# AstroTrio

***A project made by***
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This project was made as part of the COM-480 - Data Visualization at EPFL

# Project Goal

This project offers a set of interactive visualizations that explore space across three levels: Earth, the Solar System, and the Milky Way. Each module focuses on a specific theme: the rocket launches over time, a comparative planetary data analysis, and the discovery of exoplanets, using real-world dataset. Together, these visualizations aim to render complex astronomical information more accessible and engaging, especially for educational purposes.

# Dataset

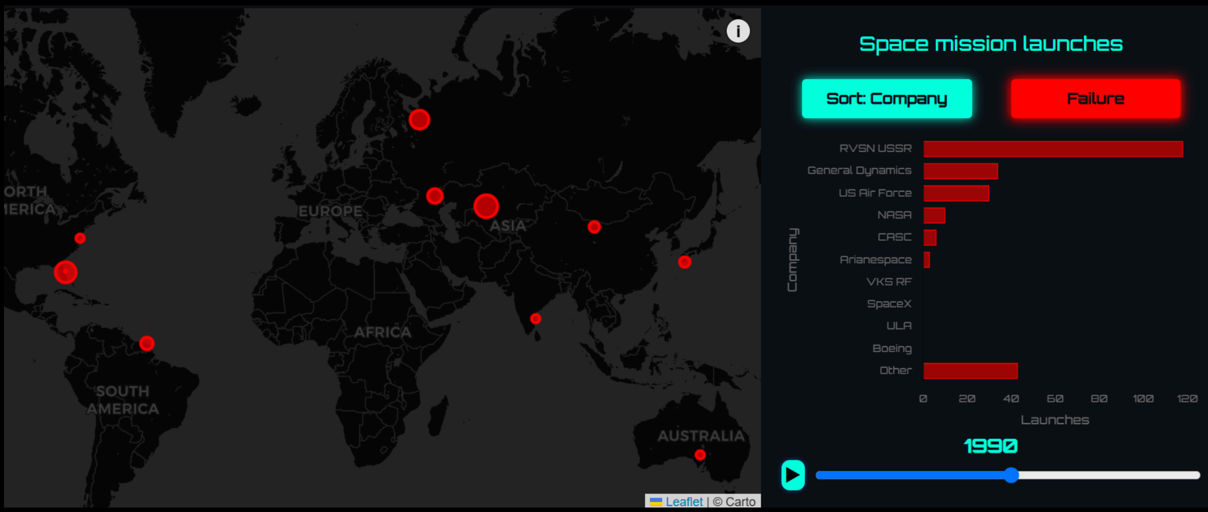
At the start of the project, we considered using a synthetic dataset to explore abstract space-related patterns. However, after initial exploration, we realized that it lacked depth and did not allow for meaningful or engaging visualizations. We therefore pivoted to real-world datasets, which offered richer, more relatable data and aligned better with our educational objectives.
We ultimately selected three datasets from Kaggle, one for each module of the project:

- Rocket Launches: It contains all the space missions launched on Earth from 1957 to 2022. It contains the company, the launch station and whether the mission was a success or a failure.
- Planetary Characteristics: This dataset compiles various physical and atmospheric characteristics of the eight planets in the Solar System, such as mass, diameter, gravity, temperature, and composition. It enabled both comparative and educational visualizations.
- Exoplanet Discoveries: This dataset includes data on confirmed exoplanets discovered by NASA, featuring properties like distance from Earth, orbital radius, temperature, and type of planet.

# Visualisations

## Launch Map

The first visualization we decided to create focuses on a historical exploration of global rocket launches from Earth since 1957. Our goal with this visualization is to provide a dynamic overview of space exploration activity over time, highlighting the evolution of launch frequency, geographic distribution, and national contributions to spaceflight. By displaying this data on an interactive world map, we aim to make the scale and growth of global launch efforts both engaging and accessible.

