Space Exploration's Geopolitical Narrative: Chronicles of the Cosmos

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Our Path

Initial Brainstorming and Vision

Team began the project with a detailed brainstorming session to define the vision for our website and decided which datasets would teach users the most. When think the geopolitical complexity and significance of space warfare of the history, we aimed to objectively visualize space missions related dataset mostly in cold era, using historical facts from carefully selected datasets. My team inspired by John F. Kennedy's 1961 speech that set the goal of landing a man on the moon, we investigated the evolution of spacecraft and the lessons learned from past missions, that is important for us as engineers.

Section Explanations

In this section, we will be discussing which datasets we used in the main categories.

Timeline of Space Exploration

The first critical component of our presentation is the timeline of space exploration history. We utilized the dataset `milestone_space_exploration.csv` to create a milestone timeline spanning from 1959 to 2019. To highlight the differences between the USA and the USSR, we developed separate timelines up until the end of the Cold War in 1989. Post-1989, a unified timeline better represented the collaborative nature of space exploration efforts.

Apollo Evolution and Moon Mission

Employing datasets including `extra-vehicular_act.csv` and `Global_Space_Launches.csv`, My team highlighted the USSR's space progress and the USA's response to them. The response began with John F. Kennedy's pivotal address and demonstrated the spacecraft's historical advancement as well as the historic lunar landing using the interactive timeline with the key events, extra-vehicular activities are also included in this part if they exist, along with important milestones and difficulties faced.

Living in Space

For this section, we utilized the `extra-vehicular_act.csv` dataset as well as information from [1] to create graphs and visualizations. These graphs show detailed information when the cursor hovers over them. We also included a big picture overview and subcategories that display only the relevant parts when the cursor is on a specific category. This interactive design helps users better understand the complexities of living in space.

Rocket Mission

Using the `Global_Space_Launches.csv` dataset, we created a detailed section on rocket missions. This is actually a bubble chart using React and D3.js with bubbles replaced by rocket icons to give it a nice space touch. There is three hierarchical levels: countries, companies, and finally rockets, where users can select a rocket and drill-down to the next level. The size of each rocket (bubble) represents the cost linked to the space missions related to that component.

Lessons Learned

Important lessons from previous space missions are collected in this section, which uses the `Global_Space_Launches.csv` and `astronauts.csv` databases. It highlights how important these lessons are to preventing catastrophes on future missions and guaranteeing the security and prosperity of current and future space exploration projects using scatter plots, and interactive galleries with detailed popups.

Implementation Strategy

In order to provide the best possible user experience, the implementation strategy was based on Nielsen's 10 heuristic principles[2] and the Value Proposition Canvas[3].

Nielsen's 10 Heuristic Principles

My team used the following heuristics:

- **Visibility of System Status:** Our team provided clear indicators to show users which section of the website they are in. For instance, users can easily navigate between categories and within each category as well.
- **Match Between System and Real World:** The user interface was designed to be intuitive and user-friendly, employing widely recognized icons, clear labels, and straightforward instructions.
- **User Control and Freedom:** The site allows users to navigate freely between sections without feeling trapped. Breadcrumbs and back buttons are examples of intuitive nav-

igation tools that improve user experience by making it simple for users to follow their path.

- **Consistency and Standards:** The website was designed with uniform design elements in the same categories. This consistency helps users build familiarity and reduces the learning effort associated with using the site.
- **Aesthetic and Minimalist Design:** To avoid information overload, the design is simple and focuses only on what is necessary. This strategy guarantees that users won't be distracted from their ability to concentrate on the material.

Value Proposition Canvas

To ensure our website met the needs and expectations of users, Our team also considered the Value Proposition Canvas framework as a reference:

- **Customer Jobs:** Understanding what users want to achieve by using our website. Users want to learn about space exploration history, understand technical details, and explore interactive elements.
- **Pains:** Identifying user pain points such as difficulty in finding reliable information, complex navigation, and overwhelming data presentation. We addressed these by providing clear navigation and using consistent design elements.
- **Pain Relievers:** Easy navigation, clear information, and minimalist design to prevent information overload.
- **Gains:** Highlighting what users gain from our website, such as easy access to well-organized historical data, engaging interactive content, and a comprehensive understanding of space missions.

