**Mission to Pluto**

**ASE 374K**

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**Mission Overview**

This section discusses the framework of the Pluto surface explorer mission. The mission objectives, needs, concept of operations, requirements, and the environment that the craft will encounter are included below.

**Objectives and Tractability Matrix**

Objective 1 – Characterize Pluto’s surface and atmospheric composition.

Objective 2 – Characterize Pluto’s moon, Charon, surface composition.

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| **Science Objective** | **Measurement** | **Instrument** | **Functional Need** |
| ***Characterize Pluto’s surface and atmospheric composition*** | Measure the density and temperature of the atmosphere | Temperature and pressure sensors able to cancel out any atmospheric entry effects. | The sensors need to have the ability to sense a temperature in the range of 30 K to 60 K and a pressure near 0 atm. The pressure sensor needs to have a resolution of 0.0001 atm. The temperature measurement needs to be accurate to within 1 K. Each of these sensors needs to sample the atmosphere at a rate of 60 Hz. |
|  | Measure the surface temperature and density | High impact resistant temperature and pressure sensors. | The sensors need to have the ability to sense a temperature in the range of 30 K to 60 K and a pressure near 0 atm. The temperature measurement needs to be accurate to within 1 K. |
|  | Determine the geomorphological context of a sample taken from the surface | Drill and capture design, a narrow field-of-view, visible light camera, Wide field-of-view, visible light camera, thermal infrared camera, and temperature sensor. | Need to determine if water and/or nitrogen exist in the sample by processing locally, and then send the raw data captured. The equipment needs to be sensitive to both nitrogen and water and have the ability to sense these chemical compositions in temperatures between 30 K and 60 K. The drilling apparatus needs to have the ability to drill through frozen dense material. |
| ***Characterize Pluto’s moon, Charon, surface composition*** | Measure the surface temperature and density | High impact resistant temperature and pressure sensors. | The sensors need to have the ability to sense a temperature in the range of 30 K to 60 K and a pressure near 0 atm. The temperature measurement needs to be accurate to within 1 K. |
|  | Determine the geomorphological context of a sample taken from the surface | Drill and capture design, a narrow field-of-view, visible light camera, Wide field-of-view, visible light camera, thermal infrared camera, and temperature sensor. | Need to determine if water and/or nitrogen exist in the sample by processing locally, then send the raw data captured. The equipment needs to be sensitive to both nitrogen and water and have the ability to sense these chemical compositions in temperatures between 30 K and 60 K. The drilling apparatus needs to have the ability to drill through frozen dense material. |

**Concept of Operations**

**Overall Mission ConOps**

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| Macintosh HD:Users:zacharytschirhart:Desktop:space-x-falcon-9-launch.jpg  **1**. Mission launch at t = 0. | Macintosh HD:Users:zacharytschirhart:Desktop:images.jpeg**2**. Systems check once in orbit around Earth at t + 4 hours. | Macintosh HD:Users:zacharytschirhart:Desktop:JupiterFlyby.jpg**3**. Start transfer to Jupiter for flyby and gravity assist at t + 1.5 earth years. |
| Macintosh HD:Users:zacharytschirhart:Desktop:NH_jupite_m.jpg  **4**. Test imaging and communications on Jupiter flyby at t + 1.5 earth years. | Macintosh HD:Users:zacharytschirhart:Desktop:KBO_m.jpg**5**. Continue flight to Pluto t + 10 years | Macintosh HD:Users:zacharytschirhart:Desktop:NH_pluto_m.jpg**6**. At 2 earth days before the flyby of Pluto, start probes separation from main vehicle. Ignite probes onboard thrusters and guide one to Pluto and the other to Charon. |
| Macintosh HD:Users:zacharytschirhart:Desktop:Europa_Penetrator.jpg**7**. Probes reach each surface and start transmitting any results found at 1 earth day before the flyby of Pluto. | Macintosh HD:Users:zacharytschirhart:Desktop:Encounter_01_m.jpg  **8**. Satellite collects images and other onboard sensor data of Pluto and Charon. Transmits any results or pictures taken. Priority given to probe data at 1 earth day past flyby | Macintosh HD:Users:zacharytschirhart:Desktop:NewHorizonsatPluto.jpg  **9**. Satellite continues on past Pluto and transmits pictures and other sensor data periodically back to Earth at t > 10 years. |

