PROJECT

PHOENIX

Introductions

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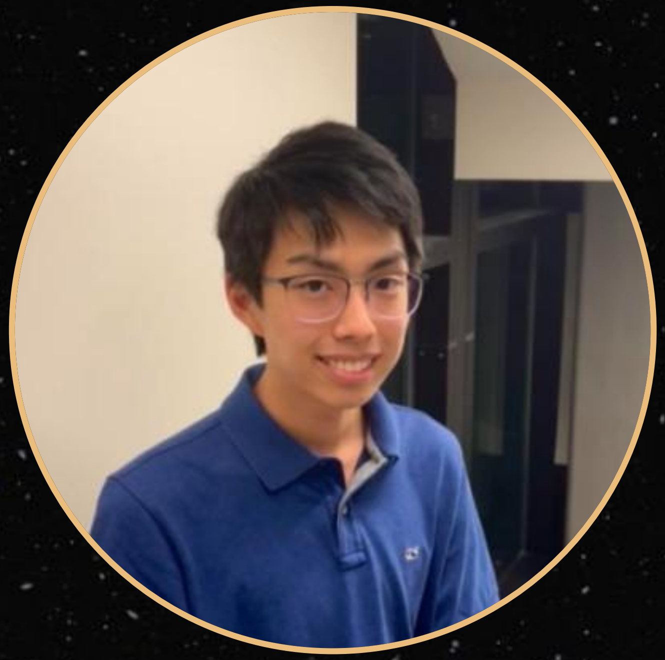

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Mission Statement

We aim to investigate Venus's superrotation (and specifically how updrafts over extreme geologic formations affect super rotation) using an orbiter and three smaller gliders. The orbiter will serve as the central hub, collecting and transmitting data to Earth, while the glider measures wind speed, as well as (possibly) temperature and pressure at various atmospheric heights

Why?

We hope this data will help us uncover what drives Venus's superrotation. This will help us learn more about how planets' climates work, improve weather models, and prepare for future space exploration.

Our Focus

Main goal-> narrow focus on one aspect of the probe: control/communications

Top Level Requirements

1. Launch orbiter into stable Venusian orbit
2. Deploy drones to collect data
   a. Place drones in key locations with high altitude to investigate super-rotation
   b. Transmit data from drones

Launch & Orbit

Step 1: Launch & Earth Departure

- Use a **Falcon Heavy** to launch the orbiter into **low Earth orbit (LEO)**.
- Perform a **trans-Venus injection (TVI)** burn to set the orbiter on a **Hohmann transfer trajectory** toward Venus.

Step 2: Cruise & Mid-Course Corrections

- The spacecraft will **coast for ~4-6 months**, adjusting its trajectory with **small thruster burns** to ensure proper alignment with Venus.

Step 3: Venus Orbit Insertion (VOI)

- As the orbiter approaches Venus, it will conduct a **major braking burn** (aerobraking or retrograde engine burn) to **slow down and be captured by Venus' gravity**.
- The burn will place it into an **elliptical orbit**, which can be adjusted later.

Step 4: Orbital Adjustments & Science Operations

- Perform final orbit **circularization burns** to achieve the desired operational orbit.
- Begin **science operations**, collecting data and transmitting it back to Earth.

Quick Launch Explanation

A **Trans-Venus Injection (TVI)** is a high-speed maneuver that sends a spacecraft from **low Earth orbit (LEO) onto an interplanetary trajectory toward Venus**. This maneuver is executed by firing the spacecraft's **main engine** (or an upper stage) at a precise point in Earth's orbit to give it the **necessary velocity to escape Earth's gravity and enter a heliocentric (solar) orbit** that intersects Venus' path.

- **Timing:** The TVI burn is carefully timed so that Venus will be at the correct position when the spacecraft arrives. This is based on launch windows, which occur **every ~19 months** when Earth and Venus are optimally aligned.
- **Delta-v (Δv):** The required change in velocity depends on the spacecraft and rocket, but it's typically around **3-4 km/s** beyond Earth's escape velocity (~11.2 km/s).
- **Result:** After TVI, the spacecraft is now in an orbit around the Sun, gradually making its way toward Venus.

A **Hohmann transfer** is the most **fuel-efficient** way to move a spacecraft from one circular orbit (Earth) to another (Venus) using **two engine burns**:

1. **First Burn (TVI)** → Places the spacecraft into an elliptical orbit around the Sun, where its **aphelion (farthest point)** is at Earth's orbit and its **perihelion (closest point)** is at Venus' orbit.
2. **Second Burn (Venus Orbit Insertion - VOI)** → When the spacecraft reaches Venus' orbit, it fires its engines again to slow down and enter Venus' gravitational influence.

Since Venus is **closer to the Sun than Earth**, the spacecraft must **reduce its heliocentric velocity** so that the Sun's gravity pulls it inward. This is why TVI doesn't just push the spacecraft away—it actually **lowers its solar orbit to intersect with Venus.**

- **Time to reach Venus:** About **4 to 6 months** depending on the exact trajectory.
- **Efficiency:** This method minimizes fuel use but requires precise timing.

Probe Deployment & Reentry

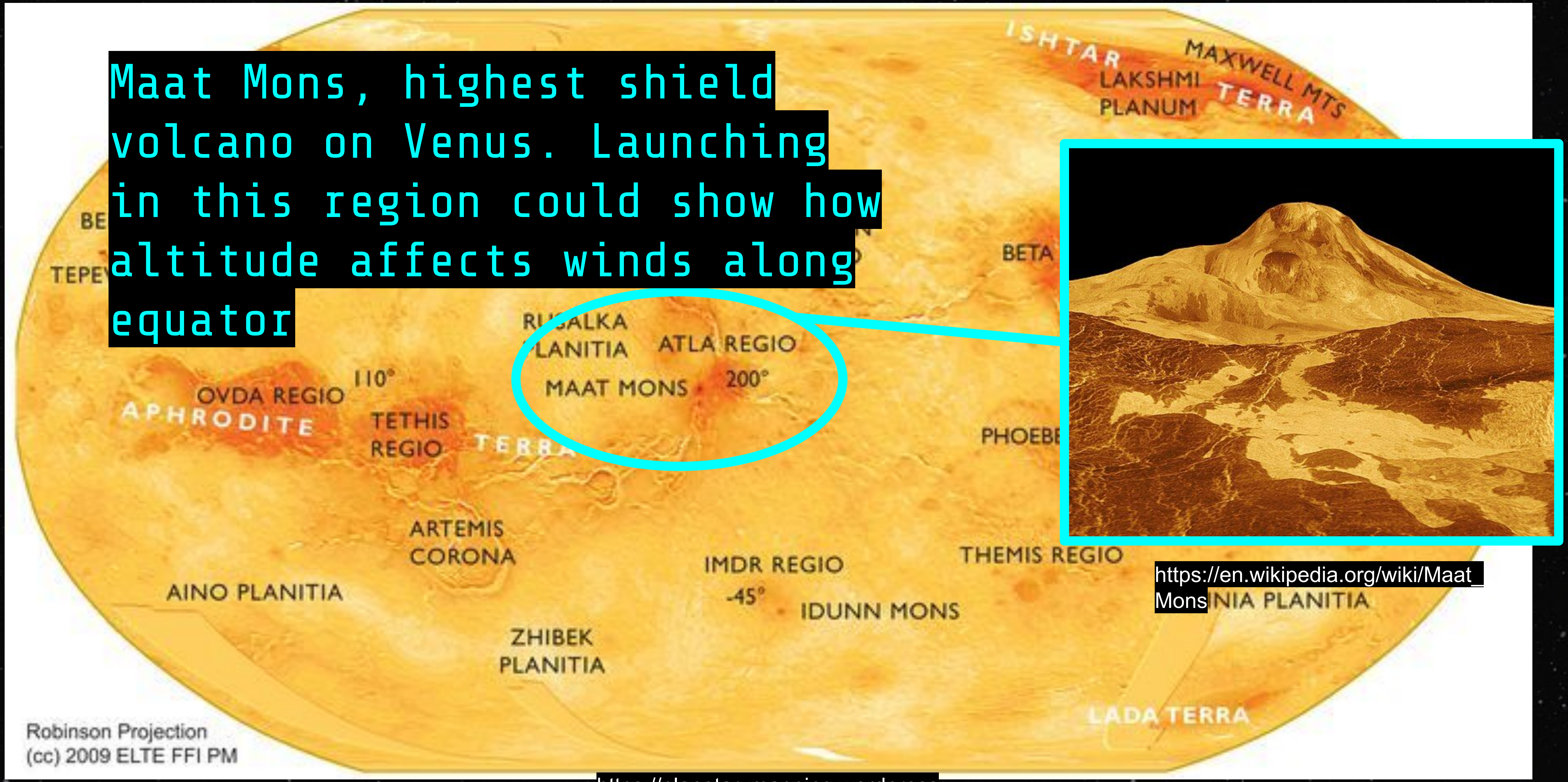
1. **Pre-Deployment Orbit Preparation:**
   - The orbiter performs an orbital adjustment to align with the designated drop zones (Maat Mons, Maxwell Montes, Phoebe Regio).
   - The drones are prepped for release, with internal batteries charged and communications tested.
2. **Atmospheric Entry Sequence:**
   - The orbiter releases the drones at an altitude of **150-200 km** above Venus.
   - Drones enter the atmosphere at a velocity of **~7.5 km/s**, requiring **aerobraking or small retro-thrusters** to reduce descent speed.
3. **Thermal Protection & Deceleration:**
   - **Heat-resistant tiles and ablative shielding** protect the drones from atmospheric heating (~460°C at lower altitudes).
   - **Parachute deployment at ~65 km altitude** slows descent to ~40 m/s.
   - Aerodynamic glider wings unfold once velocity is reduced to a safe level (~20 m/s).
4. **Glide & Navigation Phase:**
   - Drones transition from free-fall to controlled gliding.
   - **Magnetic navigation recalibrates using Venus' weak induced magnetosphere**.
   - Dynamic soaring techniques are activated to extend flight duration.
5. **Science Data Collection & Transmission:**
   - Gliders at **50 km** capture wind speed (updraft wind speed), as well as possibly collecting data on pressure and temperature.
   - Data is sent in packets to the orbiter, which transmits it to Earth.

Quantitative Mission Requirements

- **Probe Durability:** Must survive in Venus' upper atmosphere (**50 km altitude**) for at least **48 hours** before failure.
  - **Why?** Ensuring a minimum operational time frame allows sufficient data collection before environmental degradation.
- **Wind Resistance:** Probe must maintain stable flight in **60 m/s super-rotational winds**.
  - **Why?** Stability is critical to prevent loss of control, ensure data accuracy, and maintain communications with the orbiter.
- **Communication Latency:** Orbiter must transmit data to Earth within a **10-15 minute delay window**.
  - **Why?** Minimizing latency ensures near-real-time monitoring and allows mission control to make course corrections if necessary.
- **Power Requirement:** The probe must have access to around 1518W (see Power Budget slide) through a combination of solar and pre-stored battery power.
  - **Why?** Adequate power is needed to operate instruments, sustain communication, and maintain controlled flight over the mission duration.

Engineering Requirements

Launch into various geographic regions of Venus (1 glider per region)



Maat Mons, highest shield volcano on Venus. Launching in this region could show how altitude affects winds along equator

https://en.wikipedia.org/wiki/Maat_Mons

https://planetarymapping.wordpress.com/wp-content/uploads/2016/02/venus_big.jpg

Engineering Requirements

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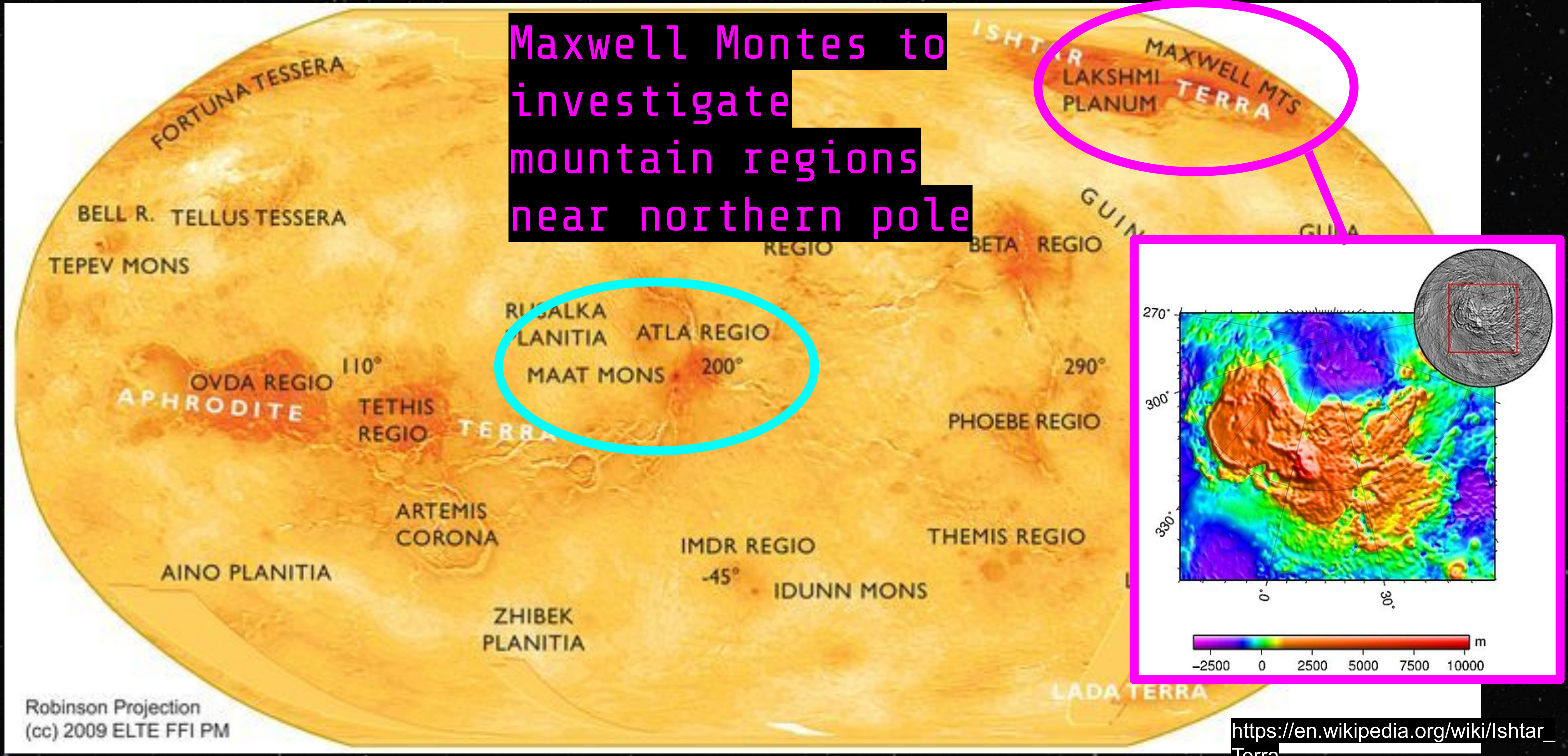

