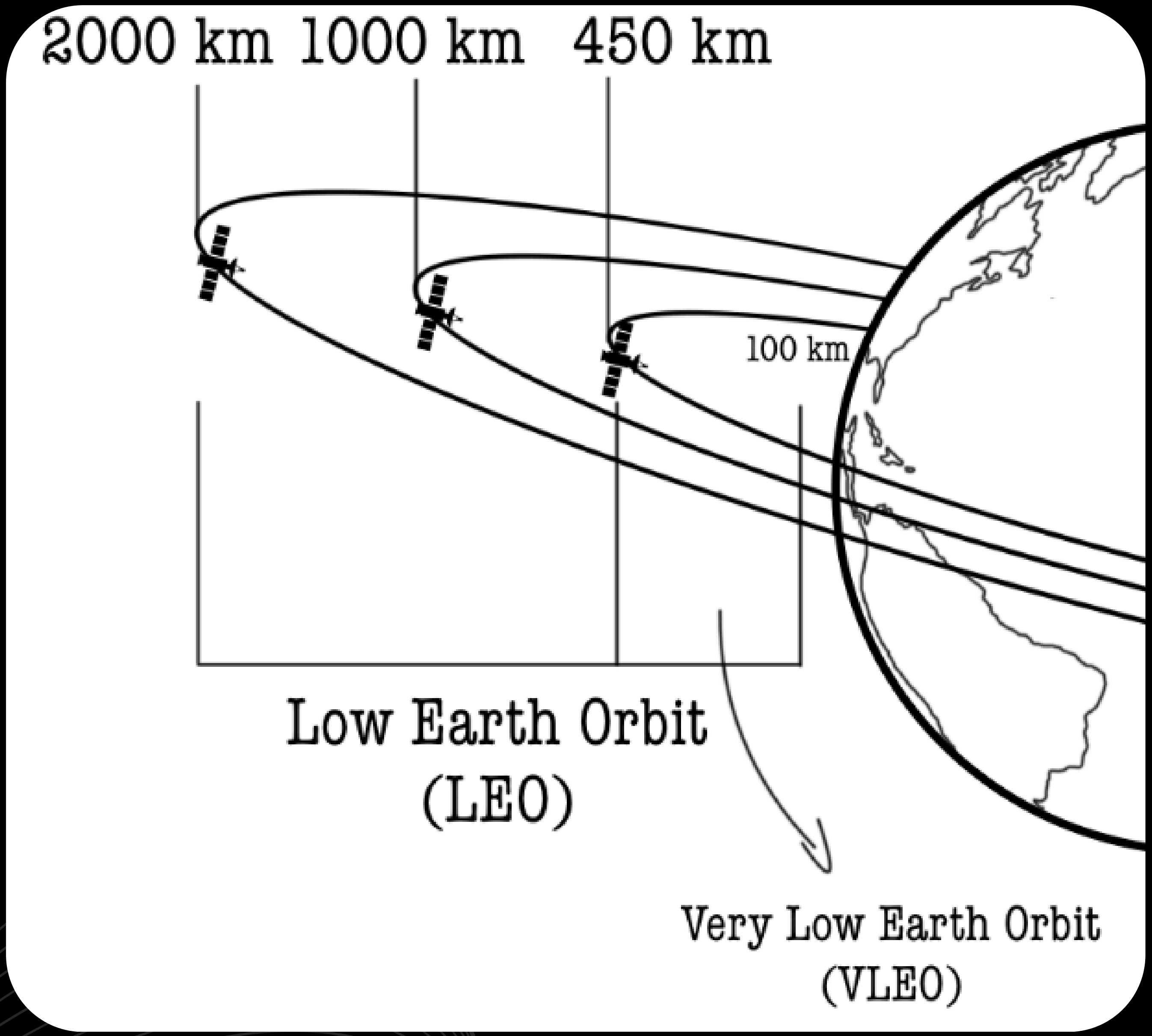
TRACE

Business
Plan Presentation

LOW EARTH ORBIT

- LEO is an Earth orbit with a period of 128 minutes or less (about 11+ orbits per day).
- It has an eccentricity less than 0.25, meaning nearly circular orbits.
- Most man-made satellites and space debris are found in LEO, especially around 800 km altitude.
- LEO extends up to about 2,000 km above Earth's surface.
- Objects in or passing through LEO are closely tracked to prevent collisions with satellites.



