Payload
Recruitment Challenge Questions

Introduction to the subsystem:

The payload of a satellite refers to the primary equipment or instruments it carries to perform its intended mission. It is the functional part that delivers the satellite's purpose, unlike support systems like power or propulsion.

Our subsystem has two payloads:-

1. A Thermal Camera (Primary payload): To capture long wave infrared (LWIR) images of the earth. You will need to use image processing tools to enhance raw images and extract useful data.
2. Electrodynamic tether (Secondary payload): To test a low work function tether's ability to passively deorbit a satellite.
   You will need a sound understanding of:-
   a. Physics: Electromagnetism and eventually plasma physics to calculate the optimal dimensions for the tether.
   b. Material chemistry: to find materials with the optimal balance of the desirable properties for the tether.

ML (Image processing):

Our primary payload is a thermal camera, you need to utilize image processing tools to perform the following actions.

1. https://www.kaggle.com/datasets/pandrii000/hituav-a-highaltitude-infrared-thermal-dataset/data

   Train a model on this dataset to identify vehicles.
   (min 0.9 accuracy)

2. https://www.kaggle.com/datasets/quadeer15sh/augmented-forest-segmentation

   Train a model on this dataset for segmentation of forest cover in aerial images. (min accuracy 0.9)

Electrodynamic Tether:

1. A spacecraft in the LEO deploys a conductive electrodynamic tether of length $L=300\,m$, which carries a steady current $I=2\,A$, The tether is oriented such that it forms an angle of $\theta=45^\circ$ with respect to the Earth's magnetic field, which is locally uniform with magnitude $B=0.2\,T$.
   The tether lies in a plane that includes the satellite's center of mass and is rigidly fixed to it. Assume that the satellite is a symmetric rigid body of moment of inertia $Is=100\,kg \cdot m2$ about its yaw axis (which is perpendicular to the tether-B plane).

   a. Derive the expression for magnetic torque acting on the tether due to its interaction with the magnetic field.
   b. Calculate the magnitude of the torque experienced by the tether.
   c. Assuming no other external torques act on the system, calculate the angular acceleration of the satellite about its yaw axis due to this torque. How does this affect the satellite's attitude over time?

2. Ionosphere is a region of cations, anions and free electrons, in the lower earth orbit (LEO) and we have a satellite of mass 5 kgs with a Tether 10 km long attached to it with mass 10 kgs (The tether has a uniform cross section and made of the same material throughout) and there is a 1Kg electron emitter attached to the lower end of the tether. The satellite is orbiting at 600 Km above the earth's surface.

a. What is the tension experienced at the base of the satellite? (assuming that the satellite is fixed at a point)
b. What should be the angular velocity of the satellite?
c. Why don’t we have the electron emitter at the satellite where the electron density is lower and the electron collector at the lower end of the tether where the density of electrons is higher?