. During these phases, data analysis and reports should be provided.

4.2 Planning Process

Recourses: 200$, team(12 employees), Fablab facilities

Resources shall be divided equally among all the mission stages. That means in every phase all the team members participate. Given money are separated 40$ per phase for salary and other expenses. In case of unexpected extra expenses with the approval of all team members money can be transferred from one phase to another, but not more than 50% of stack (20$). Fablab facilities can be used during any phase as much as it is necessary to fulfill the phase goals without any constraints.

4.3 Operations Execution Processes

Platform shall provide stable work during the whole execution process. The power of the system shall exist until the end of the mission with a preassigned reserve of it in emergency cases. Thermal support shall work permanently. During the flight life data shall be provided with the defined frequence.

Mission timeline:

- Pre-launch phase
- Launch and early-operation phase
- Transfer phase
- Operation phase
- Post-operations phase

In pre-launch phase there should be validation of the main spots of the system. Commands transmission, payload state, sensors work shall be checked. Constituent elements can be individually integrated and tested. Simple mounting/dismounting procedures should be used such that items such as the payloads can be installed/removed late in the integration sequence.

Early operation phase includes execution of photogrammetry part. Platform shall provide several shots of the surface at different times. Pictures will be saved in the memory of the camera.

Transfer phase define ascend of the system to stratosphere.

At the operation phase platform shall gather and downlink the FSS information to the ground services from other platforms. The ground segment system health monitoring will provide data history archiving and downlink exchange

During the post-operation phase platform shall descend to the surface by using a parachute subsystem and provide continuous beaconing after the landing. All internal parts shall withstand it and be operating.

4.4 Evaluation Process

Quality Evaluation of photos is conducted by the customer after the mission. Quality of FSS transmutation is evaluated by the customer. To evaluate the safety of the payload during mission parameters of the environment (temperature and humidity) inside and outside the payload are conducted using thermosensor and humidity sensor. To evaluate the parachute serviceability a sensor on the parachute box is installed.

4.5 Mission Exploitation Process

After mission execution the team shall provide:

- ➔ Final report of mission, which shall include:
  - ◆ Description of the mission: what are the goals, what was done, what were the steps and middle results;
  - ◆ Evaluations descriptions and numbers during mission;
  - ◆ Samples of collected photos and FSS transmitting data code;
  - ◆ Analysis of achieved goals;
- ➔ Summary of the flight data shall include:
  - ◆ How much data was collected;
  - ◆ Description of the mission route: GPS coordinates of the route, attitude dynamics, outside and inside temperature dynamics, mission time;
- ➔ Presentation shall include:
  - ◆ Description of the mission: what are the goals, what were the steps;
  - ◆ Roles in the team and areas of responsibilities;
  - ◆ How the evaluations were made;
  - ◆ Samples of collected photos and FSS transmitting data code;
  - ◆ What goals were achieved and analysis of how they fulfill the mission statement (table form);
- ➔ Data and equipment delivery to the customer:
  - ◆ All collected data shall be provided to the customer after the mission;
  - ◆ The customer shall be provided with his payload in it's initial conditions after the mission. The full-functionality test for the payload is provided before and after the mission.

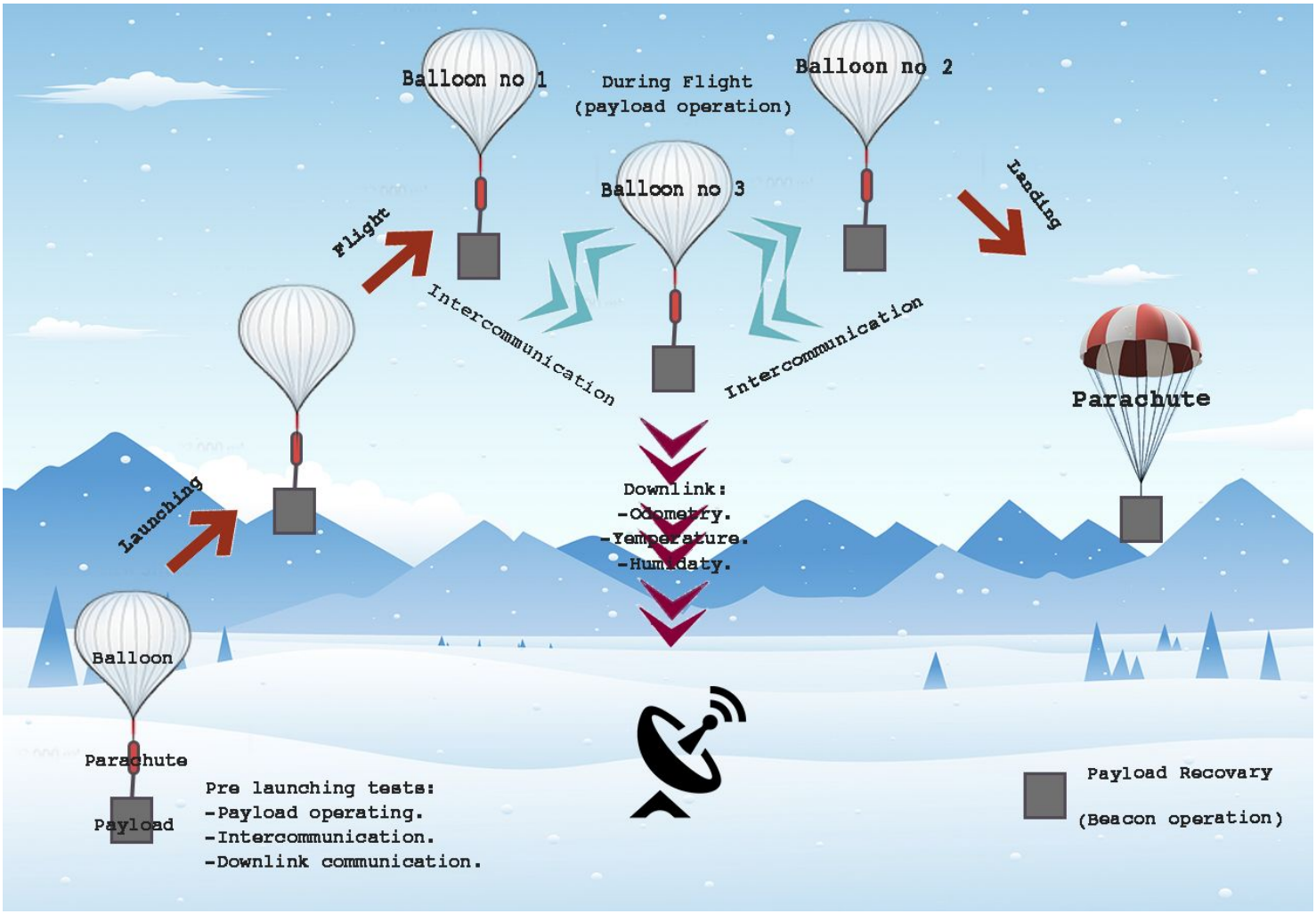

Figure 1 - Concept of operations