CubeSATs and Geometry

Written by Vanessa Bellotti, March 28 2025

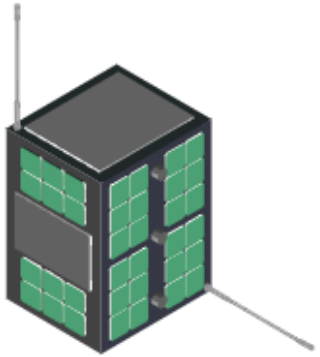
About the Team

Space Debris

Source: esa.int/ESA_Multimedia/Videos/2019/02/Distribution_of_space_debris_in_orbit_around_Earth

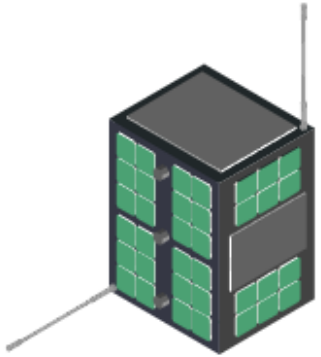
“We must consider that such debris travel at a speed of about 20 km/s, which turns them into hypersonic bullets that can tear a steel panel like it was made of paper. This is a huge hazard for day-to-day satellite operations, and a threat for the future of space exploitation.”

— Stefano Antonetti, VP Business Development at D-Orbit

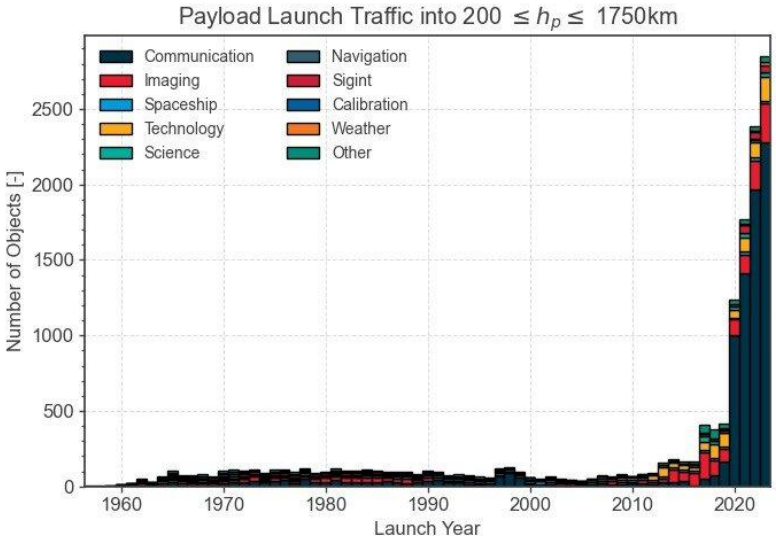


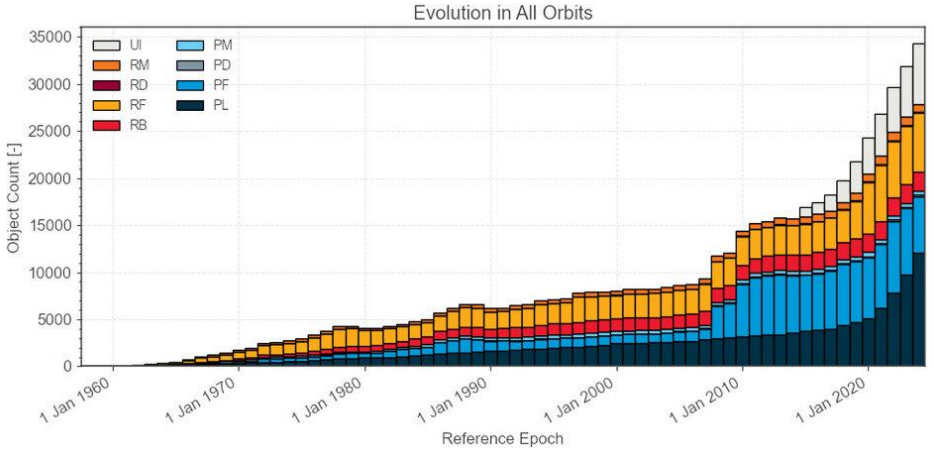
"Debris 1 mm in diameter (mass approximately 1 mg) and larger for Low Earth Orbit (LEO) and 5 mm and larger for Geosynchronous Earth Orbit (GEO) is a source of concern because these debris have sufficient energy to critically damage an operating spacecraft."

