



Design opportunities of the NASA Solar System Treks website

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A study of the user experience issues and design opportunities of the NASA Solar System Treks website.

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Abstract

The report is the final result of a research framed by the course *Individual project in interaction design, minor (CIU235)* at Chalmers University of Technology. The project originally comes from Thommy Eriksson, my supervisor and Emily Law from JPL, based on their collaboration to improve the website.

The website is called the Solar System Treks. It is online, browser-based portals that allow you to visualize, explore, and analyze the surfaces of other worlds using real data returned from a growing fleet of spacecraft. You can view the worlds through the eyes of many different instruments, pilot real-time 3D flyovers above mountains and into craters, and conduct measurements of surface features. The portals provide exciting capabilities for mission planning, planetary science, and public outreach.[1]

The goal of this project is to investigate usability issues of the Solar System Treks website and the potential design solutions.

The project went through five design phases from analysis to design and evaluation iterations by using *design thinking* methods. *Remote usability evaluation* and *think-aloud protocol* were done in the beginning to discover the problems and needs of our target. *A Prioritization Metrix* was used to analyst the finding and define the most urgent issues to fix. After that *Brainstorming and Sketch* were carried out to find the initial and possible design. *Low and Hi-fidelity prototypes* were created to determine the design decision. After each prototype, *usability tests (semi-structured observations and interviews)* were conducted to obtain negative and positive feedback and in the design. The test results were analyzed using *Prioritization Metrix*, and the highest impact and effort were fixed in a later prototype. Two usability tests with target users and two feedback sessions with JPL were conducted in the evaluation phase, containing 11 participants in total.

The results of this project contain an interfaces design proposal, user feedback, an interactive Figma prototype, and a report.

Acknowledgement

I wish to express our sincere appreciation to those who made this project possible.

To our supervisor Thommy Erikson, at Chalmers University of Technology, for your feedback, guidelines and fully support throughout this project. Thank you for giving me the opportunity and trust to carry out this project.

To Emily Law, Catherine Suh, at NASA's Jet Propulsion Laboratory(JPL), for your support and professional advice. Thank you for taking your time in giving me reviews and supportive materials.

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Table of Contents

1.	INTRODUCTION	7
2.	THEORY	8
2.1.	MENTAL MODEL	8
2.2.	REDUCING WORK AND ELIMINATING EXCISE	9
2.3.	DESIGNING FOR THREE LEVEL OF EXPERIENCE	9
3.	METHOD	10
3.1.	DESIGN PROCESS	10
3.2.	EMPATHY.....	11
3.2.1.	<i>Remote Usability evaluation</i>	11
3.2.2.	<i>Think aloud</i>	11
3.3.	DEFINE	11
3.3.1.	<i>Prioritization Metrix</i>	11
3.4.	IDEATE	12
3.4.1.	<i>Brainstorming and Sketch</i>	12
3.5.	PROTOTYPE	12
3.5.1.	<i>Low – Fidelity (Low – fi) prototype</i>	12
3.5.2.	<i>Hi – Fidelity (Hi – fi) prototype</i>	12
3.6.	TEST	12
4.	EXECUTION AND PROCESS.....	12
4.1.	EMPATHY.....	12
4.1.1.	<i>Remote Usability evaluation and think aloud method</i>	13
4.2.	DEFINE	15
4.2.1.	<i>Prioritization Metrix</i>	15
4.3.	IDEATE	17
4.3.1.	<i>Brainstorming and Sketch</i>	17
4.4.	PROTOTYPE AND TEST	18
4.4.1.	<i>Low – Fidelity (Low – fi) prototype</i>	18
4.4.1.1.	<i>Homesite and Treks portal information section</i>	19
4.4.1.2.	<i>Galleries section</i>	19
4.4.1.3.	<i>VR section</i>	20
4.4.1.4.	<i>Feature/ How it works</i>	21
4.4.2.	<i>Hi – Fidelity (Hi – fi) prototype</i>	22
4.4.2.1.1.	<i>Homesite and Treks portal information</i>	23
4.4.2.1.2.	<i>Galleries</i>	26
4.4.2.1.3.	<i>VR Library</i>	26
5.	THE DESIGN SOLUTIONS.....	29
5.2.	GALLERIES SECTION.....	31
6.	DISCUSSION.....	34
6.1.	REMOTE USABILITY EVALUATION	34
6.2.	LIMITATION OF TIME	34
6.3.	MORE UNDERSTANDING BEHIND THE DESIGN OF THE WEBSITE	34
7.	CONCLUSION	34
8.	FUTURE WORK	35