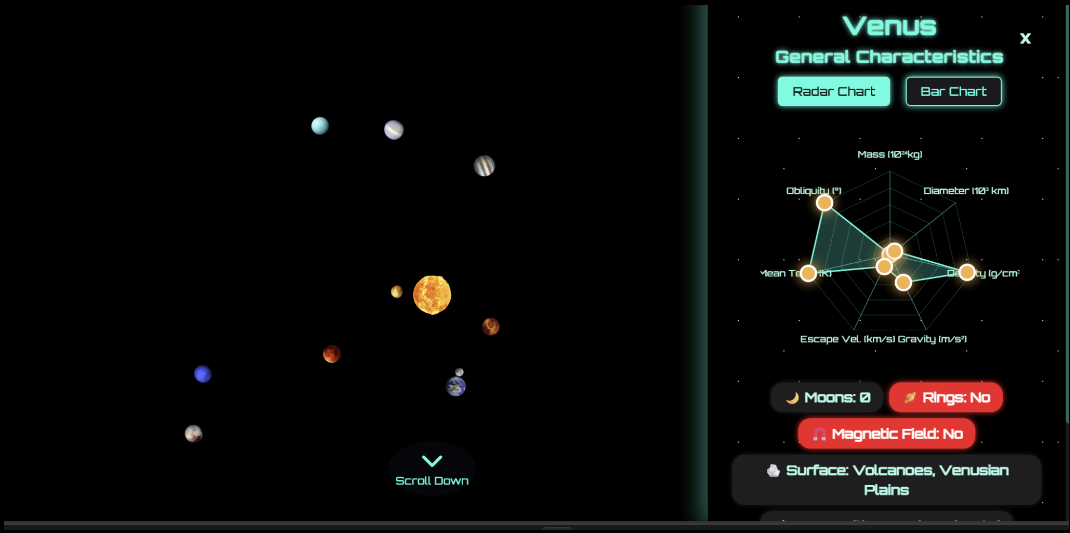


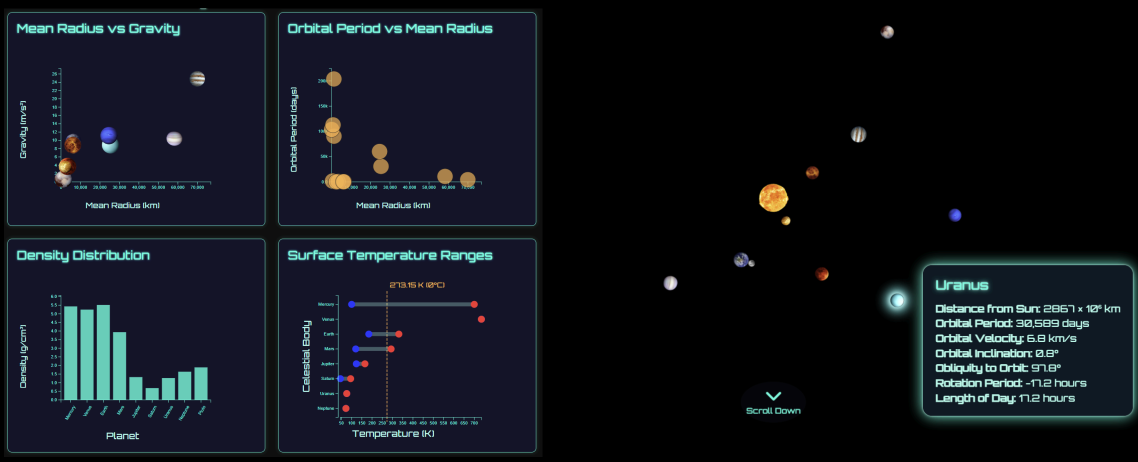

The launch map features a time slider that animates launches year by year, allowing users to observe how launch activity has shifted across decades. Users can filter the data by success or failure, and a horizontal bar chart displays the top countries by number of launches for the selected year, offering a comparative perspective. The user can also choose to sort by company instead of country, and click on individual companies to view additional contextual information and descriptions.

Additionally, this visualization encourages reflection on the geopolitical and technological developments that have shaped modern space exploration, while laying the groundwork for future enhancements such as mission classification or destination mapping.

# Solar system

The second visualization centers on an educational exploration of the Solar System, offering users an interactive interface to compare and understand the characteristics of planets and other major celestial bodies. The goal of this visualization is to provide an intuitive and engaging way to examine planetary data, encouraging users to explore both numerical properties and categorical features such as composition, and surface characteristics.