– NASA Technical Standard on Process for Limiting Orbital Debris



Prevalence of Space Debris in LEO

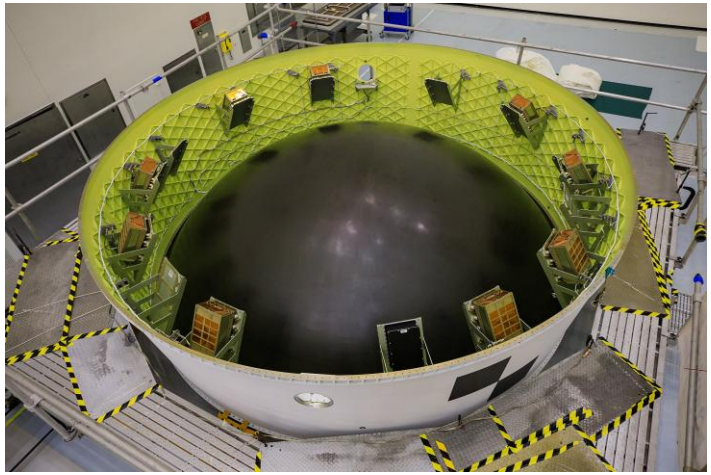




Source: [ESA - ESA Space Environment Report 2024]

Launch and NASA CSLI

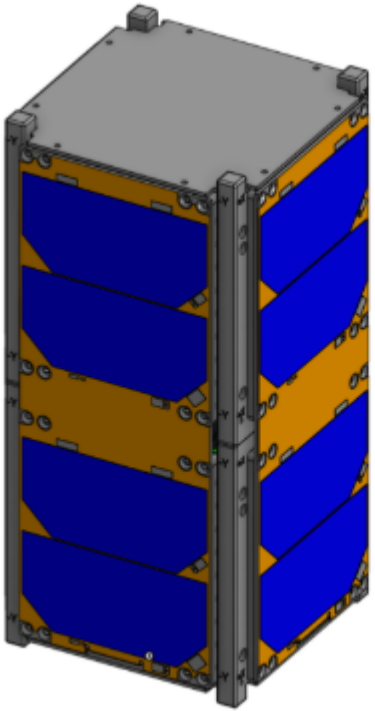
- Application to the NASA CubeSAT Launch Initiative (CSLI) Educational Launch of Nanosatellites (ELaNa)
- Launch Vehicle
  - Type: Falcon 9 or SLS based on recent ELaNa launch vehicles used
- Launch Window
  - Estimated Launch Window: Summer 2026-Winter 2026
  - Orbit Insertion: LEO