Challenges

Timeline of Space Exploration

The main challenge of this section was to establish the timeline layout in the most legible and comprehensible way possible for the user. We decided to keep a classic timeline layout with a vertical date-by-date arrangement. Next, the complexity of the layout lay in managing the dataset and using it in the best possible way to extract the most important information. It seemed obvious to highlight the name and precise date of the mission, and then to provide more information thanks to the info point added at each date. The challenge with this layout was to find a way of doing this without copying and pasting every line of the dataset. Unfortunately, this was very hard to manage, which meant taking a considerable amount of time to manage the dates one after the other. Finally, the last challenge was to position the information point and create an interactive interface with this object.

Apollo Evolution and Moon Mission

Narrative and Structure

To present the Apollo Evolution and Moon Mission section, we divided the narrative into three parts: the USA's political context and JFK's speech setting the moon landing goal, seven pages detailing key missions leading to the moon landing, and NASA's strategic Lunar Orbit Rendezvous decision crucial for success.

Technical challenges

- **Interactive Timeline and Scatter Plot:**
  - Provided clear visual indicators for user status.
  - Used real-world data visualizations to make interactions intuitive.
- **User Navigation Across Multiple Pages:**
  - Added seven additional clickable pages for improved user experience.
  - Ensured consistent design and navigation patterns across all pages.

Rocket Mission

Narrative and Structure

To present the main dataset of all missions, Our team decided to use bubble chart that is mentioned in the our path section. This approach allows users to explore launches by specific years, providing a clear and engaging way to explore through the data.

Technical Challenges

- **Data Cleaning:** We relied on the main dataset `Global_Space_Launches.csv` where mission costs values were crucial but were missing in few records. We filled these gaps with the average cost for the corresponding company or, if unavailable, the country. Any remaining empty values were discarded.
- **Bubble chart:** Designing a bubble chart with D3.js and React was challenging due to the need to integrate dynamic data visualization with hierarchical levels, and customize the icons and making sure that everything is looking nice and visible to the user.

Living in Space

Narrative and Structure

Representing more extravehicular activity dataset, we chose to focus on the Mir space station as a representative example. This decision provided a clear, detailed view of life in space

and extravehicular activities.

Technical Challenges

- **Interactive Elements:** Implementing hover-over effects and ensuring that detailed information is displayed appropriately was challenging, particularly in terms of maintaining a user-friendly experience.

Lessons Learned

Narrative and Structure

To narrate the lessons learned from the Soyuz 23 and Soyuz 11 missions, we divided the information into detailed categories focusing on the key events and outcomes. This helps in understanding the challenges faced and the solutions to be implemented in future.

Technical Challenges

- **Integrating Interactive Visuals:**
  - Used D3.js to create scatter plots and interactive elements.
  - Implemented scrollable popups to show detailed information.
- **Dramatic Narrative:**
  - Emphasized key moments to create an engaging narrative.
  - Included multimedia elements to enrich the storytelling experience.

Sketches

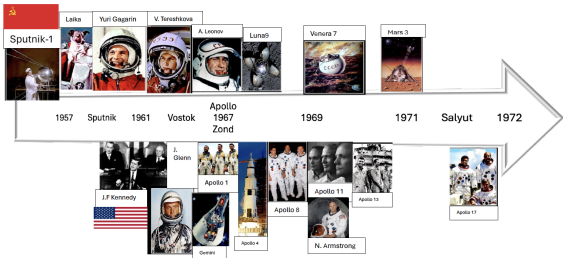
In this section, we will explore some samples of the web server schreenshots and compare them with what we planned to check whether we succeeded.