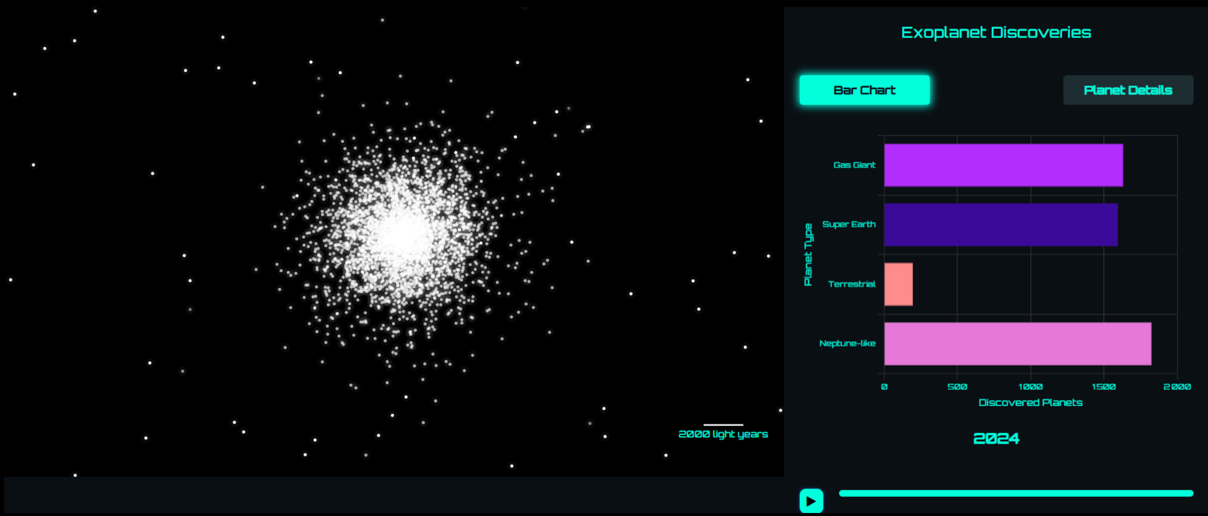



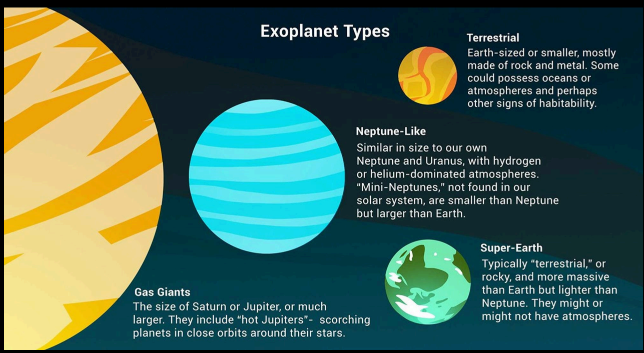

At the core of the interface is a dynamic Solar System view, where planets orbit the Sun and can be selected to reveal detailed information in a radar chart. This comparative chart visualizes key quantitative attributes such as mass, diameter, gravity, and temperature, providing a multidimensional perspective on planetary differences. Users can also scroll down to explore other static charts highlighting temperature ranges and additional comparisons across Solar System bodies.

This visualization is designed to be both informative and exploratory, helping users grasp the diversity of our Solar System through interactive elements. Future improvements could include support for elliptical orbits, the inclusion of other moons and artificial probes, or even 3D rendering to enhance spatial understanding.

## Milky way

The third visualization focuses on the discovery of exoplanets within the Milky Way. It offers an animated view of how exoplanet discoveries have evolved over time, highlighting key trends and the growing reach of astronomical observation. Users can explore when and where planets were found as well as the type of exoplanets in the first dynamic exoplanet discovery map. A detailed presentation of the types of exoplanets is available when clicking on a planet's details. Earth is in the center, and the exact positions are randomly generated, but with the correct distance (more information in *key challenges*).