https://en.wikipedia.org/wiki/Ishtar_Terra

Engineering Requirements

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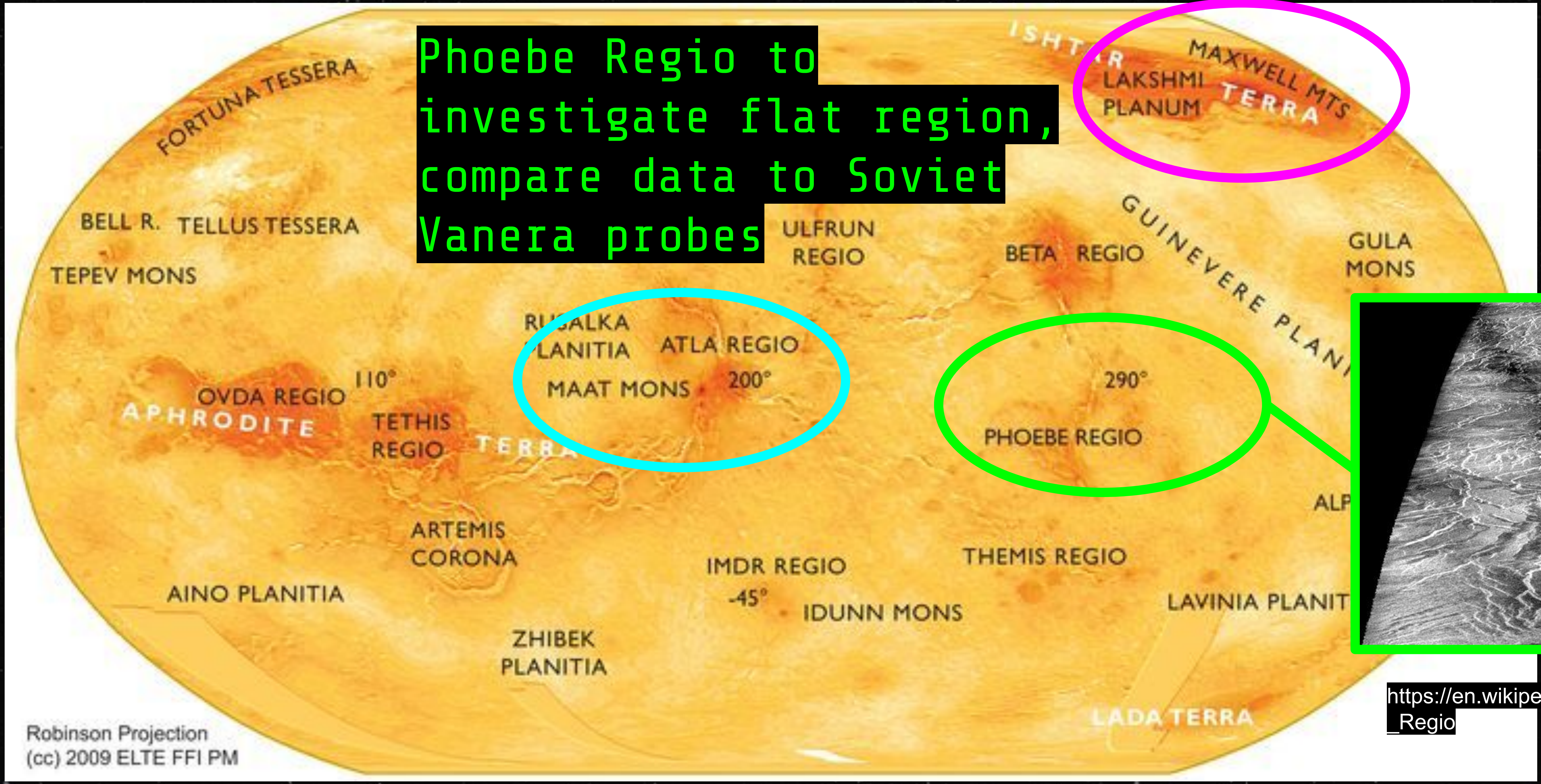
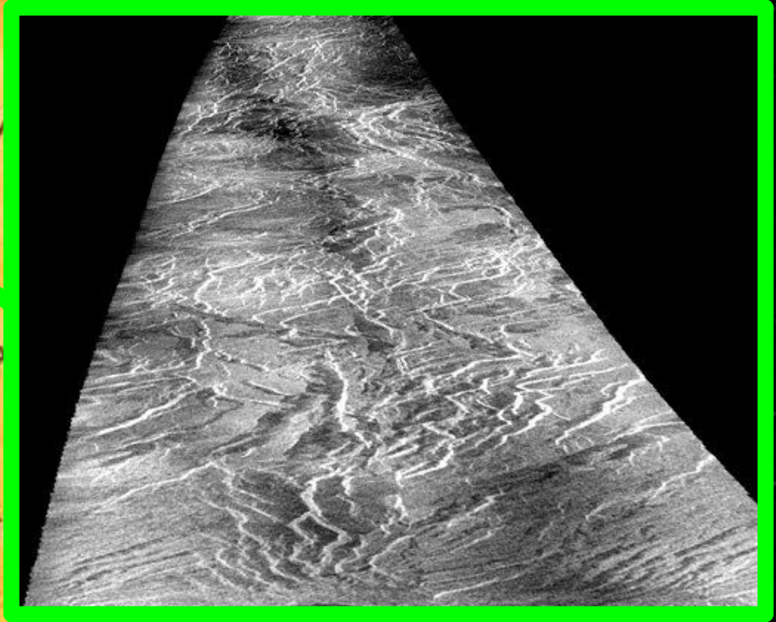




https://en.wikipedia.org/wiki/Phoebe_Regio

Engineering Requirements

Venus Orbit Insertion & Probe Deployment:

- Orbiter enters polar orbit, enabling global coverage over three target regions:
  - Maat Mons (equatorial volcanic region).
  - Maxwell Montes (mountainous terrain, northern pole).
  - Phoebe Regio (flat plains for comparative analysis).

- At each region, the orbiter deploys one probe:
  a. Low-Altitude Probe (LAP) (~50 km) → captures atmospheric wind speeds, temperature, pressure, and magnetospheric fluctuations.
- Orbital maneuvering ensures precise probe drop timing and positioning.

Justification of Winged Architecture

Winged Glider (Chosen)	- Can generate lift for extended loiter time.- Enables controlled flight path for targeted data collection. - Reduces drift caused by Venus' high winds. - large wing surface area allows us to collect power	- Requires more complex navigation. - High-energy demand for control surfaces.
Balloon	- Simple design, minimal power needs. - Passive data collection possible.	- Drifts uncontrollably with winds. - Limited altitude control.
Lifting Body (Disk Drone)	- Higher aerodynamic efficiency. - Better stability in turbulence.	- Complex manufacturing. - Limited deployability in Venus’ atmosphere.

Engineering Requirements

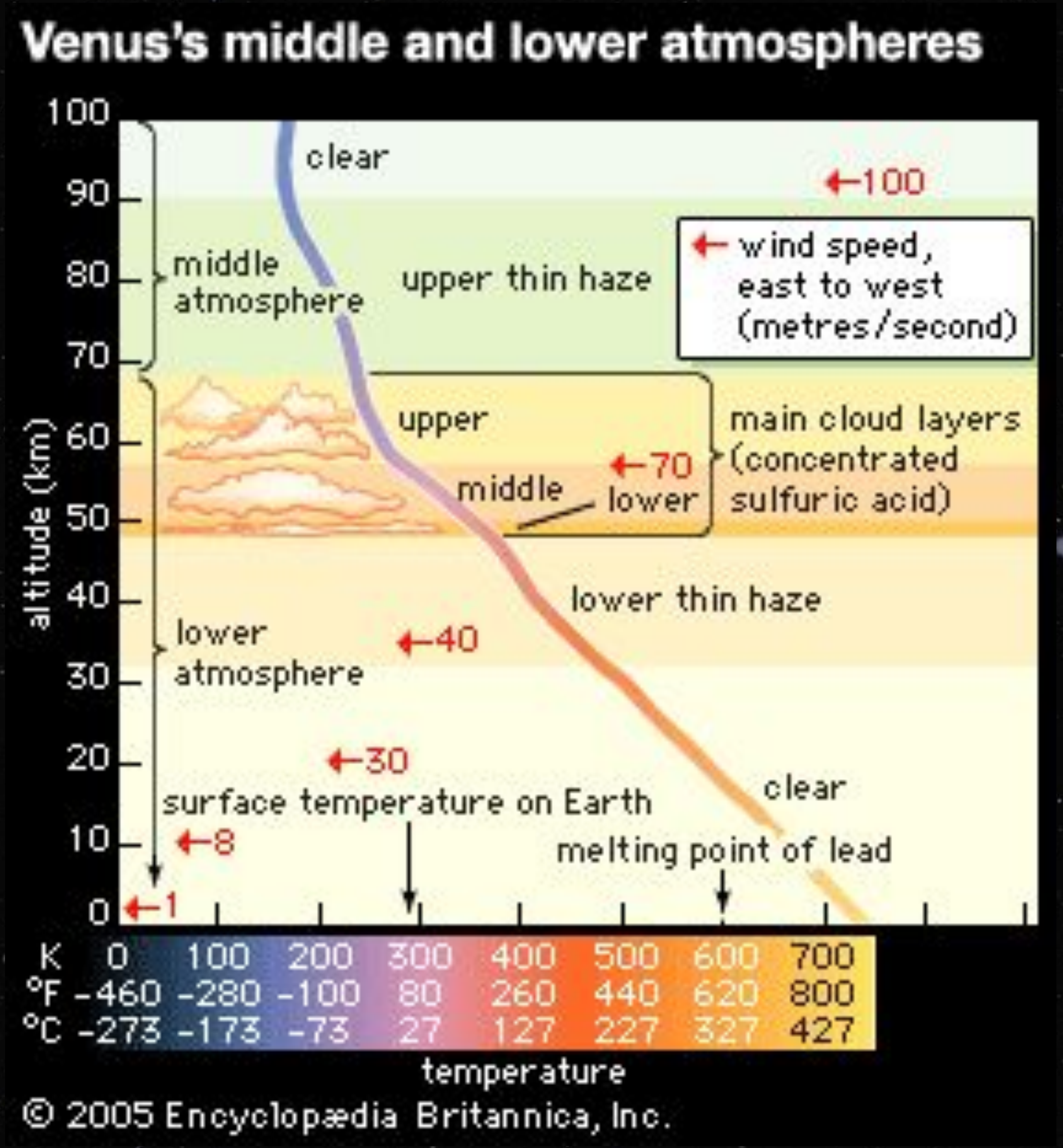
Collect data from launched drones

- Communications system pipeline: atmospheric probe/drone -> orbiter
- In order to collect meaningful data, we have decided to transition to a magnetic guidance glider system for the launched drones.
- Area of sample zone of interest = 530x435 miles^2
  - Balloons following random trajectories may drift outside of regions of interest:
    - Data collection time minimum = (435/2 miles)/(134mph) = 1 hr 37 mins.
  - Gliders following magnetic navigation could potentially follow a straight path:
    - Data collection time minimum = (530 miles)/(134mph) = 3 hours 57 minutes.

Engineering Requirements

- **Target Altitude:** 50km
  - 60 m/s winds
  - Sulfuric acid clouds
  - Approximately earth-like temperatures and pressures
  - Low visibility due to dense atmosphere/cloud cover

- **Why?:**
  - Earth Like conditions make this a particularly suitable region for drone deployment.
  - Able to collect wind speed, temperature, and composition data about venus' atmosphere necessary to investigate super-rotation.



https://www.britannica.com/place/Venus-planet/The-atmosphere

Engineering Requirements

Gliders need to be able to withstand atmospheric conditions for days at a time.