APPENDIX A	38
APPENDIX B	39
APPENDIX C	45
APPENDIX D	47

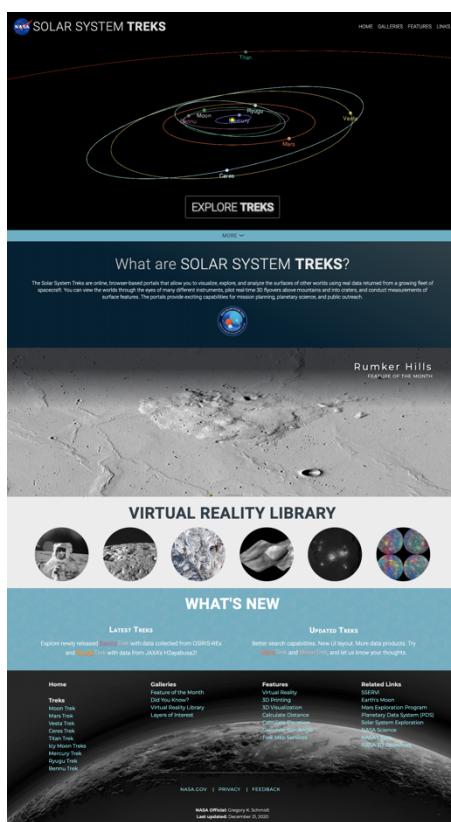
1. Introduction

1.1. Background

The NASA Solar System Treks website is an online, browser-based portal. It allows users to visualize, explore and analyze the surface of other worlds. The Treks website provides an updated space exploration content, mission, pictures from other planets, etc. Users can measure, explore or fly over the planets. Moreover, the portal provided a non-immersive simulation of visual reality in which users can explore the solar system via many mediums for example a web browser, mobile phone, virtual reality (VR) glasses, or Google cardboard.

In addition, the main website and Treks portals are developed separately. Thus, the user will be led to a different web portal later. There are advanced tools for expert users or users who provide good justification why they need to use advanced tools that are mainly for engineers who plan a mission, or scientists who do research.

The website focuses on three main target users which are mismatched in knowledge and expertise. Firstly, scientists use this website to do scientific research. Secondly, engineers use advanced tools to plan missions. Lastly, public users who interested in the space-exploration. They can explore this website without requiring advance tools. It can be concluded that the website is easy to use for any type of user.



Picture 1. The NASA System Solar Treks website : <https://trek.nasa.gov/#>

1.2. Aim

The Solar System Treks website aims to introduce and educate public users to the space exploration domain. But so far, this website has not been evaluated with public users. This project aims to discover and improve the existing usability issues, focusing on the navigation and layout. It includes reformulating tutorial guidelines and providing an efficient way to access information. The main target user in this project is a public user.

1.3. Project scope

This project mainly focuses on discovering usability issues on the navigation and layout of the website's desktop version. The usability problems when using the website in the Virtual Reality and mobile mode did not include in this study. With the limitation of the VR design knowledge, this project didn't apply any VR design guidelines during development. The advanced feature user interface that requires a permission to access and a Treks portals user interface will not be considered in this project.

1.4. Jet Propulsion Laboratory or JPL

The Jet Propulsion Laboratory (JPL) is a NASA field facility in Pasadena, California. It is a government-financed research and development center. NASA owns JPL, which was founded in the 1930s and is overseen by the adjacent California Institute of Technology (Caltech). The primary purpose of the laboratory is to build and operate planetary robotic spacecraft, but it also conducts Earth-orbit and astronomy missions. It is also in charge of running NASA's Deep Space Network.[26] JPL developed the NASA Solar System Treks website as an educational tool for public users as well as a tool for planning the mission for scientists and engineers.

The project happened because of the collaboration between Thommy Erikson from the Interaction Design and Technologies program, Chalmers University and Technology, and Emily Law, the engineer from JPL, NASA. They have been searched for a student to improve the Treks website efficiency. This includes improving the user interface and usability.

2. Theory

2.1. Mental model

Mental models are central in human-computer interaction (HCI).[20] It's crucial to figure out what users know and how these various types of knowledge fit together in terms of learning and performance. It refers to the difficulty of developing systems and training programs that are simple to use and efficient to learn.[19] A mental model is a representation (in the mind) of a physical system or software that is running on a computer. It's characterized as reflecting

the user's perception of what the system contains, how it works, and why it operates the way it does.[21]

2.2. Reducing work and eliminating excise

One of the designers' goals is to reduce the amount of unneeded work that users have to perform. For the users, the result might be a stressful experience. They'll have a hard time connecting their mental representations of the activities they wish to do with the product interface that's been designed.[18]

The authors of About Face categorize what users do into two categories: Goal-Directed tasks and Excise tasks. Goal-directed tasks are activities that help users get closer to their objectives. *Excise tasks* are activities that are performed in order to meet the needs of your tools or other agents. There are 4 types of excises which are:

