A picture containing text

Description automatically generated[Chair of Pico and Nano Satellites, and Satellite Constellations](https://www.asg.ed.tum.de/en/pns/home/)   
Chair of Space Propulsion and Mobility  
[TUM School of Engineering and Design](https://www.ed.tum.de/)  
[Technical University of Munich](https://www.tum.de/en/)

**Introduction to Spaceflight - Project Report - Summer semester 2023**

|  |  |
| --- | --- |
| **Chosen Project:** | **Group Number:** |
| **Last name, First name:** | **Matriculation Number:** |
| -, Armaan Mohammed | 03758638 |
| Ali, Ahsan | 03760449 |
| Izaaryene, Anas |  |

**Requirements**

*Contributor: Name(s)*

Here you shall state the mission requirements and the main system level requirements. In the following you will also find examples on how to insert tables or images.

|  |  |
| --- | --- |
| **Trip** | **Costs [€]** |
| Hotel | 350.4 |
| Car | 49.6 |
| **Intermediate result** | **400** |
| Booking Fee | 20 % 80 |
| **Total** | **480** |

Table 1: Example of a table caption.

A drawing of a house

Description automatically generated  
*Figure 1: Example of a figure caption.*

**System Architecture**   
Mass & Power Budget  
*Contributor: Name(s)*

Mission Orbit, Δv- & Propellant Budget  
*Contributor: Name(s)*

Mars Mission Feasibility  
*Contributor: Name(s)*

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Feasibility of Launcher Selection  
*Contributor: Ahsan Ali*

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Ariane 62 reaches its desired orbit in three phases with the help of three stages: the booster stage, core stage, and upper stage. These stages work in tandem to propel the vehicle and facilitate its ascent to the desired initial orbit. In the first phase, the booster stage plays a crucial role, employing two strap-on boosters to provide initial thrust at lift-off. This phase propels the Ariane 6, starting with an initial mass of 507 tonnes, achieving a delta-v of 2110.30163176386 m/s. As the boosters' propellant is depleted, the launcher's mass is reduced to 223 tonnes. Following the booster stage, the core stage takes over propulsion duties in the second phase. With a mass of 200 tonnes, it provides additional thrust and delta-v of 5065.177217761922 m/s. The core stage effectively reduces the launcher's mass to 60 tonnes upon the jettisoning of the boosters. In the third phase, the upper stage assumes control. Powered by the remaining 49.5 tonnes, it provides the necessary thrust to achieve a delta-v of 4488.051627584800 m/s, enabling the ascent into the desired orbit. At the end of this phase, the launcher retains a mass of 18.5 tonnes. An analysis of the combined delta-v from all three stages reveals a total delta-v of 11663.5 m/s, surpassing the required delta-v of 8084.3 m/s for ascending to the desired orbit. Furthermore, the thrust-to-weight ratio, calculated at 1.128933394022151, confirms the feasibility of a successful lift-off. However, it is important to note that the launcher's feasibility to reach the desired orbit is contingent upon the payload's mass. Based on the analysis, the launcher is deemed unfeasible for payloads mass 25.94 tonnes or more. (NOT FINALIZED YET).

Calculation results and interpretations including thrust to weight ratio. Something maybe from esa website and cite it (not necessary if nothing makes sense to add). Maybe also add the maximum payload weight that Ariane 62 can transport, beyond which it cant.

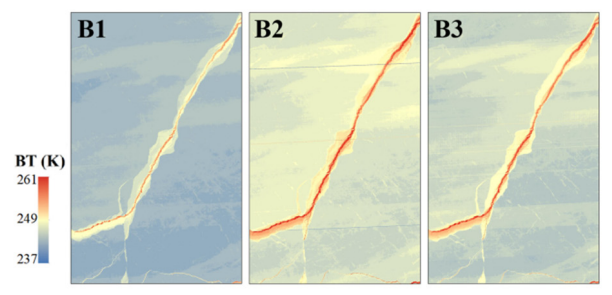
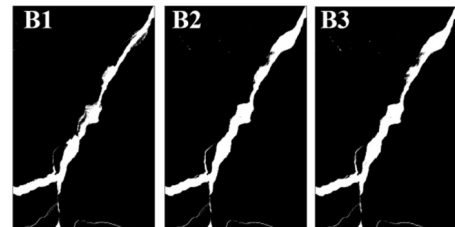
Spacecraft Design  
*Contributor: Armaan Mohammed, Anas Izaaryene*

**Payload Aperture**

*Contributor: Armaan Mohammed, Anas Izaaryene*

To ensure accurate monitoring and assessment of the polar ice caps, it is essential to choose the appropriate wavelength of electromagnetic radiation for remote observation. A highly effective method is the utilization of Synthetic Aperture Radar (SAR) technology. SAR operates using radio waves, which possess the unique ability to penetrate through clouds, fog, and darkness. [1] This exceptional characteristic allows satellite sensors to capture data even in adverse weather conditions and during nighttime. Satellites such as Cryosat-2 and Sentinel-1 employ SAR technology, providing high-resolution images that offer detailed information about Earth's ice cover due to the longer wavelength utilized. [2]