- Problem: Passing Through Sulfuric Acid Clouds
- Approach: Necessary to ensure that vital electronics are sealed from the surrounding atmosphere. Magnetic propellers to reduce exposure to elements. Sulphuric acid resistant materials such as teflon and titanium used in probes.

- Problem: Dense Venusian Atmosphere Causing Decreased Solar Efficiency
- Approach: Probe can perhaps ascend to higher altitudes to reclaim power, onboard batteries to allow for longer operation. Selected sensors need to be effective in low visibility conditions. Suitable for our mission, where we are measuring wind speeds and temperature fluctuations.

- Problem: Surviving Atmospheric Entry
- Approach: Heritage carbon-phenolic thermal protection systems, shallow flight path angle to minimize thermal load. Aerobraking necessary to get to operational speed and deploy glider.

Essential Payload Subsystem Overview: The Glider

Doppler Lidar

- **Purpose** : **Measures wind speed at different altitudes** by using Doppler shift in laser pulses reflected from atmospheric particles
- **Why:** We can identify how updrafts over extreme geological features affect super rotation
- **Relevance:** Identify direct effect of updrafts on super rotation

Magnetometer:

- **Purpose:** needed for navigation and control purposes to allow for autonomous flight over specific areas, also useful for studying effects of solar wind (nonessential secondary purpose)
- **Why**: we must have a stable reference point to allow for effective navigation over specific regions

Probe Sensor Array (Non-Essential)

Pressure Sensor

- Purpose: Measure pressure gradients at different altitudes
- Why: Can detect small scale atmospheric waves and turbulence that might contribute to momentum transfer
- Relevance: Helps explain how momentum is being transferred in Venus' atmosphere

Cloud Particle Analyzer

- Purpose: Measure size, concentration, and other distribution of cloud particles
- Why: Help understand how cloud formation and particle interaction might contribute to momentum transfer
- Relevance: Cloud particles act as tracers that reveal the strength/characteristics of updrafts

Non-Essential (Nice to Have) Payload

Subsystem Overview: The Glider

Infrared Radiometer

- **Purpose:** Measures **temperature** at different altitudes by measuring thermal infrared radiation
- **Why:** Thermal tides are caused by temperature differences
- **Relevance:** Interaction between **thermal tides and planetary waves might contribute to super rotational winds**

Spectrometer (High-Resolution Visible & Infrared)

- **Purpose:** Analyzes the **composition of Venus' atmosphere** and presence of different gases
- **Why**: Gases like CO2 and SO2 contribute to atmospheric temperature
- **Relevance:** Quantify effect of **radiative heating on thermal tides**

Other Non-Essential (Nice to Have)

Payload Subsystem Overview: The Orbiter

UV and Infrared Cameras

- **Purpose:** Track cloud movement
- **Why:** Provides **spatial understanding** of temperature variations
- **Relevance:** Identifies heat distribution driving atmospheric motion

Radio Occultation Instrument

- **Purpose:** Measures **temperature, pressure, and density** of atmosphere by analyzing how radio waves are refracted as they pass through different layers of atmosphere
- **Why**: Analyze vertical temperature fluctuations
- **Relevance:** Complements Doppler Lidar and cloud tracking to **link temperature variations to wind speed and superrotation**

Other Necessary Hardware

Radio Communications

- Directional radio needed for communication glider and orbiter
- High-gain directional antenna needed for communication with Earth

Cooling System (possibly)

- Probe may benefit from on-board cooling system to allow it to survive harsher temperatures at lower altitudes

Memory System

- probes will need to be able to store information on-board until the next pass over of the orbiter, at which point data will be transferred to orbiter and subsequently transmitted back to Earth

Control Sensor Hardware:

- magnetometer as a reference point, gyroscope & accelerometer sensors for orientation

More Subsystems

Power Subsystem (Solar)

- At 50 km, solar intensity is similar to Earth (~1300 W/m^2)
- Glider will benefit from high solar intensity and manageable temperatures, making it ideal for solar power
- Battery: Silver-zinc batteries are robust enough for Venus' atmosphere

Propulsion (Hybrid)

- Dynamic soaring
  - Leverages super rotational winds to generate lift and propulsion
  - Requires a script to implement adaptive control
  - Reduces reliance on stored energy
- Solar-electric propulsion
  - Unlimited energy supply in upper atmosphere
  - Requires battery

Important Notions

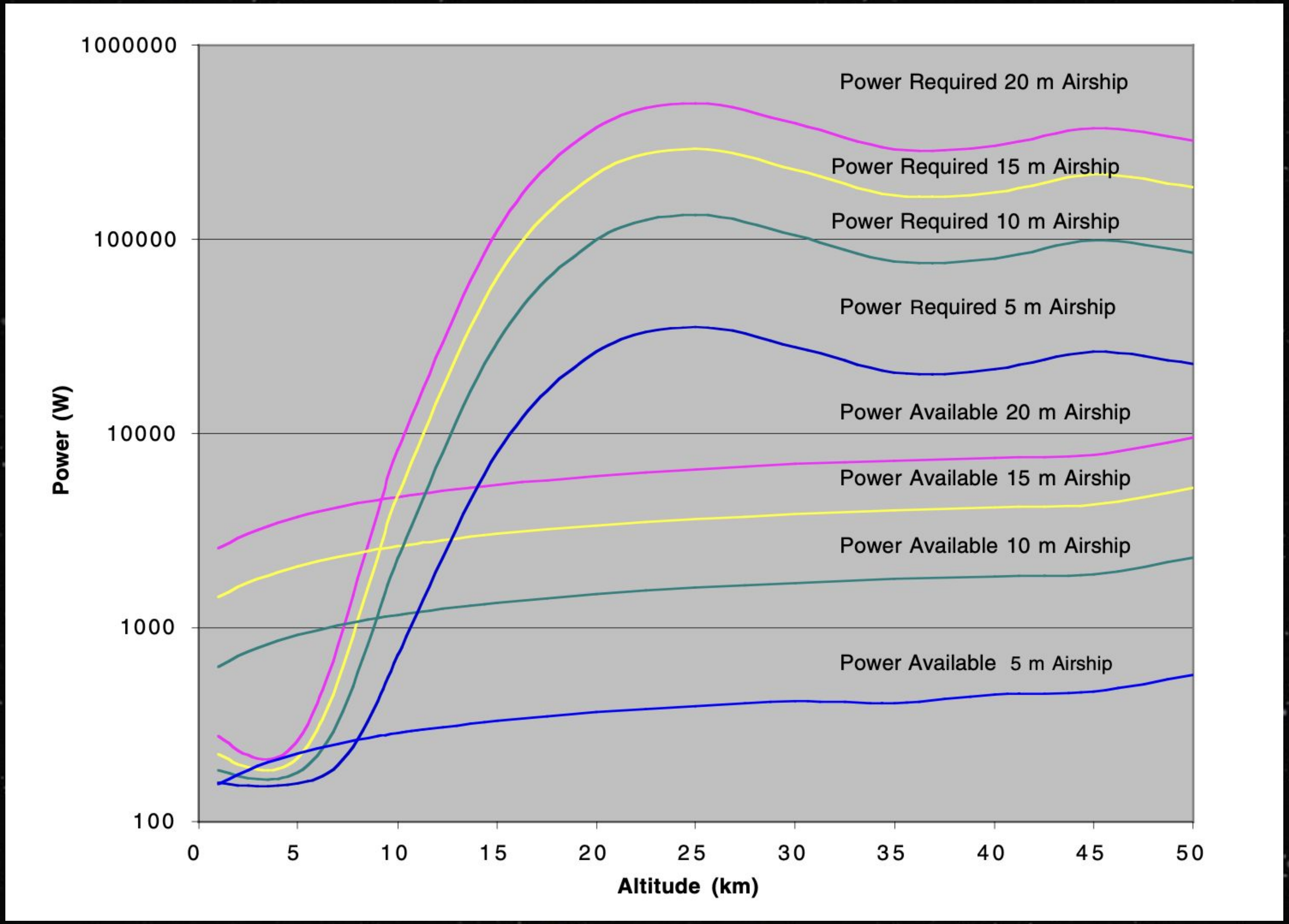
Wind speeds at 50 km are around 60 m/s

Drone must generate significant power to avoid drift

Additionally, some concerns are:

- High Energy Demand: Propulsion must overcome strong atmospheric winds, increasing power consumption

- Power Limitations: Solar power may be insufficient in cloud-covered regions below 65 km (problem for us since we are aiming to fly at 50 km → will need to supplement with batteries).



Mission Critical Technologies

- Payload Subsystem:
  - Holds our instruments critical to the mission
- Power Subsystem:
  - Must ensure our power subsystem can fully support the payload weight and navigate long distances.
- Radio Communication Subsystem:
  - Necessary to transmit data to and from the earth so it can be useful to researchers on Earth.
  - High-gain directional antenna, X-band relay system, onboard storage.
- Environmental Resilience:
  - Necessary to sustain the extreme temperatures of Venus.
  - Thermal shielding, acid-resistant teflon coatings, Silver-zinc batteries to supply stable power, solar panels for supplemental power.

Main Build Overview

- One critical aspect of our mission is communication between the orbiter and the glider system. We will focus on this aspect of the design by developing a directional transmitter/receiver system that will allow the transmitter on the glider to accurately point toward the receiver on the orbiter (and vice versa) as both move along their respective routes.
  - **Physical system:** the transmitter will need to be mounted on a robotic "arm" to allow it to point in any direction
  - **Stability Control:** the glider's movement is unstable, so we will need to stabilize the transmitter as it attempts to point at the target
  - **Tracking Algorithm** : we will need to develop some way to allow the transmitter to find the position of the receiver and keep that position as the glider moves
  - **Main Tasks:** develop physical "arm" with servos and gyro/accelerometer sensors, develop all control and stability algorithms, attach our transmitter device to a drone and test whether it can track a moving ground target (using either a laser or radio)

Project Plan

Phase 1: Concept Development & Feasibility (Months 1-6)

- **Define key mission objectives and science goals.**
- **Select orbiter and probe payloads (LIDAR, spectrometer, magnetometer).**
- **Conduct initial simulations for orbital trajectory feasibility.**

Phase 2: Engineering Design & Prototyping (Months 7-14)

- Construct orbiter and probe prototypes, focusing on thermal shielding (Venus heat resistance), power management (solar vs. RTG feasibility), and communications testing (orbiter-to-probe link validation).
- Perform wind tunnel and vacuum chamber tests for Venus' conditions.

Project Plan, Continued

Phase 3: Integration & System Testing (Months 15-22)

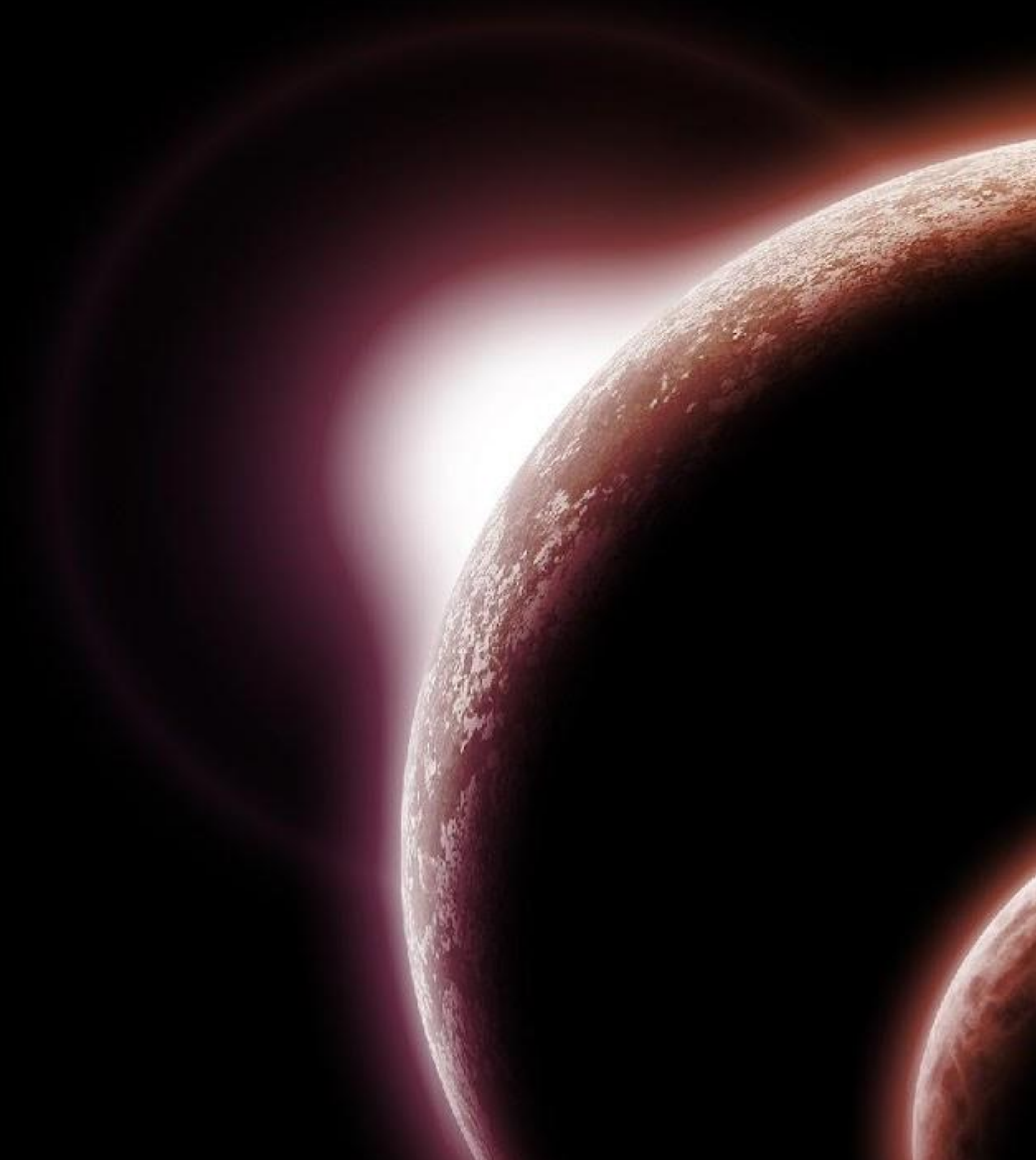
- assemble final flight model with all subsystems integrated.
- conduct rigorous vibration tests for launch coordinates.
- high-altitue balloon trials to simulate Venus' upper atmosphere.