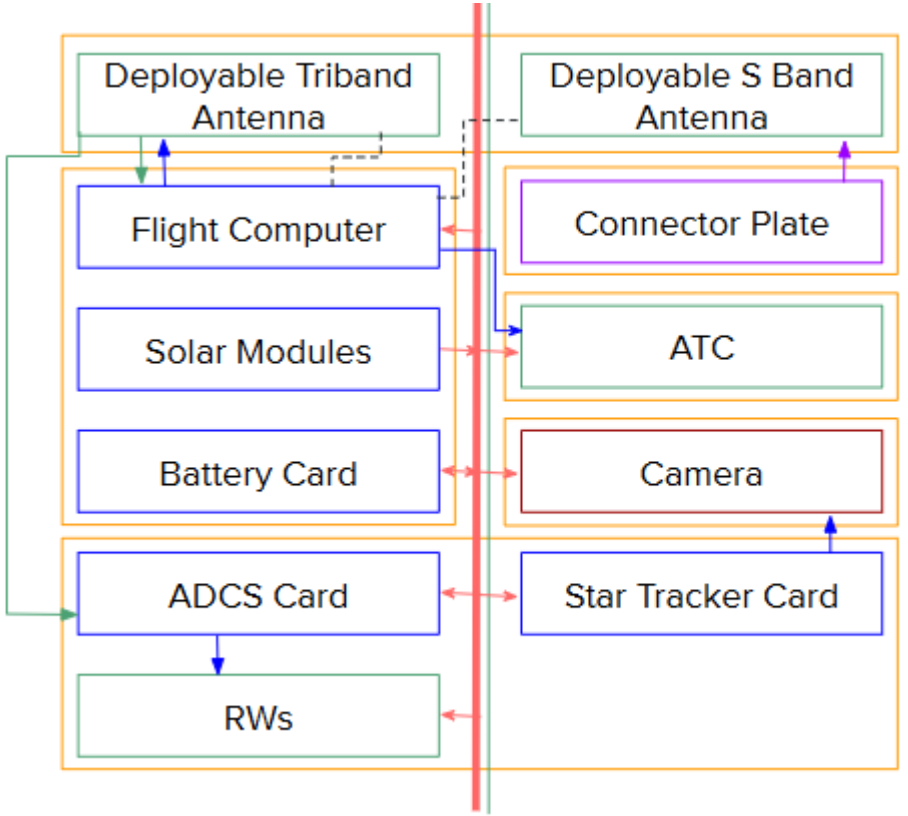


Installation of CubeSATs for Artemis I

By NASA Kennedy Space Center / NASA/Cory S Huston

Systems Overview and Architecture





How does Geometry Factor Into This?

Helps us determine where to place the camera and how to angle it

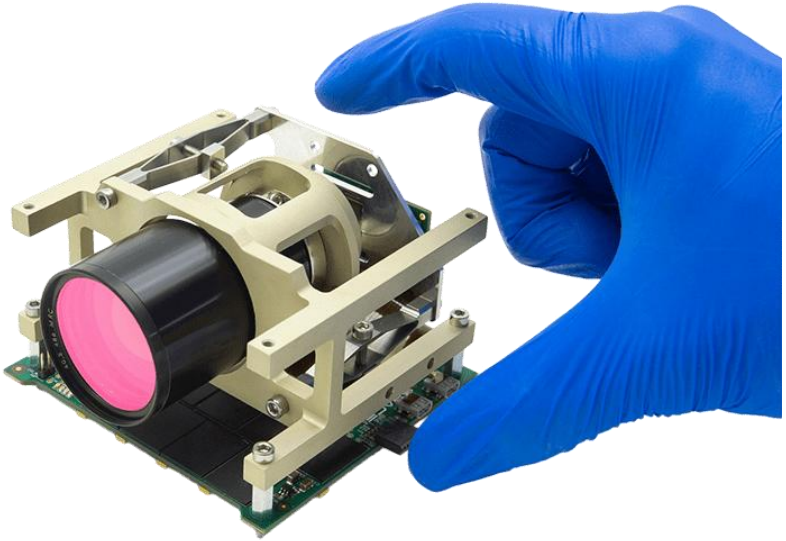
Helps us to determine camera specifications such field of view

Pythagorean's Theorem enables us to join two separate images containing vertical and horizontal edges into one filtered image

Provides the basis for some of the trajectory calculations we do for orbital mechanics