For optical payloads, thermal infrared imagery obtained from a Thermal Infrared Spectrometer (TIS) onboard satellites like SDGSAT-1 and Landsat-8 becomes the preferred choice. Icebergs, having higher temperatures than the surrounding sea ice, exhibit noticeable temperature contrasts. By monitoring these temperature variations over an extended period, it becomes possible to estimate and monitor the size of these glacial structures accurately. [3] The Thermal Infrared Spectrometer employs three infrared bands centred at 9.3 µm (8.0-10.5 µm, Band 1), 10.8 µm (10.3-11.3 µm, Band 2), and 11.8 µm (11.5-12.5 µm, Band 3). Its high spectral resolution allows for the detection of temperature differences as low as 0.2°C (@ 300 K). [3] To achieve a target resolution of 50 meters at an altitude of 750 kilometres, let's consider the highest wavelength of 12.5 µm. Using the equation GRD=2.44hλ/D, we can calculate an aperture diameter of approximately 45.75 centimetres. The determination of Ground Sampling Distance (GSD) depends on the specific sensor and swath width, playing a crucial role in the analysis of this remote data.

*Figure 1: SAR data of Beaufort Sea Ice Lead from Sentinel-1 data acquired at 15:52 UTC on the same day.*

*Figure 1: TIS data of Beaufort Sea Ice Lead from SDGSAT-1 acquired at 04:28 UTC on April 28, 2022.*

**Attitude and Orbit Control**

*Contributor: Armaan Mohammed*

Accurate and precise pointing of a satellite is not only vital for communication with the ground but also for effective Earth observation. This essential task encompasses a range of key roles, including determining the satellite's current attitude, controlling its attitude, making pointing corrections, performing detumbling manoeuvres after release into orbit, and adapting operational modes to match the mission status. However, the demands placed on the satellite's performance are exceptionally stringent.

While the communication system, which utilizes the VHF-band, allows for a relatively coarse accuracy requirement, the payload itself necessitates an astonishingly low attitude control error of less than 30 µrad. [4] Additionally, the knowledge error should be less than 46 µrad, and the knowledge stability must remain within 0.12 µrad over a duration of 2.5 seconds or less than 1.45 µrad over 30 seconds, throughout the satellite's operation. [4] Meeting such rigorous requirements leaves no alternative but to employ a three-axis stabilization architecture for the satellite to exert complete control over its attitude.

To fulfil the demanding pointing accuracy and knowledge requirements, highly accurate actuators and sensors are indispensable. For this purpose, the satellite is equipped with two star trackers, with an additional one for redundancy. These star trackers outperform the Coarse Earth and Sun Sensors, which are primarily used during coarse pointing or safe mode, as exemplified by the Landsat-8 and Cryosat-2 missions. [4] [2] Since the satellite operates in close proximity to Earth, it can exploit the Earth's magnetic field for attitude control. Accordingly, three hot redundant magnetometers are positioned in the satellite's nose (opposite to the magnetorquers) to serve as rate sensors and control the magnetorquers.

To achieve three-axis stabilization and control the attitude, the satellite utilizes electrically powered reaction wheels, also known as momentum wheels, which are installed along three orthogonal axes within the spacecraft. A common practice is to employ a four-wheel pyramid configuration, with an extra wheel for redundancy. These reaction wheels possess remarkable precision, which is of paramount importance for the success of the mission. Furthermore, three magnetorquers, aligned in parallel with the satellite's reference axes, are located at the aft of the platform, far from the magnetometers, and are carefully designed to exhibit a low residual dipole moment. Crucially, all these components are required to function flawlessly even in frigid temperatures as low as -30 degrees Celsius.

**Propulsion**

*Contributor: Name(s)*

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**Power**

*Contributor: Name(s)*

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**Thermal Control**

*Contributor: Name(s)*

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**Telemetry, Tracking, and Command**

*Contributor: Name(s)*

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CubeSat Mission Design*Contributor: Name(s)*

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**Note: Page limit**

Please keep in mind that the page limit for the report is 5 pages (excluding bibliography)!

**Note: Content of Paragraphs**

Please keep in mind that you should not only state your results, but also explain how you have achieved/calculated your findings. It is also important to interpret and comment the presented results (e.g. Concluding if something is feasible or not, based on your calculations). Both points should be considered in all of the paragraphs.

**Note: Use of References**

References e.g., books, data sheets or company websites have to be cited, when used in the report.   
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**Monography (online):**J. K. Author, “Title of chapter in the book,” in Title of Published Book, xth ed. City of Publisher, Country: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx. [Online]. Available: http://www.web.com

**Books with Editors**J. K. Author, “Title of chapter in the book,” in Title of Published Book, X. Editor, Ed., City of Publisher, Country: Abbrev. of Publisher, year, pp. xxx–xxx

Example:  
L. Stein, “Random patterns,” in Computers and You, J. S. Brake, Ed., New York, USA: Wiley, 1994, pp. 55–70

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| [1] | IEEE Periodicals Transactions/Journals Department. “IEEE REFERENCE GUIDE”. ieeeauthorcenter.ieee.org. <https://ieeeauthorcenter.ieee.org/wp-content/uploads/IEEE-Reference-Guide.pdf> (24.05.2023) |
| [2] | J. K. Author, “Title of chapter in the book,” in Title of His Published Book, xth ed. City of Publisher, Country: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx |
| [3] | First Name Initial Name / Company, “Title of Datasheet,” Publication date. Web Address (retrieved Date Accessed) |