Phase 4: Launch Preparation & Deployment (Months 23-30)

- Secure launch vehicle (Rocketlab Electron or Falcon 9).
- Perform final system validation at launch site (Cape Canaveral/New Zealand).
- Align launch with optimal Venus transfer window (every ~19 months).

Phase 5: Mission Execution & Data Collection (Months 30+)

- Perform Venus Orbit Insertion (VOI) and deploy probes.
- Monitor and analyze wind speeds, pressure,



Mission Plan - Coordinated Data Collection

Two-Tiered Transmission Process:

1. Probe navigates magnetically:
   a. Uses magnetometer guidance to maintain position despite Venus’ extreme winds.
   b. Captures real-time atmospheric fluctuations, ensuring extended data collection.
2. Orbiter transmits to Earth:
   a. Stores and forwards data to Deep Space Network (DSN) via X-band high-gain antenna.
   b. Enables continuous scientific monitoring across different atmospheric regions.

Mission Plan - Mission Execution

Sequential Region Deployment Strategy:

- After completing Maat Mons observations, the orbiter executes a controlled orbital shift to deploy the next glider at Maxwell Montes, followed by Phoebe Region.
- Each glider system remains operational for several days, ensuring:
  - Stable magnetometer-based navigation prevents uncontrolled drift.
  - Extended atmospheric sampling provides unparalleled climate data.
  - Comparative analysis across all three regions enhances planetary models.

Scientific Goals and Future Impact:

- Unlocking Venus’ superrotation mechanics through studying effects of updraft in geologically extreme locations.
- Refining planetary climate models for future Venus and exoplanet missions.
- Pioneering magnetic-field-guided flight for sustained atmospheric exploration.

Business Case (Source of Funding)

Main selling point: All-purpose probe that can withstand extreme environments

Type	Pros	Cons
Government Space Agencies (NASA + JAXA)	1. Expertise in space missions/have tools and equipment to make it happen 2. Prioritizes research and discovery	1. Lengthy Bureaucratic Processes 1. Funding depends on political priorities
Defense Organizations (US Space Force)	1. US funnels money into our military 2. Expertise in space missions/have tools and equipment to make it happen	1. Military Alignment 1. Limited focus on exploration and research
Private Space Sponsorships/VC	1. More willing to take risks/experiment with approaches 1. Can hit the ground running (vs bureatic process)	1. Loss of Creative Control/control over mission 1. Profit Oriented over scientific exploration

Red Tape

Legal Considerations:

1. *Data Sharing/Licensing*: Intellectual Property protection, open data policy (NASA) vs data restrictions (Military), technology licensing for software and hardware

1. *International Space Law:* Liability Convention :(1972)-> financially responsible for any damage caused by mission, Registration Convention (1976) -> prove will need to be registered with UN’s Office of Outer Space Affairs with detailed intentions/mission parameters,

1. *US Regulations*: a lot more restrictions if mission involves a private company

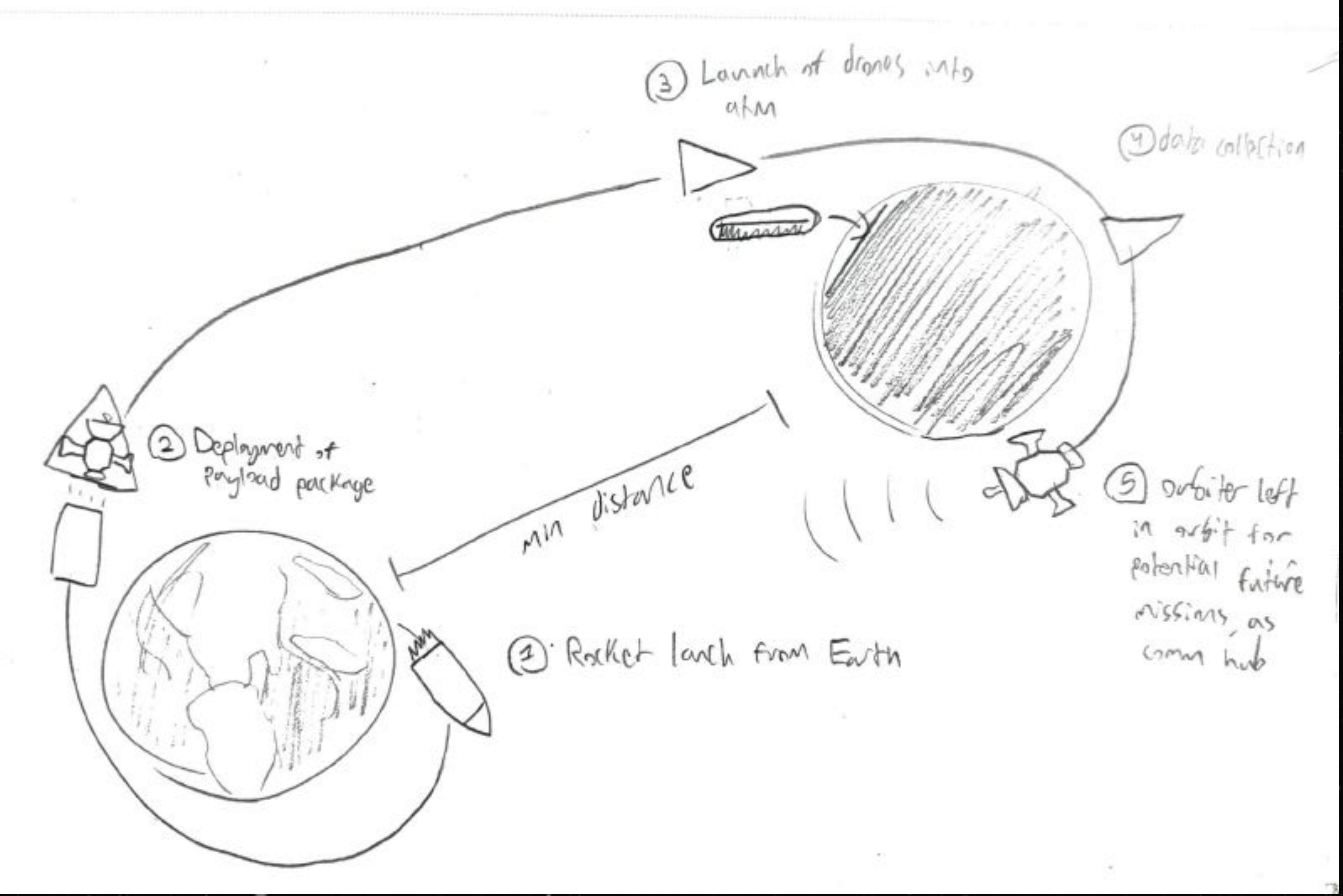
Safety Considerations

1. *Launch Safety:* work to minimize risk of launch failure and any injuries that come with it

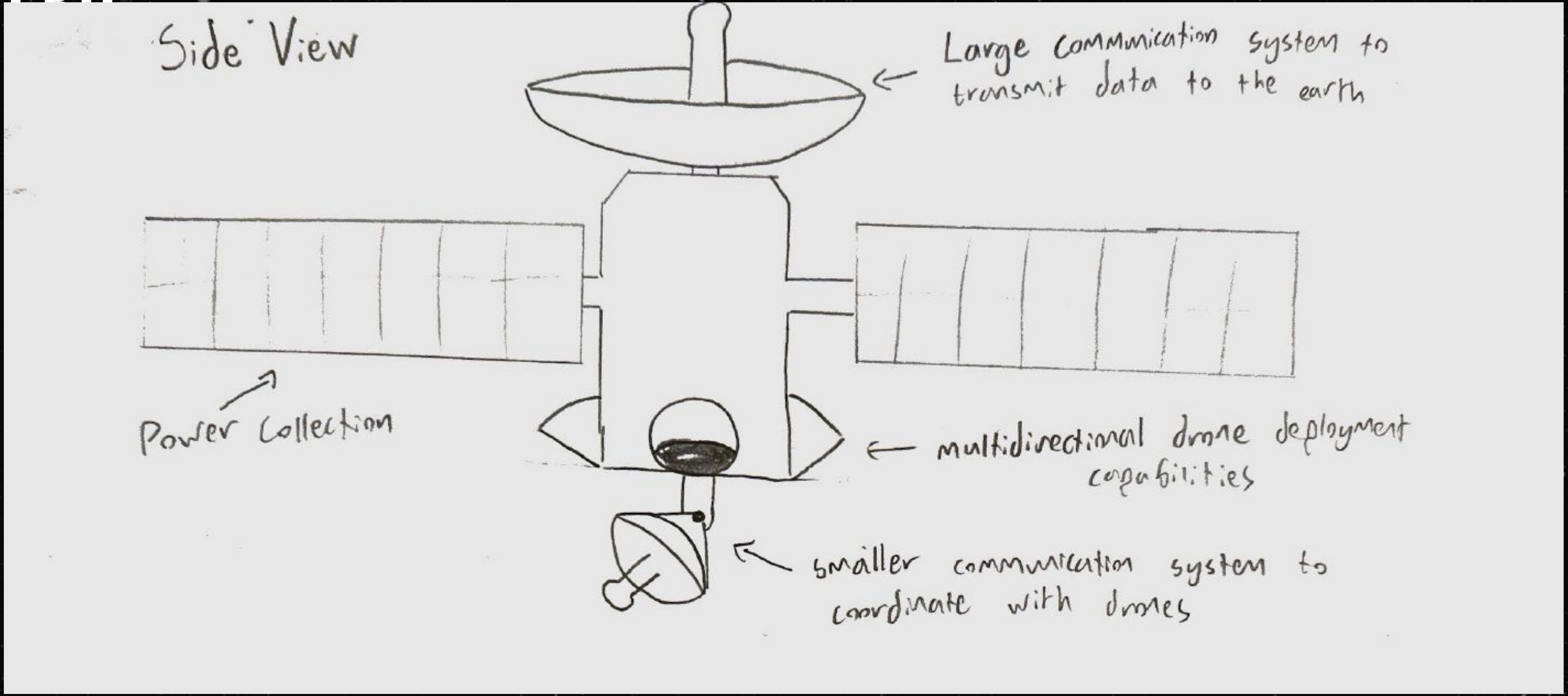
1. *Planetary Protection:* Minimize any contamination of Venus from Earth based Microorganisms

1. *Spacecraft Safety:* Probe withstand Venus’ extreme environment -> rigorous testing ->work to minimize any injuries/disasters go with trial and error