INTRODUCTION

- The number of satellites and debris in Low Earth Orbit (LEO) is increasing rapidly, leading to growing congestion.
- Predicting satellite lifetime and reentry is crucial to reduce collision risks and protect both space assets and people on Earth.
- Sustainable planning for satellite end-of-life is essential to maintain a safe and usable orbital environment.
- We present a computational tool designed to estimate orbital decay and support responsible satellite management.

OVERVIEW

- Accurately predict satellite reentry timelines using physics-based atmospheric drag and orbital mechanics models
- Develop an interactive, user-friendly tool tailored for small satellite operators and mission planners
- Facilitate proactive decision-making to enhance space debris mitigation efforts
- Ensure compliance with international space sustainability guidelines and regulations

CALCULATION OF RE-ENTRY [LOGIC]

- Satellites in Low Earth Orbit (LEO) experience atmospheric drag due to the thin upper atmosphere.
- This drag slows the satellite, causing a loss of altitude over time — a process called orbital decay.
- The decay can be estimated using the following equation:

$$\frac{dr}{dt} = -\frac{C_d \cdot A \cdot \rho(h) \cdot r^2 \cdot v}{m}$$

source:
https://www.researchgate.net/publication/330402042_Satellite_orbit_decay_due_to_atmospheric_drag

LOGIC(CONT..)

Variable Name	Meaning
r	Radius or distance (possibly orbital radius)
t	Time
Cd	Drag coefficient
A	Cross-sectional area
rho(h)	Air density as a function of altitude (h)
v	Velocity
m	Mass

$$\frac{dr}{dt} = -\frac{C_d \cdot A \cdot \rho(h) \cdot r^2 \cdot v}{m}$$

This equation calculates the rate of orbital decay due to atmospheric drag, predicting satellite lifetime and reentry based on a circular orbit and exponential atmospheric model.

SOFTWARE IMPLEMENTATION[PROTOTYPE]

- **User Interaction:** Simple interface lets users input key orbital parameters (altitude, mass, area, Cd).
- **Simulation Logic:** JavaScript engine applies orbital decay equations to model altitude loss over time.
- **Data Visualization:** Chart.js graph dynamically displays altitude vs. time for clear visual analysis.
- **Result Output:** Provides reentry time summary in days, making results easy to interpret.

PROTOTYPE FEATURES

- Input of satellite parameters via terminal or web interface
- Computation of orbital decay over time
- Display of estimated years to reentry
- Visualization through altitude vs. time graph or table
- Optional scenario analysis — effects of drag sails, mass variation, or solar activity changes

PROTOTYPE LIMITATIONS

- Air is almost gone up high: Above 450 km, the air is so thin that the simple formula makes drag almost zero — the satellite seems to "never slow down."
- The model's atmosphere is wrong: The basic exponential model doesn't match real air density in space — it's millions of times too low up there.
- It ignores the Sun's effect: Solar activity heats and expands the atmosphere, changing drag a lot — the simple model doesn't include that.
- It assumes a perfect circle orbit: Real orbits aren't perfectly round, and drag affects them unevenly, so the math breaks down.
- It runs out of precision:The drag is so tiny that computer rounding errors become bigger than the real effect, stopping the decay.

EXPECTED OUTCOMES

- The program outputs how long (in days or years) a satellite will take to fall from its current orbit to about 120 km altitude, where re-entry begins.
- You see that low orbits (< 300 km) decay within days or weeks, while higher ones (500–1000 km) last for decades or centuries.
- Changing the mass, cross-sectional area, or drag coefficient immediately shows how lighter, larger, or higher-drag satellites re-enter faster.

CONCLUSION

This project revolutionizes LEO management using physics-based orbital models, empirical atmosphere profiles, and satellite design parameters (mass, area, Cd) coupled with real-time space-weather indices, it predicts decay and optimizes deorbit plans. Operators gain accurate lifetime estimates, enabling proactive collision avoidance, efficient mission planning, and targeted debris mitigation. By prioritizing robustness and accessibility, the tool helps preserve a cleaner, safer, and more sustainable LEO for future missions.