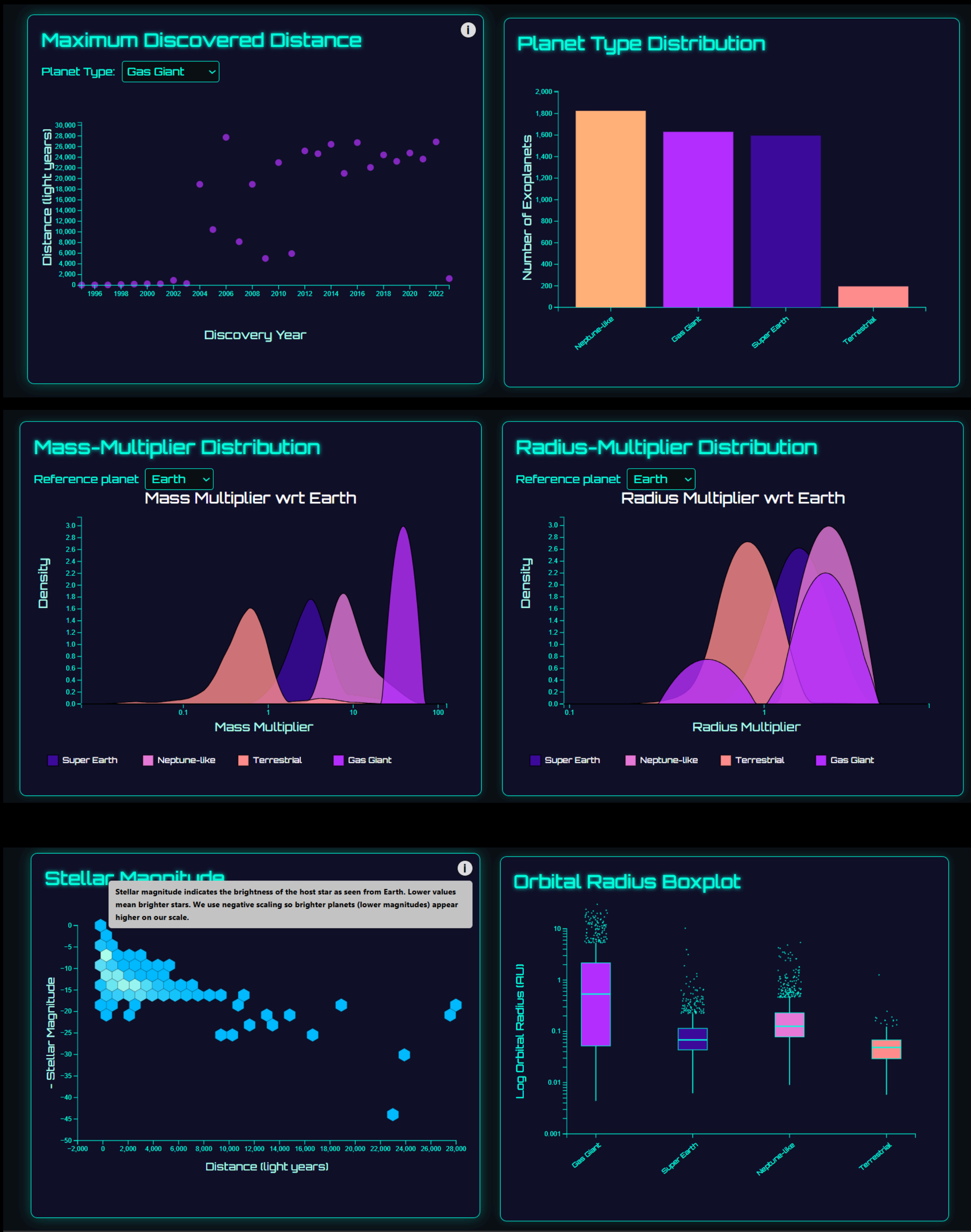


*Source: Nasa Exoplanets*

More visualizations are available when scrolling down:

- Scatter plot of the Maximum distance discovered each year, with a filter for the planet type
- Barr chart of the Number of planets per planet type
- Distributions of the mass and radius properties, in comparison to Earth (or Jupiter depending on the rows of the dataset), with a x-axis log scale to visualize the different distributions properly
- Hexagonal scatter plot comparing the stellar magnitude (how bright the exoplanets appear) to the distance. We use the negative stellar magnitude as a lower value means a higher brightness.
- Boxplot for the orbital radius per planet type, with a log scale y-axis to make easier comparisons. Outliers are displayed as well.