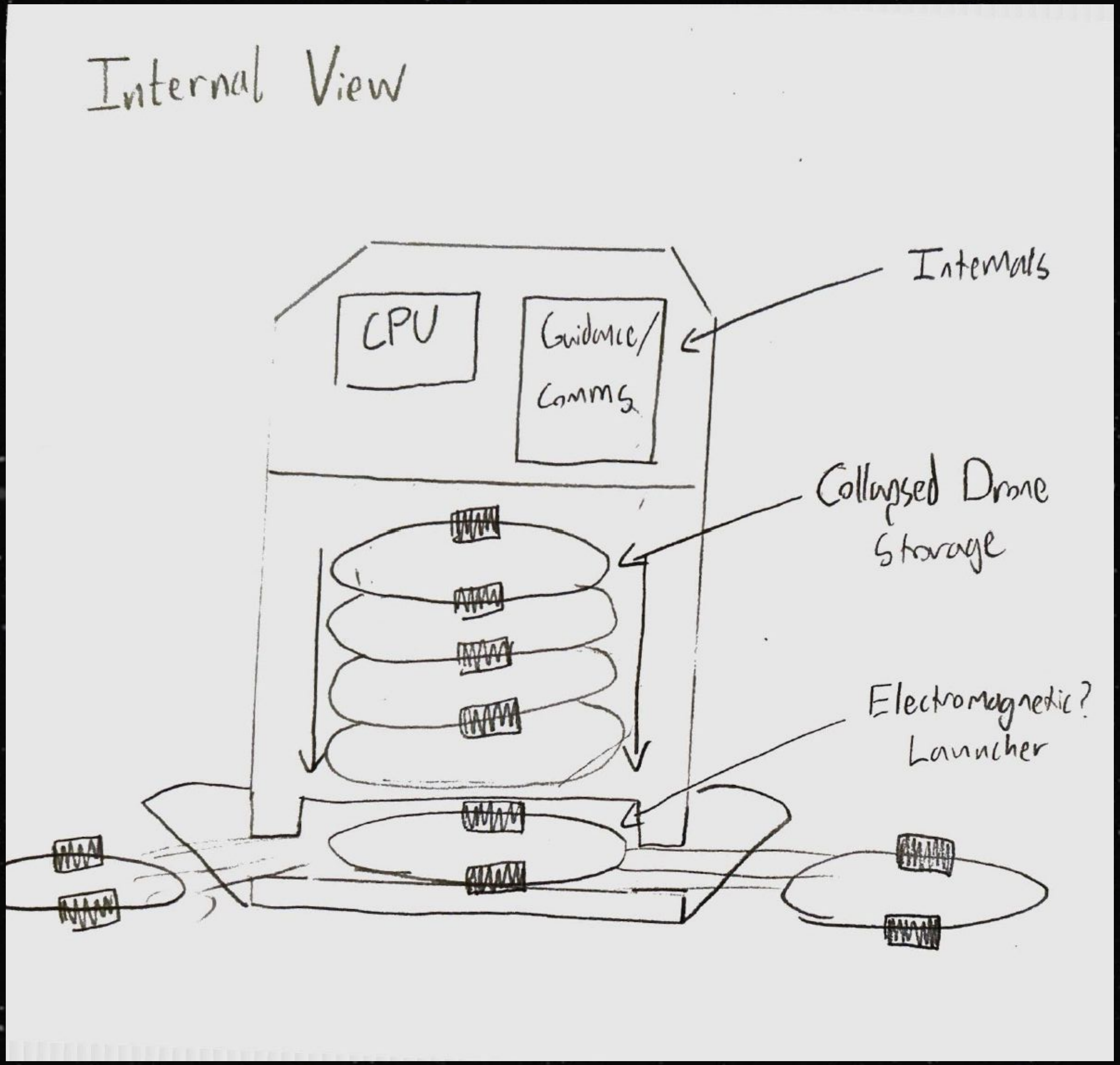
Qualitative Overview - Mission Plan

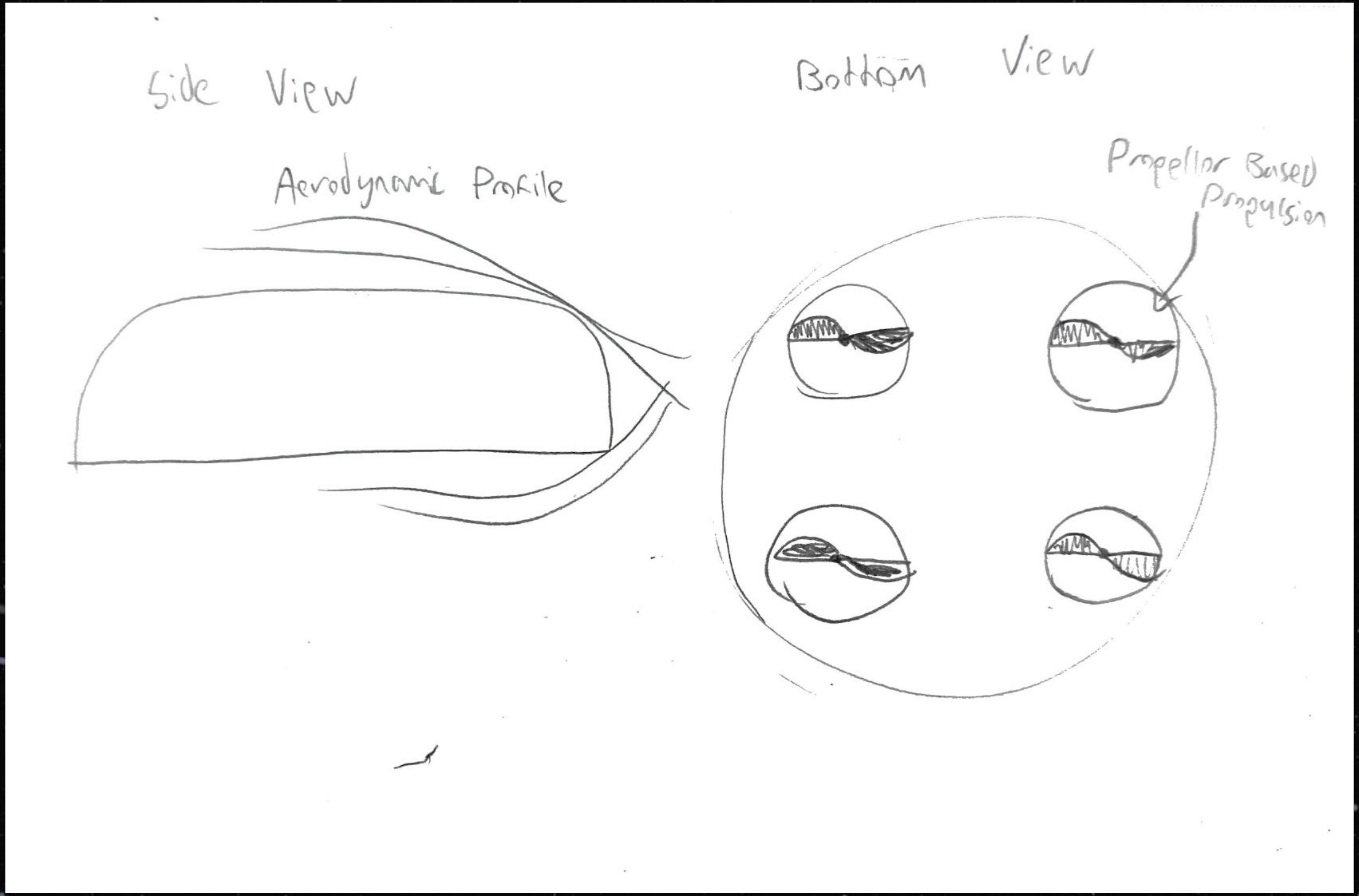


Qualitative Overview - Satellite Design

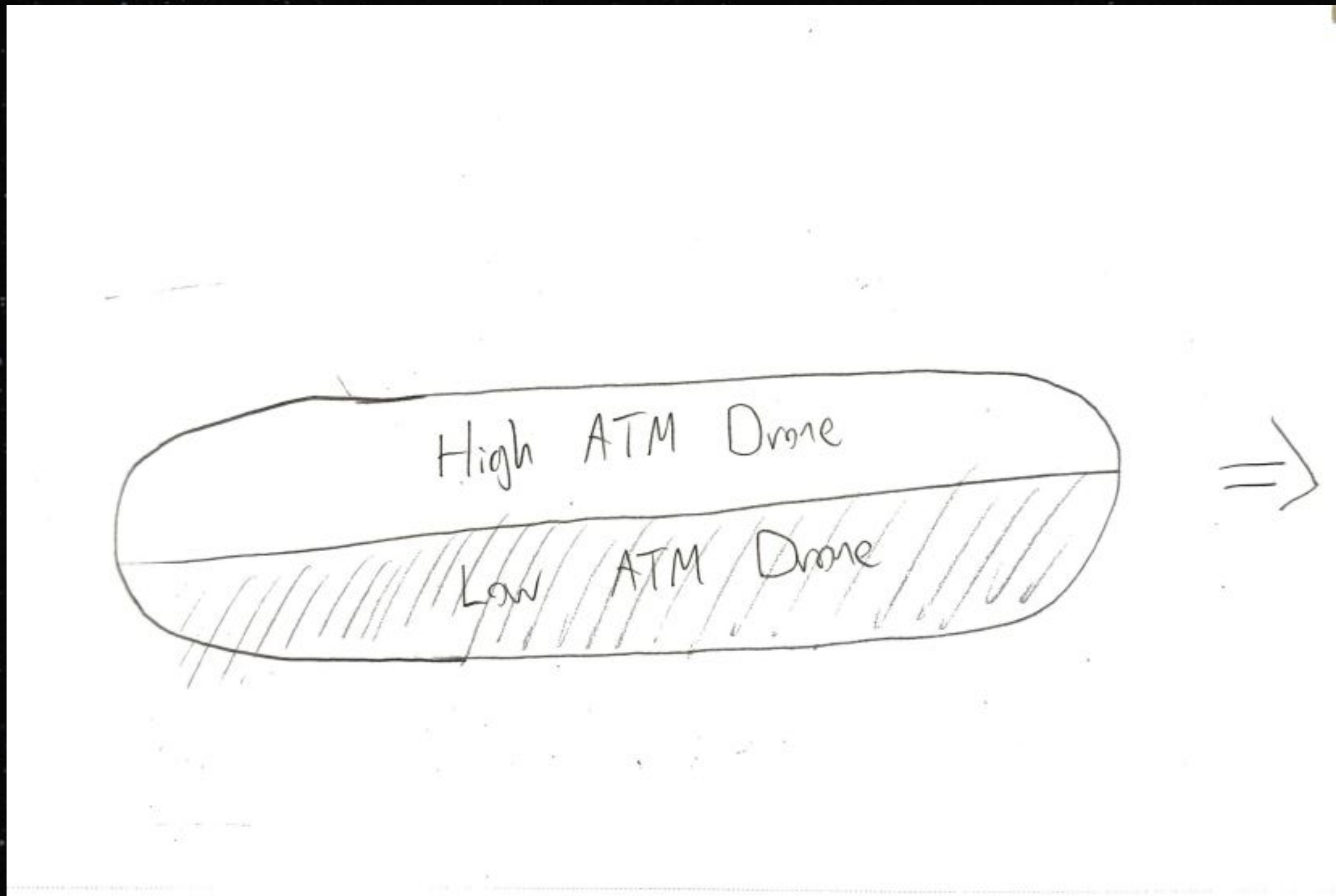


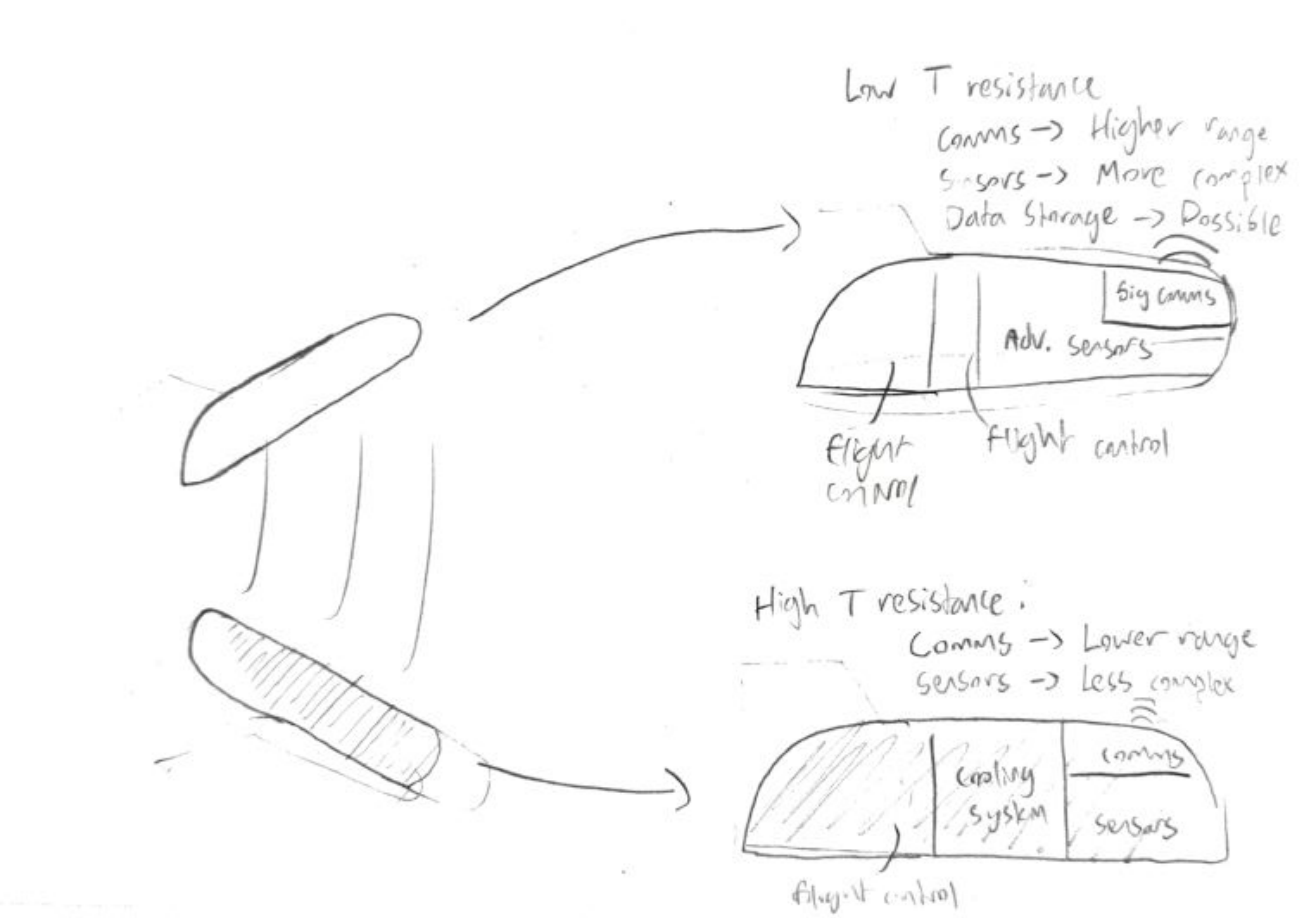
Qualitative Overview - Drone Design





Qualitative Overview - Drone Design





Power Budget (Rough Estimates)

Component	Power Consumption (W)
Avionics (Flight Computer, Sensors)	**5W**
Communication System	**7W**
Actuation System (Motors, Servos)	**1500W**
Science Instruments (LIDAR, Spectrometer, Magnetometer)	**6W**
Total Estimated Power Requirement	**1518W**

Solar Power Generation Feasibility

- Surface Area of Solar Panels: 2 m^2 (approx. for 3-3.5 m wingspan plane)
- Expected Solar Intensity: 1300 W/m^2 (at 50 km altitude)
- Solar Panel Efficiency: 32% (Triple Junction space grade with protective enclosure & AR coating added)
- Actual power acquisition efficiency: 25% (very rough estimate-see note below for justification)
- Total Power Generated: ~650W (Requires backup battery for energy shortfalls → can charge battery pre-flight on orbiter.)