Timeline of Space Exploration

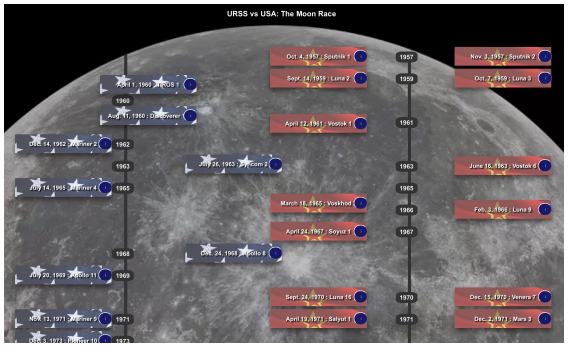
According to the milestone 2 rendering, we had a more horizontal idea of the timeline as you can see from1. However, we had to go for a vertical timeline for the user's visual comfort, which results in better understanding but also a change of direction from what was intended.

Apollo Evolution and Moon Mission

We made significant changes in this section, opting for multiple timelines with scatter plots as you can see2b to enhance engagement and provide a detailed analysis of the mission's



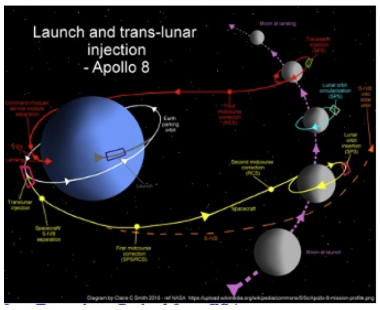
(a) This is what we wanted to do



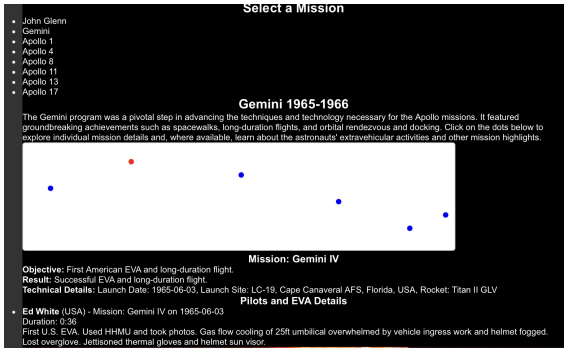
(b) This is what it ended up being

Figure 1: Comparison of intended Apollo Mission evolution vs actual one

success up to the moon and the final moon mission.



(a) Initial Concept

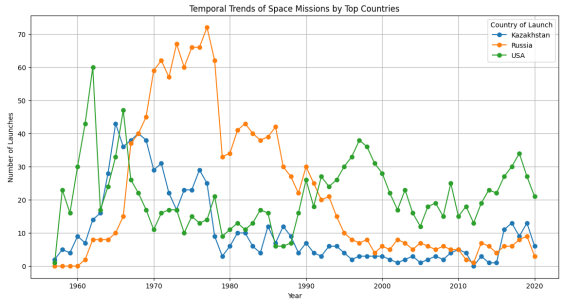


(b) Final Outcome

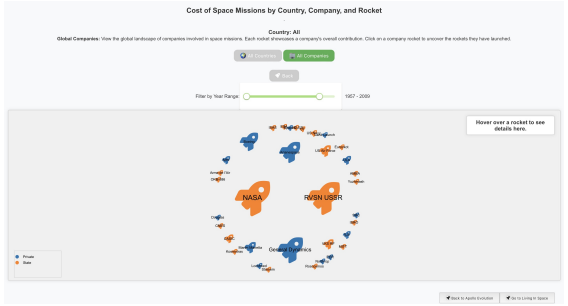
Figure 2: Comparison of Initial and Final Mission Evolution

Rocket Mission

We significantly improved this section by creating an engaging representation of the datasets instead of simple graphs as you can see from 3b.