Scenario One – Stereo Vision Type SetUp

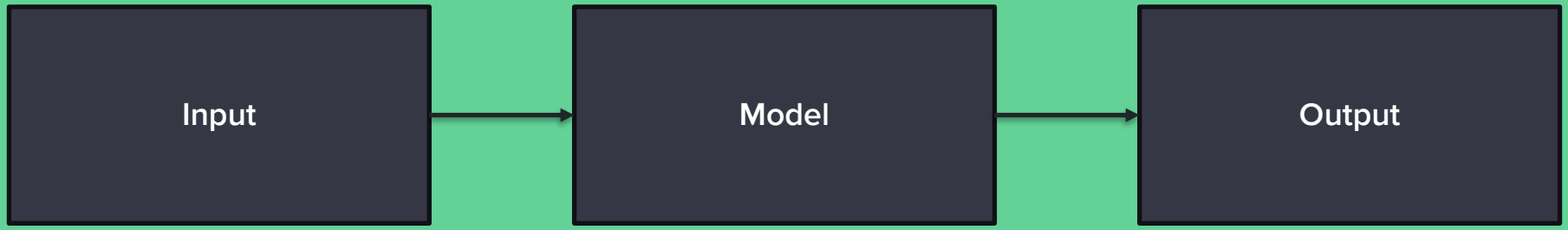
Scenario Two – Single Camera over Two Frames



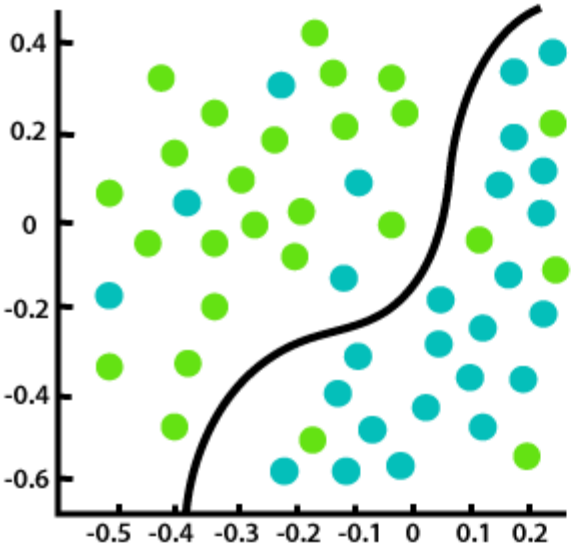
Questions?

Machine learning is the process of learning patterns from data so computers can make decisions without being explicitly programmed for every scenario.

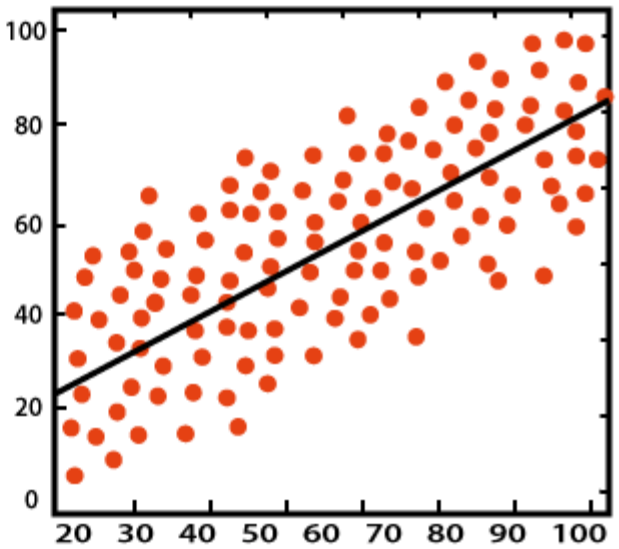
Predictions



The two main Machine Learns t



Classification



Regression

Source: Regression vs Classification in Machine Learning - Javatpoint

Training a Machine Learning Model

System learns by being shown examples (input images) paired with the correct label (debris/no debris, or type of debris).

Training data is used to train the learned weights which indicate features to the model.