*Note: Because a Venusian day is very long (around 243 Earth days), we can deploy each drone when the Sun is incident upon the target area, thus drastically improving the performance of our solar cells and allowing us to avoid efficiency losses due to the angle of the Sun. For this reason, we are leaving the estimated actual power acquisition efficiency of the solar cells high, at around 25%, which is a rough estimate.

Mass Budget (Rough Estimates)

Components	Orbiter Mass (kg)	Drone Mass (kg) (each)	Total Mass (kg)
Structural & Thermal Shielding	300	10	330
Avionics & Control System	50	5	65
Power System (Solar + Battery)	200	8	224
Communications System	75	3	84
Science Instruments	100	6	118
Propulsion (Main & RCS)	400	4	412
Parachute/Aerobraking System	N/A	5	15
Margin (20%)	225	8	249
Total Mass Estimate	**1350 kg**	**49 kg**	**1497 kg**

Optimized Mass Budget for Probe (20-25 kg)

Component	Mass (kg)	Size Estimate
Frame & Wings	5-7	2.5-3.5m span, foldable
Battery & Solar Panels	3-4	~2 m^2 panel area
Avionics & Control	2-3	Small board, integrated sensors
Science Instruments	2-4	magnetometer, IR sensor
Comms (UHF/X-band)	1-2	directional tracking antenna (transmitter)
Thermal Protection	2-3	Heat-resistant coating
Propulsion (Minimal)	1-2	Small RSC for reentry control
Margin (~20%)	3-5	Extra safety factor

Mass Budget Justifications

- **Structural & Thermal Shielding (Orbiter: 300 kg, Drone: 10 kg)** : Derived from past planetary missions (e.g., Magellan, Akatsuki). Includes high-temperature-resistant materials such as titanium alloys and aerogels, with estimates based on existing aerospace-grade shielding weights.
- **Avionics & Control System (Orbiter: 50 kg, Drone: 5 kg)** : Modeled after avionics packages in previous Venus and Mars missions (e.g., MAVEN, Akatsuki). Weight accounts for redundancies and radiation-hardened components.
- **Power System (Orbiter: 200 kg, Drone: 8 kg)** : Based on solar panel mass-energy ratios from ESA/NASA deep-space probes. Lithium-ion battery estimates drawn from high-altitude UAVs and previous Venus balloon mission designs.
- **Communications System (Orbiter: 75 kg, Drone: 3 kg)** : Mass derived from high-gain X-band antenna weights on spacecraft like Mars Reconnaissance Orbiter and Earth-Venus distance power constraints.
- **Science Instruments (Orbiter: 100 kg, Drone: 6 kg)** : Estimated using instrument payloads on comparable missions (e.g., Venus Express). Individual instrument weights taken from manufacturer specifications where available.
- **Propulsion (Orbiter: 400 kg, Drone: 4 kg)** : Calculated based on required delta-v for Venus orbit insertion, with mass breakdowns drawn from known bipropellant thruster specifications (e.g., LEROS-1b engines used in interplanetary missions).
- **Parachute / Aerobraking System (Drone: 5 kg)** : Derived from past atmospheric entry systems, including Mars Science Laboratory parachute masses scaled for Venus' dense atmosphere.
- **Margin (20%) (Orbiter: 225 kg, Drone: 8 kg)** : Standard industry practice contingency applied based on historic aerospace mission deviations.

Feasibility

Subsystem	Feasibility	Challenges
Aerodynamics/Propulsion	**Feasible**	Varying Wind Speeds
Navigation/Software	**Somewhat Feasible**	Novel Control Algorithms, Multi Body Problem
Power	**Somewhat Feasible**	High energy load for cooling/navigation… solar power may be intermittent
Environmental Hardening	**Feasible**	Done on past missions, heat in lower atmosphere most difficult
Communication System	**Feasible**	Orbiter needs to be in range, data needs to be stored
Sensors (Lidar, Radiometer)	**Feasible**	Weight Constraints

Viability (Budget)

Subsystem	Price
Orbiter Architecture/Manufacturing	50,000,000
Drone Propulsion	10,000
Power + Batteries	1,000
Environmental Hardening/Thermal	10,000
Communication System	100,000
Lidar/Radiometer/Magnetometer (3x)	128,000
Labor	30,000,000
Entry/Descent	40,000,000
R/D & Testing (probe/orbiter)	50,000,000
Launch Costs	100,000,000
Total	270,249,000

Resources & Citations

- https://astrobiology.nasa.gov/news/could-dark-streaks-in-venus-clouds-be-microbial-life/
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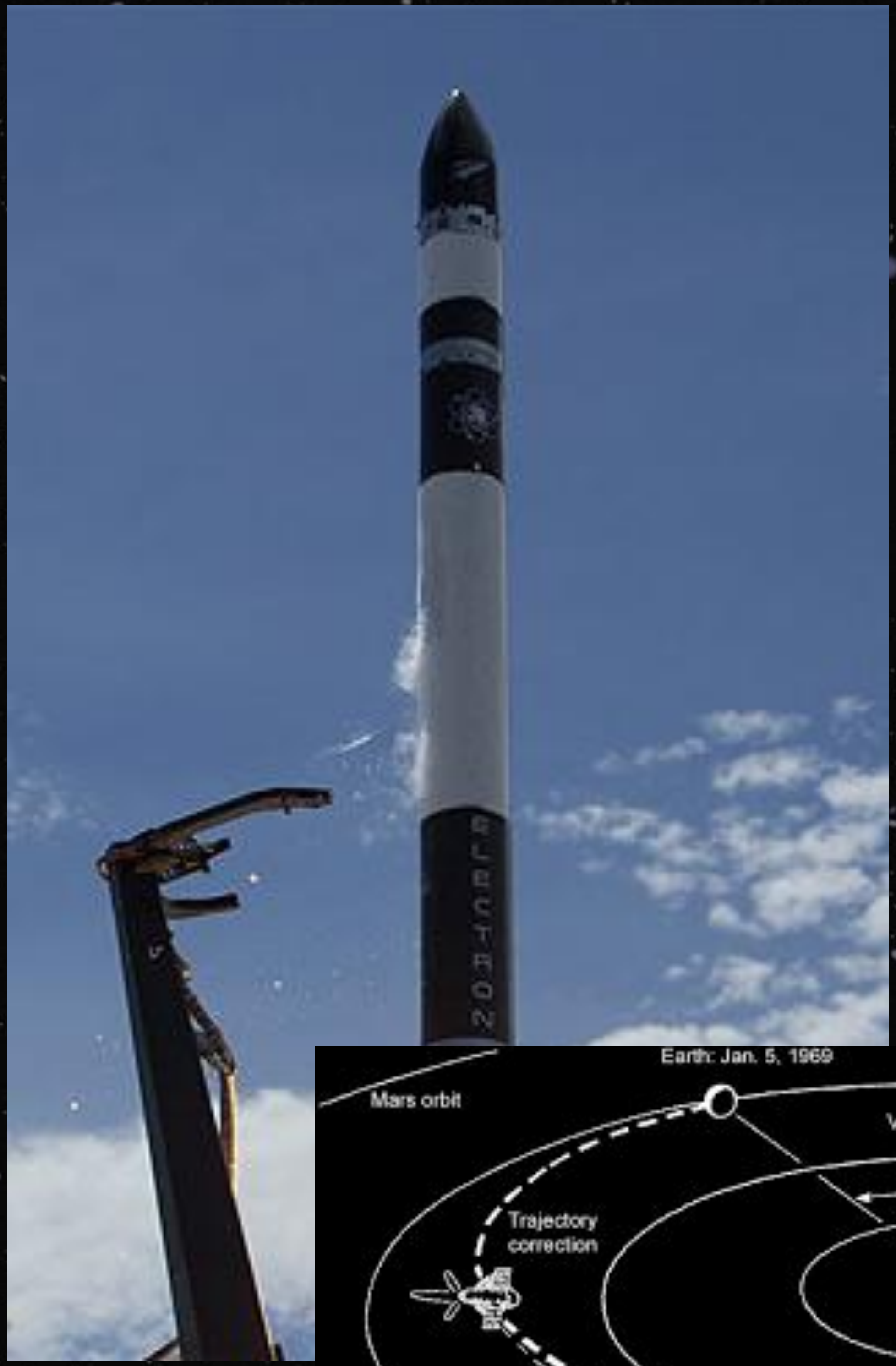
- https://mci.si.edu/infrared-and-ultraviolet-imaging
- https://www.nasa.gov/aeronautics/atmospheric-probe-shows-promise-in-test-flight/

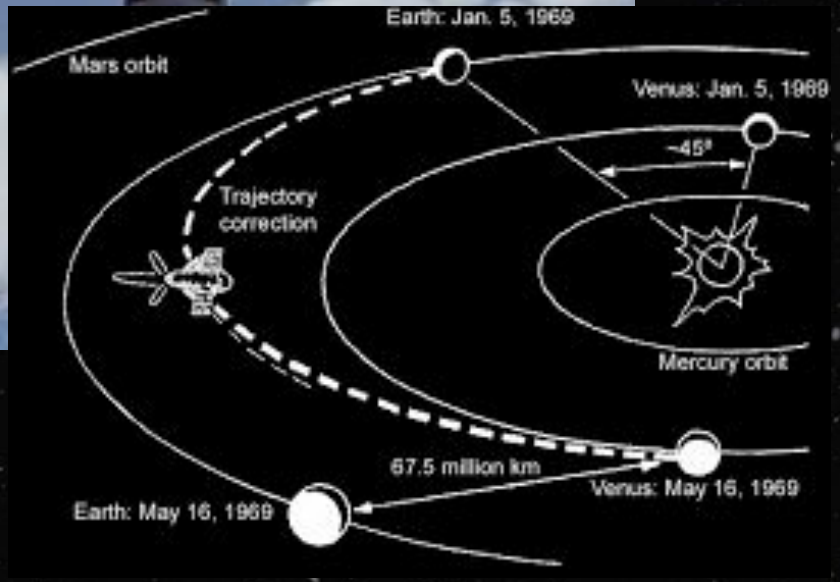
THANK YOU !