Information about each plot is available when dragging the mouse over the plot, making appear an informational pop-up.
This visualization aims to show both the scale of our galaxy and the increasing sophistication of space detection technologies. Future additions could include star–planet linking, habitability metrics, or a 3D representation of nearby exoplanet systems.

# Website implementation

The website was built using Flask, which allowed us to efficiently integrate multiple interactive data visualizations into a cohesive user experience. Each of the three main modules (Earth, Solar System, Milky Way) was developed as a HTML/JavaScript page and embedded into the Flask app through route handling and template rendering.

We structured the project so that the front-end components (JavaScript visualizations using D3.js and Leaflet) were modular and could be maintained independently. The Launch Map, for instance, uses Leaflet to display an interactive world map with animated rocket launches over time. Flask served primarily for local development and testing, providing an easy way to manage the assets and routing between the different sections of the site.

For deployment, we used GitHub Pages, which hosts the static website directly from our repository. This static build allows anyone to access the website without requiring a server to run Flask.

# Key Challenges

During the development of our project, we encountered several technical challenges. Here are the main ones:

- We did not have the geographic coordinates of the launch sites, which were necessary to plot them on the interactive map. So we manually retrieved the coordinates of each launch station using Google Maps, based on the site names. While time-consuming, this approach ensured accurate mapping and a nice visualization.
- The solar system dataset did not have information about the sun, moon, and pluto. So, we synthetically added them in the dataset. Also, the data values for moon and sun were too big/small that it added some distortion for the graphs in the sidebar, so we excluded them from the comparison and made it only for the planets. Yet, plotting the exact values of different features on the same graph (the general characteristics graph) was hard (e.g. mass, temperature,..etc), so we added a normalization drawn from the max (i.e. the planet of the maximum value gets 100% and all other graphs get a percentage of that). Thus, when you see the graph you can directly tell how it compares to other planets and when you hover on it, you see the exact value.
- We had to perform some data units adjustments to be able to have better modeling. For example, we changed the temperature units from celsius to kelvin, yet, you still can observe a dashed line that shows you where the 0 celsius is.
- The exoplanet dataset provided only the distance from Earth in light-years, without any 2D or 3D spatial coordinates that could allow for precise

positioning within the Milky Way. Since actual coordinates were unavailable or inconsistent, the positions were simulated randomly assigning angular coordinates around a central "Earth" point while preserving the radial distance. This approach maintains the relative distance information and creates a plausible spatial distribution for visualization purposes, while clearly indicating that positions are illustrative.

# Peer assessment

## Iman

Iman was responsible for the Solar System visualization. She implemented the interactive interface representing the celestial bodies and developed the comparative charts across planets. In addition, she handled the overall structure and deployment of the website, ensuring visual consistency and smooth navigation between the different sections.

## Léo

Léo implemented the launch map visualization. He developed the time-based animation, filtering options, and the bar chart comparing countries and companies by number of launches, as well as the technical explanations related to this map. He also took charge of the design and structure of the process book.

## Maud

Maud created the Milky Way visualization focused on discovered exoplanets. She managed the temporal animation of discoveries and built the interactive panels showcasing the various properties of the exoplanets, and helped refine the narrative around this part of the data story. Maud realised the production of the screencast.

# Ressources

**Datasets:**

- **Launch map**: https://www.kaggle.com/datasets/agirlcoding/all-space-missions-from-1957
- **Solar system**: https://www.kaggle.com/datasets/iamsouravbanerjee/planet-dataset
- **Exoplanets**: https://www.kaggle.com/datasets/adityamishraml/nasaexoplanets/data

**Website**: https://com-480-data-visualization.github.io/AstroTrio/

**Screencast**: https://www.youtube.com/watch?v=8p5aWBABRVQ

**Github repository**: https://github.com/com-480-data-visualization/AstroTrio