- *Navigational excise* – Users are irritated by unnecessary or complex navigation. One of the most significant and widespread issues in the usability of interactive products is poorly designed navigation.
- *Skeuomorphic excise* - Skeuomorphism is a concept used in graphical user interface design to describe interface components that look and perform like their real-world equivalents.[23] However, we may run into an issue while converting a mechanism to a digital format. This causes waste and unnecessarily restricts interaction that may be significantly more efficient than the existing paradigms allow.
- *Modal excise* – Users should not be interrupted in their flow of using the product by a modal error message or confirmation box. While certain interruptions are necessary, interrupting without cause is one of the most inconvenient forms of excise.
- *Stylistic excise* – Visual style may absolutely set an atmosphere and promote a brand, but it shouldn't come at the expense of practicality and usability by requiring users to identify which visual aspects represent control or vital information.

By eliminating excise, the website will provide less friction, easier interactions, lower cognitive burden, and make your users feel more powerful.[22]

2.3. Designing for Three Level of Experience

As an interaction designer, it's critical to create products that are both powerful and simple to use. When developing products, intermediate, novice, and expert users must all be taken into account.[18]

- *Beginner*: A new user must quickly understand the product's concept and context. The users require some training, but not a lot, and the process must be quick and precise. If the website's model closely resembles the user's mental model, the user will gain the understanding he or she requires without having to figure out the implementation

model. [18] Regardless of the platform, a well-designed interface should allow users to quickly get accustomed to and comfortable with navigation and function.

- *Intermediate*: They require quick access to the most commonly used tools. They don't need to be told what the scope and purpose are since they already know. [18]
- *Expert*: Experts may seek esoteric qualities on occasion, and they may make extensive use of a few of them. However, they will undoubtedly need speedier access to their standard toolkit, which may be extensive. To put it another way, specialists like shortcuts to everything. [18]

To summarize, the website should provide *an easy and quick way to access, efficient navigation, and understand the concept as well as a match with the user's mental model*.

3. Method

This chapter will describe the methods that were used for accomplishing this project. The design process will follow the Design thinking model, which involves five phases: Empathy, Define, Ideate Prototype and Test. After this, the relevant methods will be introduced.

3.1. Design process

Design thinking is an analytic and creative process in which a person is encouraged to explore, create, and prototype models, collect feedback and rethink.[2] The design process is divided into five phases: Empathy, Define, Ideate, Prototype and Test.

- *Empathy*: Gaining an empathic knowledge of the problem is the first step in the Design Thinking process.
- *Define*: This is the stage to analyze the information from the previous stage to address the core problems
- *Ideate*: With a solid knowledge from the two previous stages, this is a stage to collect as many ideas or answers to problems as possible. Then choose the best way to solve the problem.
- *Prototype*: The idea will be tested in this phase. Based on the users' experiences, the solutions are applied within the prototypes and, one by one, they are investigated and either accepted, improved, and re-examined, or rejected.
- *Test*: Although this is the final stage of the 5-step model, in an iterative process, the testing results are frequently utilized to redefine one or more problems and inform the users' understanding to designers.

3.2. Empathy

3.2.1. Remote Usability evaluation

Due to the epidemic, the traditional usability testing where users and designers have to be in one place, is hard to conduct. The remote usability evaluation is the suitable choice for this situation. A remote usability evaluation refers to a circumstance in which the evaluators and the test participants are not in the same room or place. [2] A facilitator and the evaluators collect data and manage the evaluation session with a remote participant (who could be at home, at work, or in another room) in real-time. Video conferencing programs or remote application sharing technologies that allow the evaluator to see what is happening on the user's screen (tools like Zoom or Google meet) may be required for the evaluation.[2]

The number of users for the test should be more than 3 – 5 people to discover 85% of the usability problems.[12] However, this question of the number of users to test is far from being solved and requires further research [2] which project will not research more on this area.

3.2.2. Think aloud

The simultaneous verbalization of thoughts while executing a task is known as think-aloud [5]. In usability testing, think-aloud is used to collect qualitative data. Participants in a think-aloud procedure are invited to speak whatever comes to mind while performing the tasks. While interacting with the prototype, this could include what people are looking at, thinking about, doing, and feeling [6]. Researchers can use the think-aloud approach to learn about participants' cognitive processes and mental models while they interact with the product or service.