Extra Slides

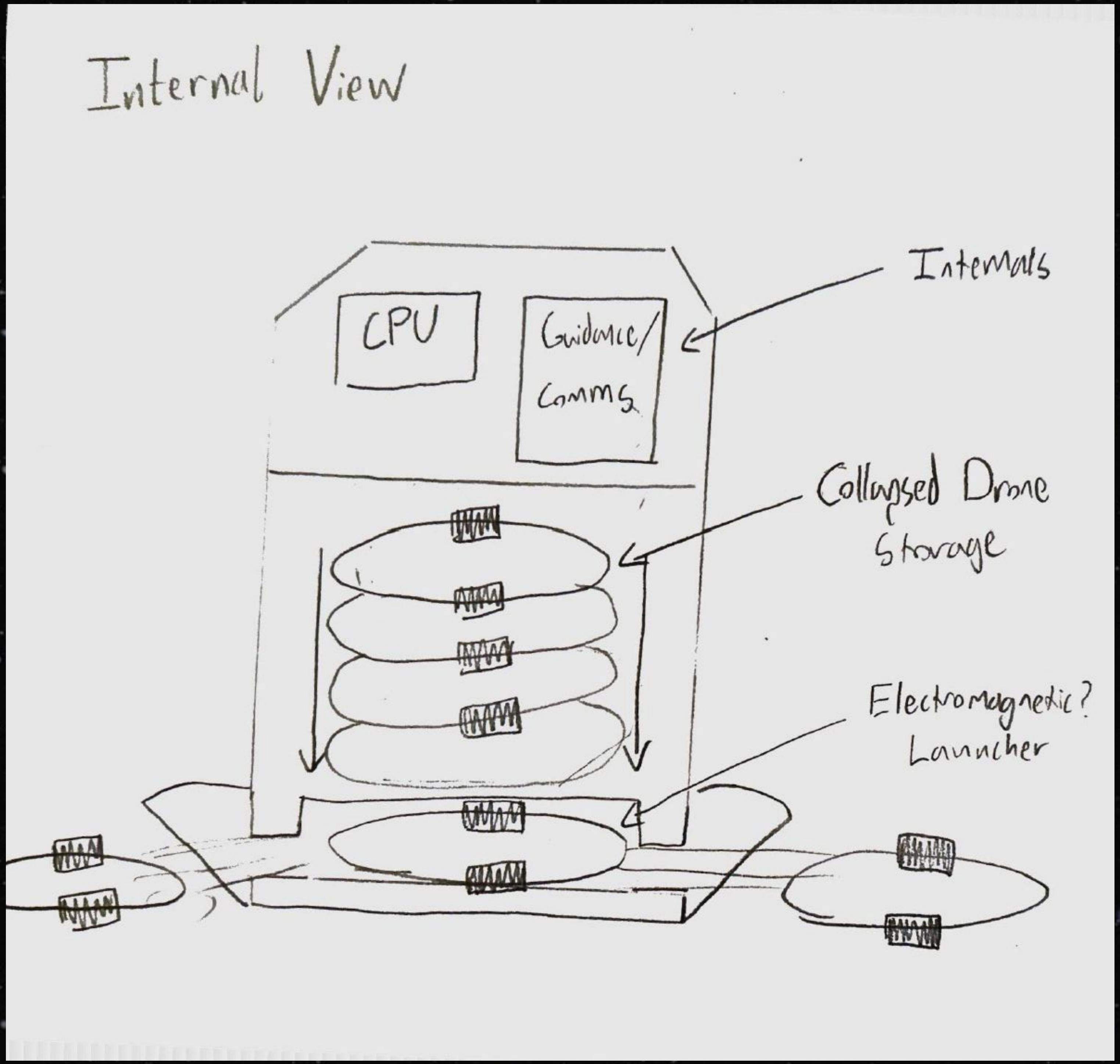
Engineering Requirements

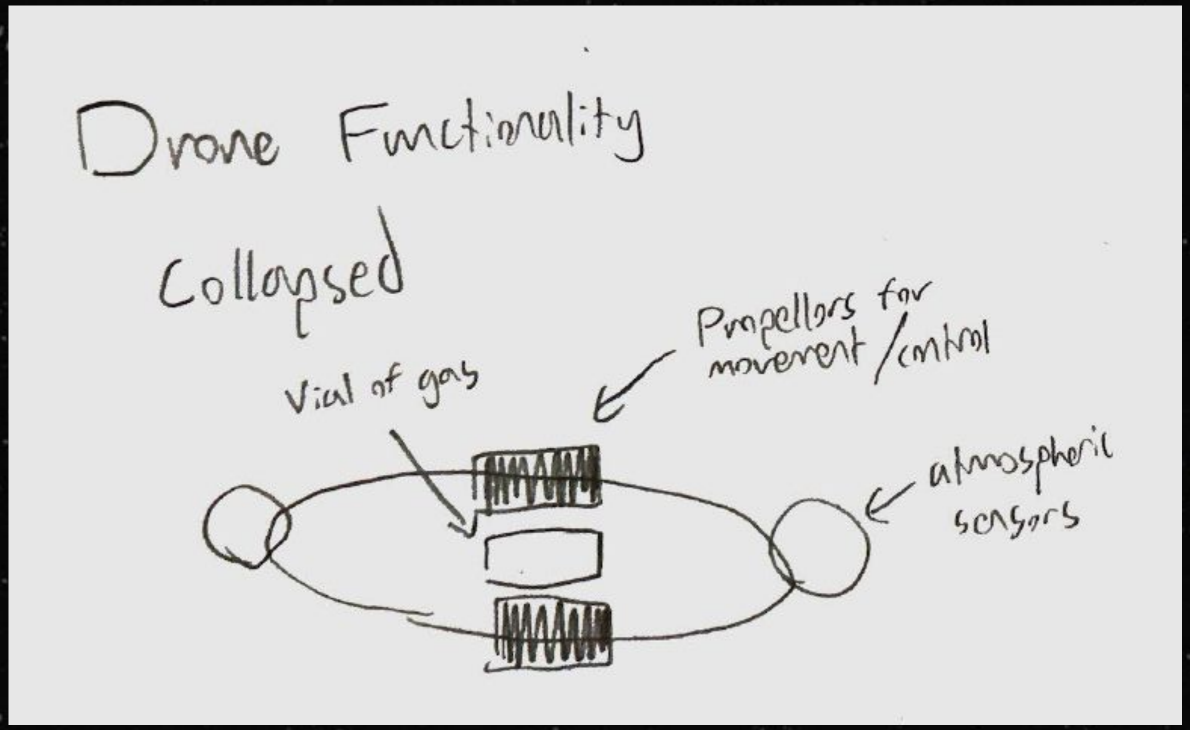
1. Launch orbiter into stable Venusian orbit
   a. Utilize RocketLab Electron launch vehicle for private mission to Venus (https://www.rocketlabusa.com/missions/upcoming-missions/first-private-mission-to-venus/?utm_source=chatgpt.com)
   b. Utilize interplanetary slingshots to optimize orbiter location (https://www.sciencedirect.com/science/article/pii/S0273117723001758)
   c. Launch within window where Earth is closest to Venus. (http://mentallandscape.com/V_VenusMissions.htm)