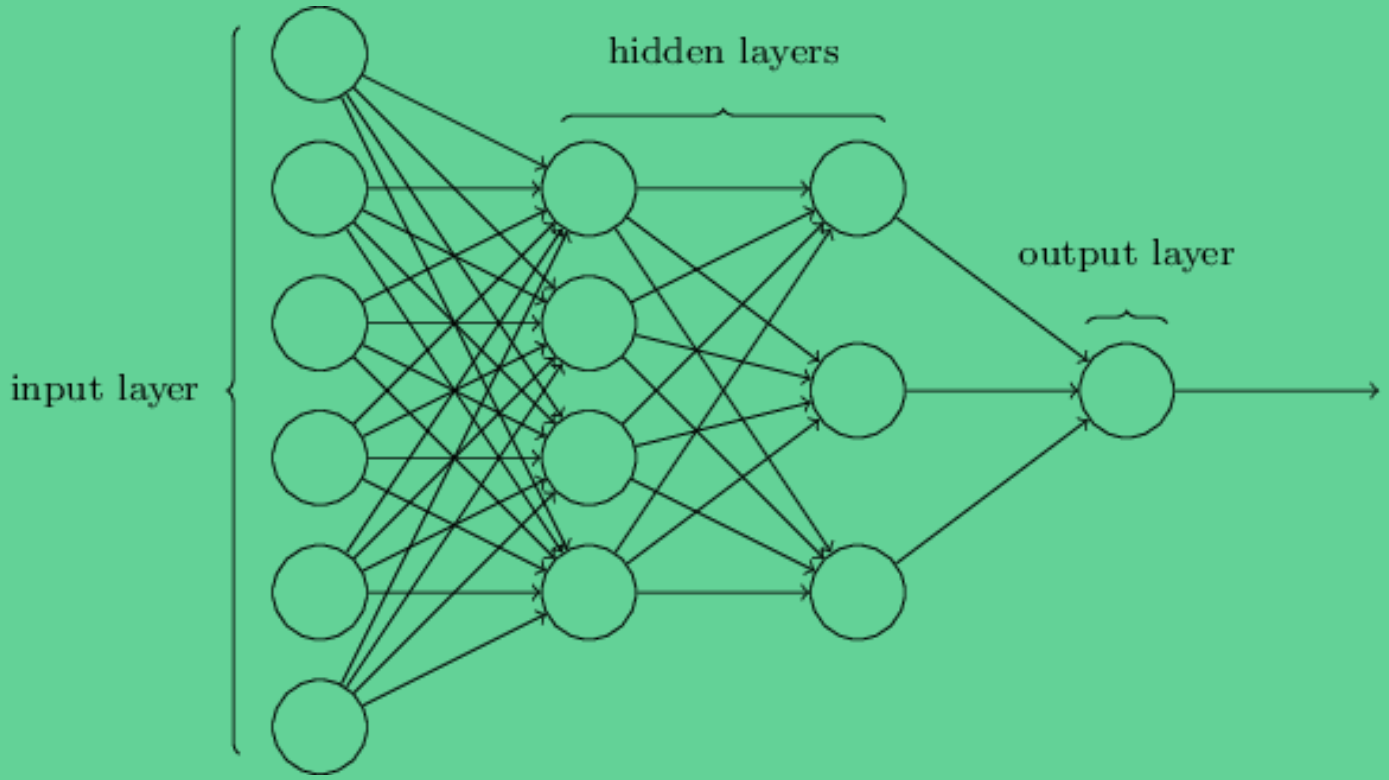
Testing data is used to evaluate the performance of the model on unseen data

Principle to live by: never show your testing data to the model while it is training!

Principle to live by: 80% of ML is actually data collection, data wrangling, and data cleaning!

Testing/Evaluating a Machine Learning Model

Why test the model?	To see how well the model performs on new, unseen data
Accuracy:	How many predictions did the model get right overall? (e.g., correctly identifying debris vs. no debris).
Precision & Recall:	Precision: Of the debris the model said was debris, how many were debris? Recall: Of all the actual debris in the images, how much did the model find?
Real-world performance	Does the model still perform well in different lighting conditions, object sizes, or with noisy images from space?
Avoiding overfitting:	We check if the model learned to handle different scenarios instead of memorizing the training data.



Source: rcassani/mlp-example: Code for a simple MLP (Multi-Layer Perceptron) (github.com)