(a) Dataset Example

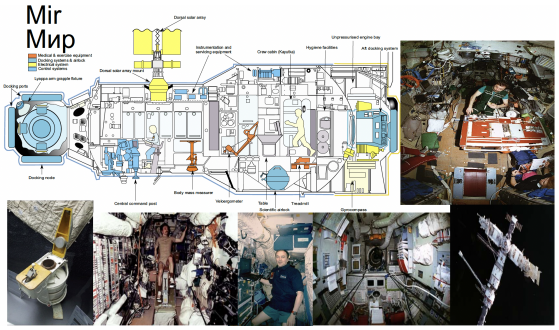


(b) Interactive Categorization

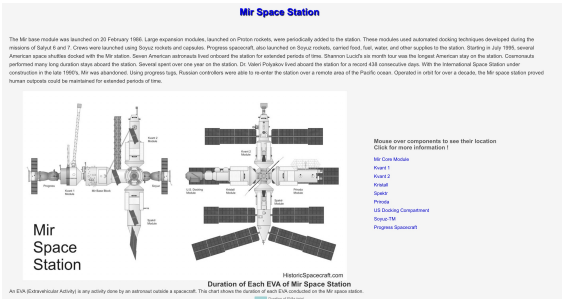
Figure 3: Improved Data Representation

Living in Space

We closely followed our initial plan, including an interactive gallery that activates upon clicking parts of the spacecraft. However, due to the lack of datasets for inside activities, we decided to work with more extra vehicular activity. We also added a cursor feature highlighting parts of the Mir station module as you can see from4b.



(a) Mir station from milestone 2



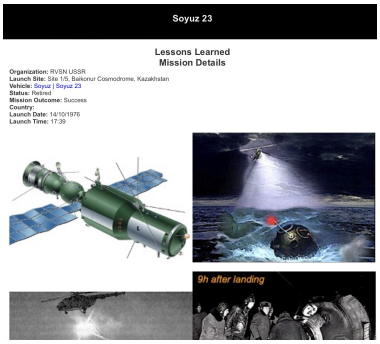
(b) Mir station

Figure 4: Matching and Improvement

Lessons Learned

We achieved our goal of an interactive gallery as you can see from5b and enhanced it with scatter plots, additional mission data, and pilot information from supplementary datasets.

(a) Interactive Gallery from Milestone 2



(b) Detailed Popups

Figure 5: Final Interactive Gallery

Conclusion

Our experience working on this project has been exciting and challenging, representing the complexity of space exploration. We chose and examined datasets with an original perspective influenced by historical turning points to produce an interesting and educational website.

We can conclude our team working as follows:

- **Clear Vision and Objectives:** Our team Inspired by JFK's 1961 speech, and aimed to present space missions objectively.
- **Challenges and Solutions:** Our team overcome difficulties in data management and UI design using Nielsen's Heuristics and the Value Proposition Canvas to make the webserver user friendly.
- **Interactive and Engaging Design:** Utilized vertical timelines, scatter plots, and interactive elements with D3.js and React.
- **Collaborative Effort:** Each team member's contributions were essential to our success.This project increased our understanding of space exploration and our skills in data visualization and web design. Hence prepared us for future engineering challenges.

Peer Assessment

- **Alexis**: My contribution to the group involved brainstorming sessions and the first two milestones, where we developed the architecture of the website. Additionally, we divided the tasks, and I was responsible for the Timeline of Space Exploration section and the corresponding process book part to explain my work. It was a pleasure to work with Ertugrul and Othmane, discovering space exploration and the world of data visualization. I am grateful for their help, as they supported me despite my limited knowledge in this domain.
- **Ertugrul**: I am very happy to be a member of this amazing project group. We worked together as a team for the first two milestones, I proposed following the Nielsen Heuristics and the Value Proposition Canvas to improve user experience as a reference. In Milestone 3, I completed the "Apollo Evolution and Moon Mission" and "Lessons Learned" sections, along with their corresponding process book parts.
- **Othmane**: We worked together for the first two milestones, and for Milestone 3 I did the "Rocket Missions" and "Living In Space" sections plus merging between all our sections and deploying the website.

Acknowledgement

Our team would like to give special thanks to Marc Toussaint for his lecture at EPFL EE-582, which provided us with valuable insights into space exploration missions.

References

[1] R. Kruse, "Historic spacecraft - photos of rockets and spacecraft," 2023, accessed: 2024-05-30. [Online]. Available: https://historicspacecraft.com/

[2] J. Nielsen, "10 usability heuristics for user interface design," https://www.nngroup.com/articles/ten-usability-heuristics/, 1995, accessed: 2024-05-30.

[3] A. Osterwalder, "The value proposition canvas," https://www.strategyzer.com/library/the-value-proposition-canvas, 2012, accessed: 2024-05-30.