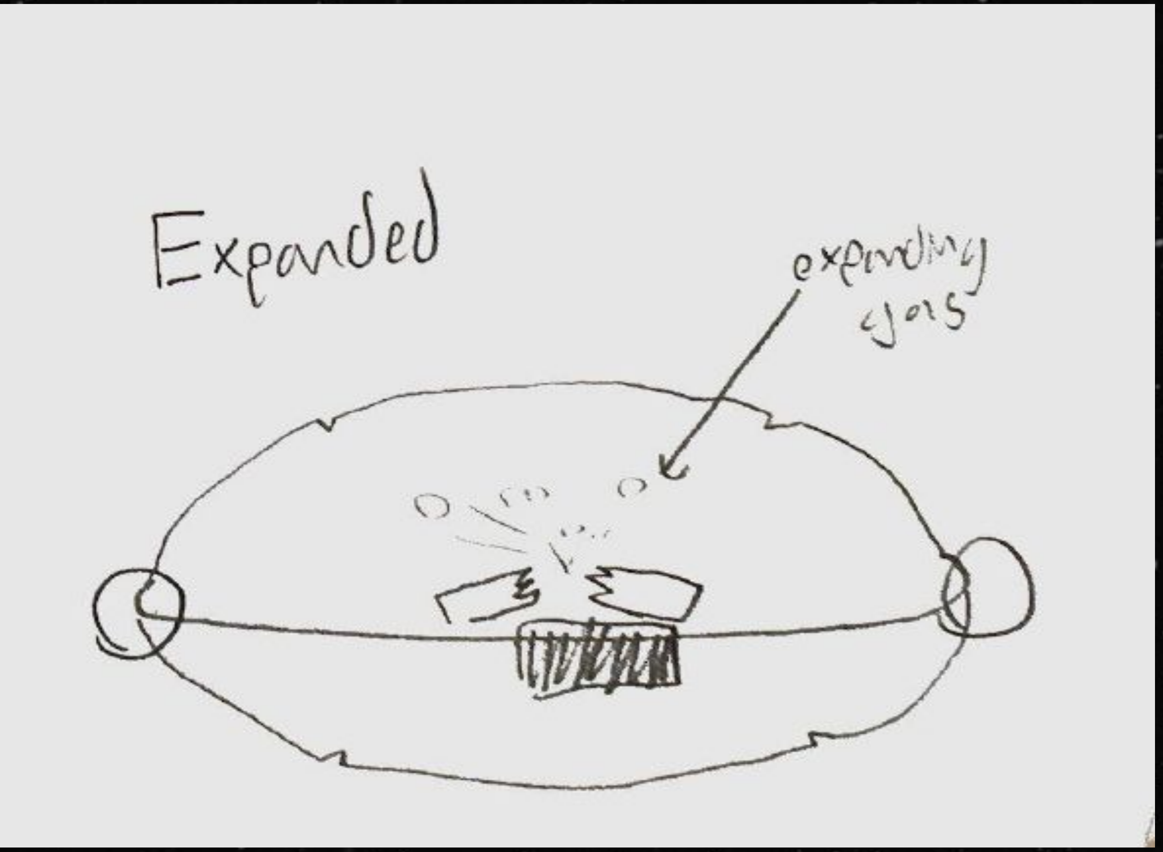




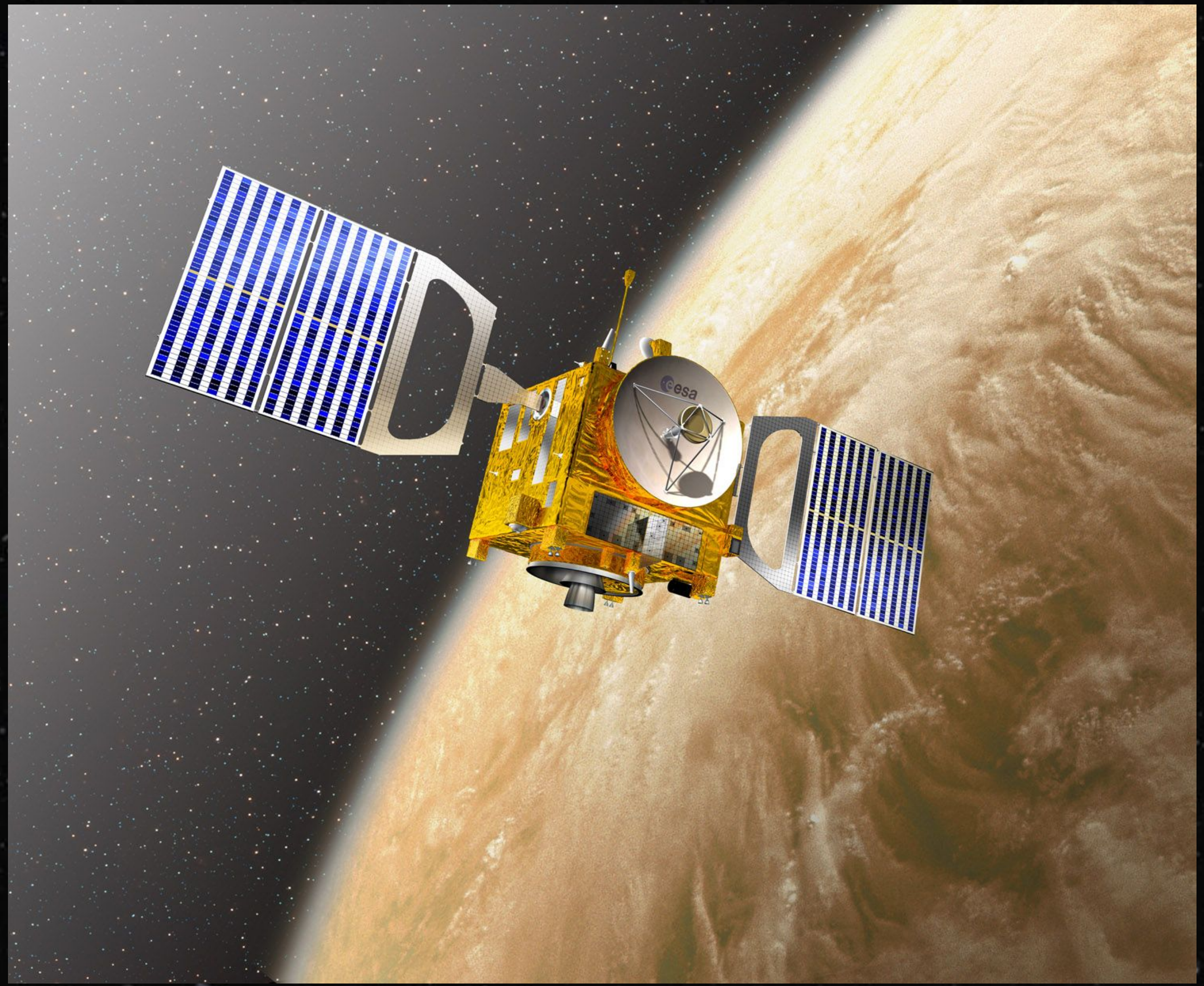
Qualitative Overview - Balloon Drones

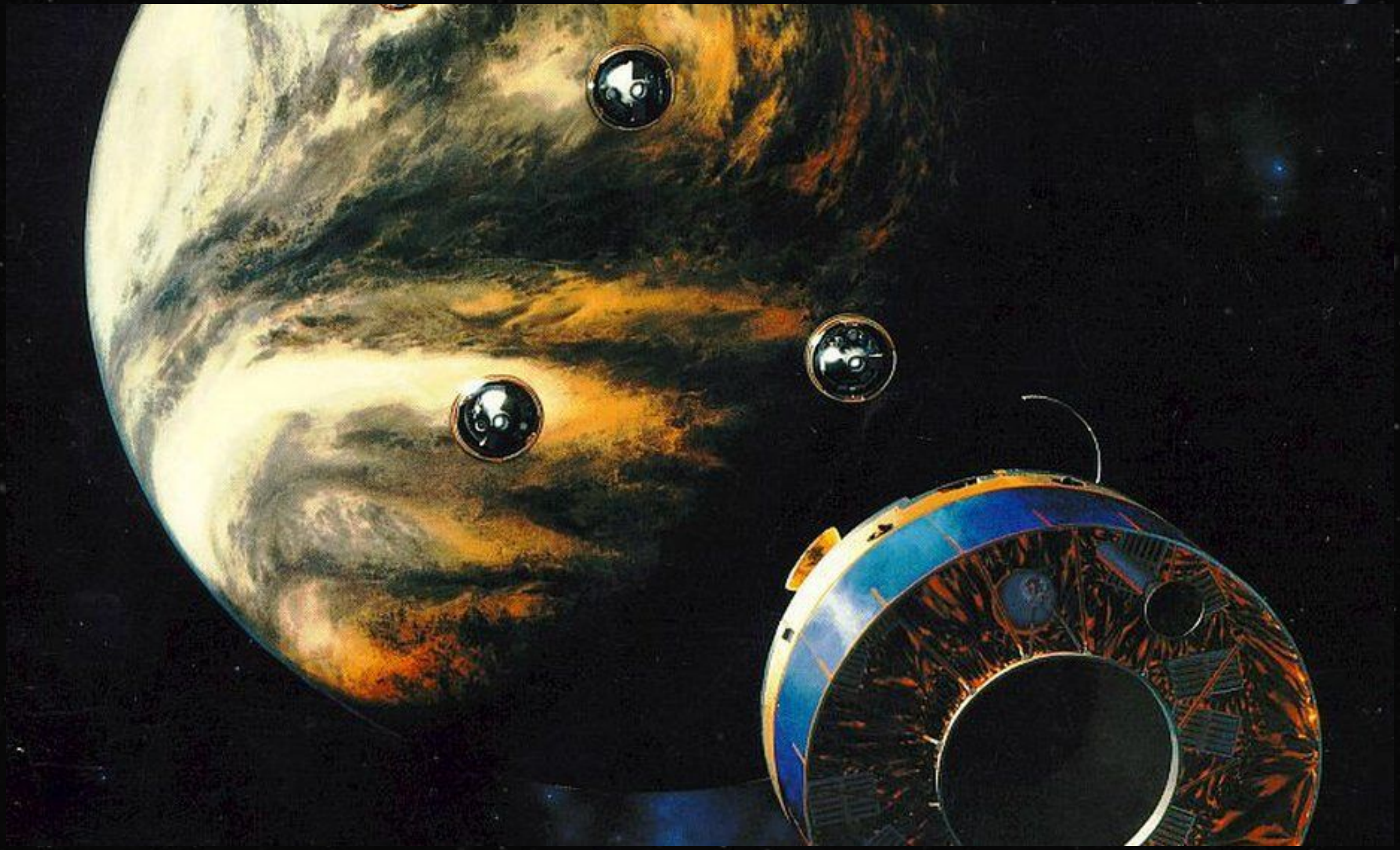




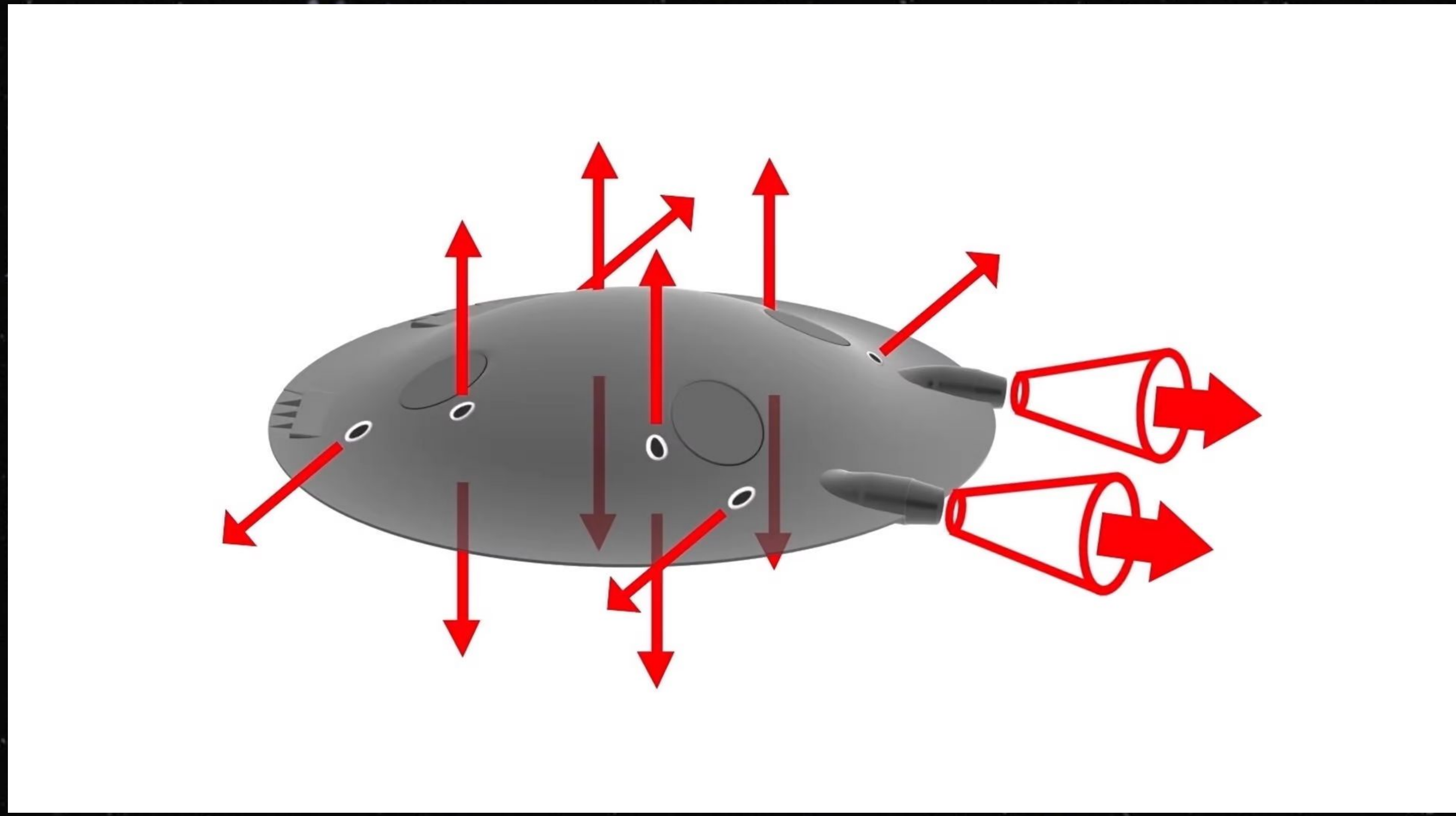


Qualitative Overview - Similar Conc





Drone Ideas



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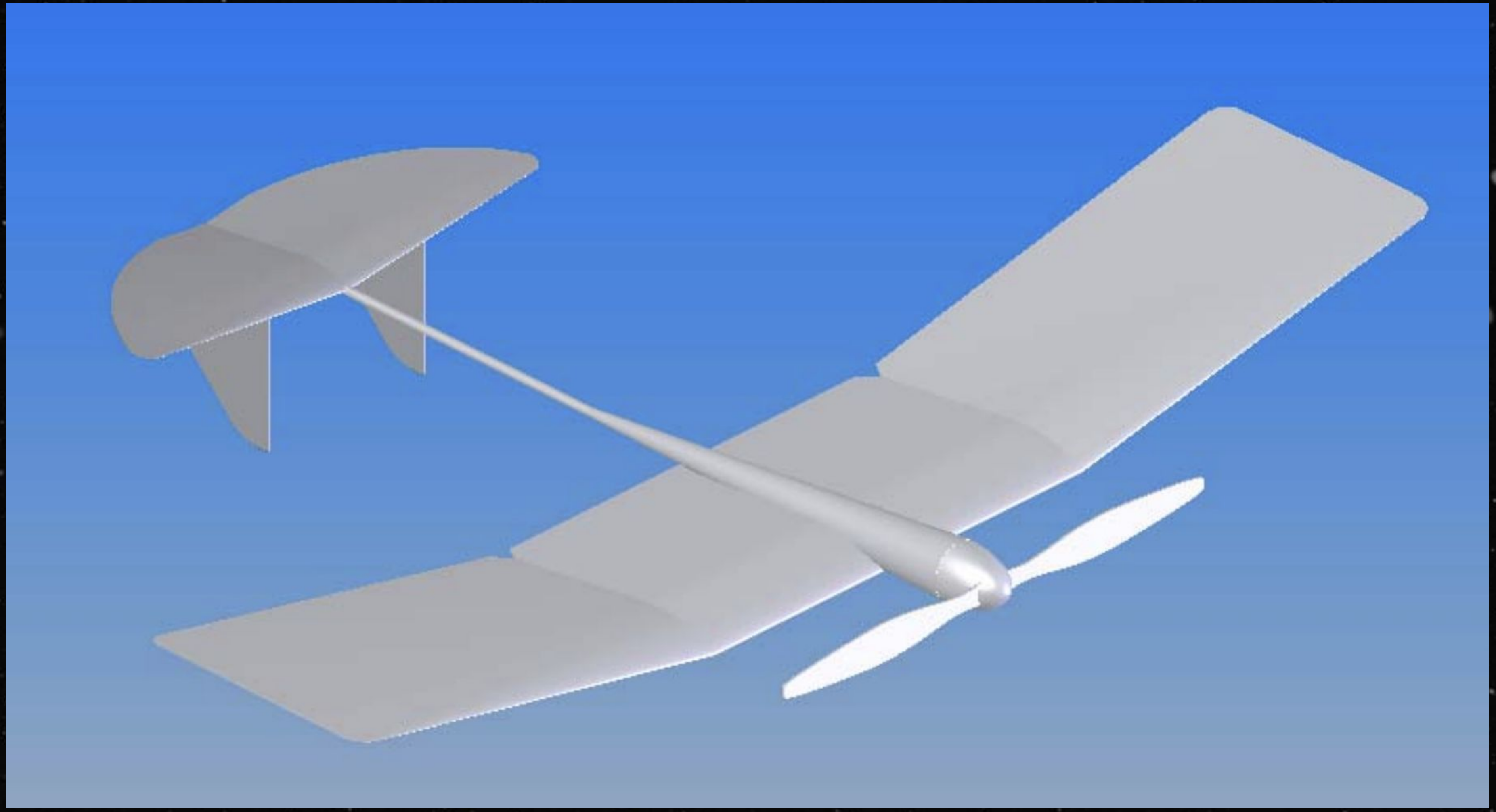
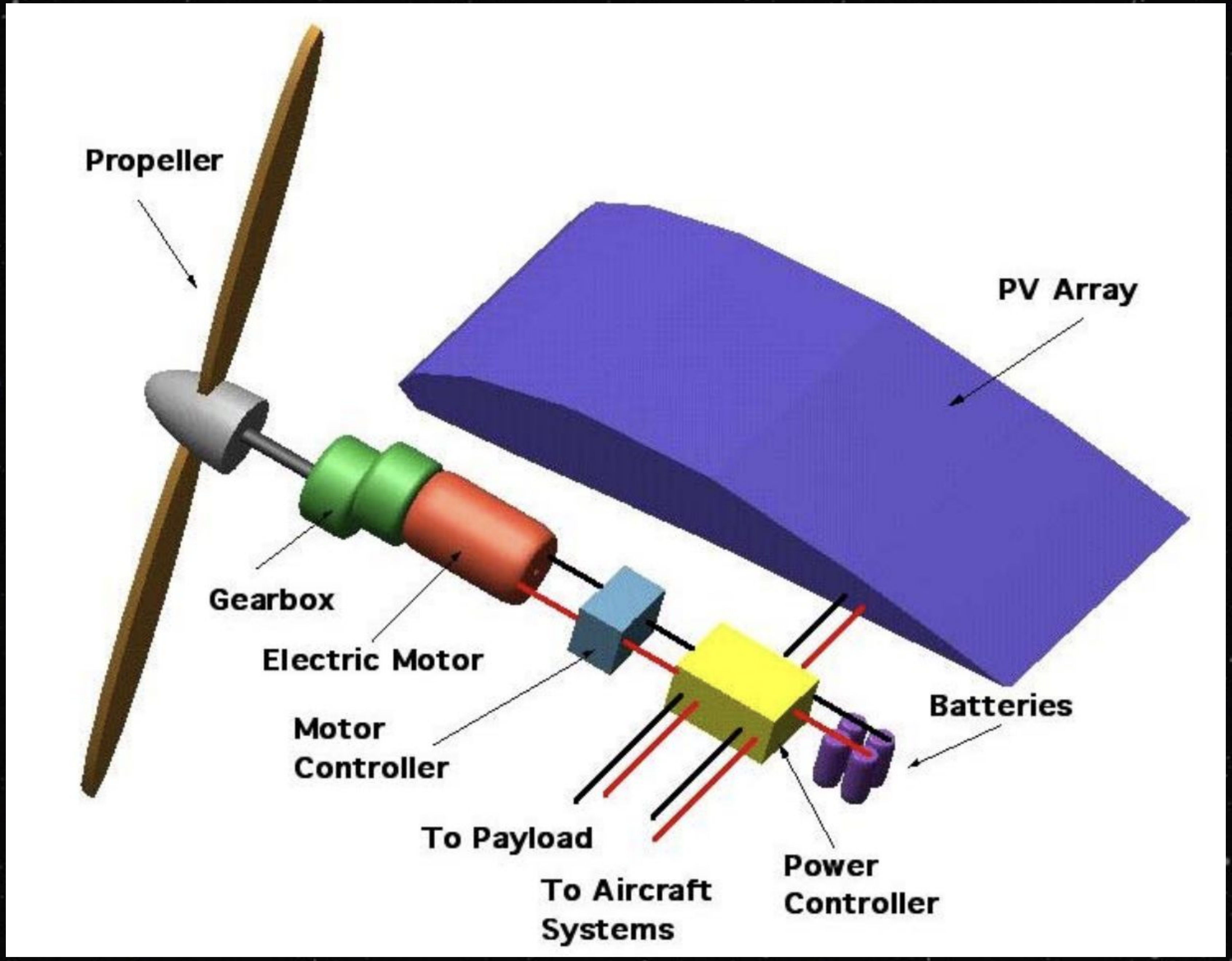
gree-surveillance/article34183091/

Basic Glider Ideas (Source Paper Linked Below)





https://ntrs.nasa.gov/api/citations/20040070782/downloads/20040070782.pdf