**Surface probe Mission ConOps**

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| --- | --- | --- |
| **1**. Probe is separated from the satellite and starts powered guidance toward Pluto at t = 0. | Macintosh HD:Users:zacharytschirhart:Desktop:NewHorizonsatPluto.jpg  **2**. Probe is 2000 km from the surface of Pluto and starts transmitting atmospheric data back to the satellite at t + 1 earth day. | **3**. Probe penetrates the surface and continues to send atmospheric data at t + 1 earth day. |
| Macintosh HD:Users:zacharytschirhart:Desktop:images-1.jpeg  **4**. The coring drill is deployed and collects a sample. While simultaneously collecting surface temperature and pressure at t + 1 earth days. | Macintosh HD:Users:zacharytschirhart:Desktop:images-2.jpeg  **5**. The sample is analyzed and imaged at t + 1.25 earth days. | Macintosh HD:Users:zacharytschirhart:Desktop:nh_panoramic_m.jpg**6**. The results of core sample, surface temperature and pressure, and atmospheric temperature and pressure are all transmitted back to the satellite for retransmission back to Earth at t + 1.5 earth days. |

The concept of operations was based on several sources including the current mission to Pluto (Horizons) and a coring mission set for one of Jupiter’s moons, Europa. The Surface probe mission ConOps was separated to give more detail on the more important part of the mission.

**Requirements**

Requirement 1 – The vehicle landing on Pluto’s surface shall transmit results to the non-landing satellite for transmission back to Earth.

Requirement 2 – The vehicle landing on Pluto’s surface shall finish all analysis needed before the non-orbiting satellite is out of transmission range and have enough time to transmit results to non-landing satellite.

Requirement 3 – The vehicle landing on Pluto’s surface shall take enough measurements of the atmosphere on the way down to get a first order approximation of what the atmosphere is composed of.

Requirement 4 – The vehicle landing on Charon’s surface shall transmit results to the non-landing satellite for transmission back to Earth.

Requirement 5 – The vehicle landing on Pluto’s surface shall finish all analysis needed before the non-orbiting satellite is out of transmission range and have enough time to transmit results to non-landing satellite.

These requirements are necessary to gather the essential data of the surface structure of both Pluto and it’s largest moon Charon. Since the mission to Pluto will be a multi-year mission to get there, the maximum amount of data should be captured and sent back to Earth. By having multiple probes collect data from two places, more information can be used to understand a dwarf planet on the outer edge of our solar system. Using at least one of the probes to also collect data on the atmosphere of Pluto on the way down before making contact with the surface, more data is likely to be collected. In the event the probe has a malfunction when coming in contact with the surface, the most likely point of failure, some of the data can be collected and sent. Having the probes send data back to the non-landing satellite before it moves outside the landers transmitting range will assure for the data to be collected and retransmitted to Earth.

**Environment**

The environments that this mission will encounter are various and common for deep space missions. The mission will be launched from earth’s atmosphere and thus will encounter large vibrations until the spacecraft is in orbit. All of the components will need to be rated to survive any vibrations during launch, and since this is the time when the largest vibrations will occur for most of the spacecraft, that is what should be designed for. The exception is the landing crafts for both Pluto and its moon Charon. These vehicles will need the ability to survive the impact of a surface landing. The most reasonable choice for a landing would be a lander that penetrates the surface of the planet using the accumulated velocity used to escape the sun’s gravity. Using this method, the device will need to survive a very high impact, and still have the ability collect samples of the surface and transmit results back to the non-landing satellite. The satellite will also need to cross Earth’s Van Allen belt region, which includes high levels of radiation. The spacecraft will need to be radiation hardened and pass this region as quickly as possible to reduce the chances of system failures. Another environment that the spacecraft will encounter is the lack of power from the Sun because of the distance away. The last major environment that the spacecraft will encounter is that there is no medium to regulate heat that is needed or generated by electronics on-board. The only way to regulate the heat is by radiation and with the lack of sun power at such a long distance; it is much more of a concern.

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