3.3. Define

3.3.1. Prioritization Metrix

A Prioritization Matrix is a valuable tool for determining which problems are the most critical to address initially. A Matrix is a tool that allows you to rank problems or concerns that arise from brainstorming sessions based on weighted criteria that are essential to a project and/or company. When we need to prioritize problems or reach a consensus on an issue or proposed solution during the Define and Prototype phases, this tool comes in handy. It's also useful for explaining how final decisions were made to others.[13] A prioritizing matrix is a two-dimensional graphic that depicts the relative importance of a group of objects using two weighted criteria.[14] The reasons for prioritizing different ideas could be their impact on the user or their feasibility. The criterion should always be taken from the project's general goals, regardless of what elements we're prioritizing.[14]

3.4. Ideate

3.4.1. Brainstorming and Sketch

Brainstorming is a technique for coming up with new and creative ideas. It's one of several approaches for ideation and it's important to the design thinking method. [7] It helps to generate new ideas to solve clearly defined design problems. Sketching is speedy, giving you more time to iterate on designs in between usability testing, or even during them. [11] During generating ideas, each idea is sketched on the paper to get the sense of how the design or part of a prototype will look like.

3.5. Prototype

3.5.1. Low – Fidelity (Low – fi) prototype

Future scenarios should be evoked by lo-fi prototypes, which should tell stories and communicate future views. [8] Sketches and other low-fidelity representations differ from the final result in terms of interaction style, visual look, and/or level of detail.[11] It transforms concepts into testable artifacts that may be used to gather and analyze feedback in the early stages of development.[9]

3.5.2. Hi – Fidelity (Hi – fi) prototype

A high-fidelity prototype is a computer-based interactive depiction of a product that is as near as possible in terms of details and functionality to the final design.[10] Designers may be hesitant to revise designs and less likely to completely explore the design space if they use high-fidelity prototypes.[11]

3.6. Test

In this phase, the remote usability testing and think-aloud protocol were used to discover the usability issues of a potential design solution as well as to determine the design decision.

4. Execution and Process

In this chapter, the project will be introduced following the Design Thinking process to accomplished the aim. Each section will describe in detail about process and method used.

4.1. Empathy

The project started by investigating what usability issues are and understanding how users feel toward and interact with the website. However, the designer must understand the overall of the website before conducting a test with a user. The designer experienced the website as a new user to learn the websites' navigation, feature and how it works. By doing this, it helps the designer to create and check mental model.

The first issue with playing was the website's navigation and layout. Because the button and content overlapped with a moving animation widget, the designer took more than a minute to navigate herself to enter chosen Treks portal. Furthermore, the instruction content (How to experience in VR mode) does not stand out enough and is not well navigate. The designer had to read the instruction repeatedly, went back and forth between two sections (feature and galleries section) to achieve each step. This took more than 5 minutes to accomplish this instruction.

There were surprise moments when exploring the Galleries section. The designer accidentally clicks the space on the right side of the paragraph and the content changed. When the designer looked closely there are faded left and right arrows over the paragraph. Moreover, users can access more information in some areas, however, the way of how the website present it doesn't match with a mental model of the designer. The designer expected that the cursor will change its form when entering the clickable area, but it does not. Overall, this website made the designer feel uncomfortable and lost.

After roughly playing through the website, the designer developed assumptions. *"If the first-time user will feel the same way and encounter the same problems or not, or they will discover new usability problem."* By answering that, the remote usability testing script and tasks were developed. See full questions and tasks in Appendix A.

4.1.1. Remote Usability evaluation and think aloud method

The series of questions and tasks were formulated to evaluate usability on the website. To discover more than 85% usability issues, the number of users should be more than 3 – 5 users. (See section 3.2.1). The target user is public users. They are one of the main targets of this website. Every user starts from the first-time user level. Solving the first-time user issues could be a benefit to other levels of users. Another reason is the general user is easy to access and recruit to the testing session. The 6 users who were interested in the space exploration context were recruited via the invitation from the designer.

- 1 is a business consultant
- 1 is an acoustic engineer
- 3 users are interaction design students
- 1 is a civil engineer

The overview of the content and the structure of the remote usability evaluation are listed below:

- Send out Zoom invitation, together with the website's link via a message application
- Introduce the purpose of this test and the overview of the project – 5 min

- Ask the user to open the website and for the user's consent to record the testing session.
- Send each through the message box on Zoom.
- Ask the user to read the task out loud.
- Begin the task
- After the test, ask the open-ended questions

They were required to complete the activities and use the think-aloud method. As mentioned in the method section, users were asked to share their screens and give permission to record the testing to determine the usage time and their behavior. This recording was performed to see what is happening on the user's screen and use for evaluation later. This evaluation did not set the time because the designer wanted to use the timestamp as the baseline when choosing the design solution.

The designer observed the user's behavior and wrote down the user's attitude that he/she expressed during the session. After the end of the usability testing, users were asked additional questions to gather their impressions of the website. The detailed usability testing tasks and questions can be found in Appendix A.

The result of the remote usability testing of empathy phase revealed the problems users faced were the same issues and they had a similar feeling during the test. This answered the designer's assumption. They were annoyed with the navigation, content, and layout. Here is the summary of the feedback from 6 users. The full details of feedback can be found in Appendix B.

4.1.1.1. Feedback of Homesite and Treks portal information section

The moving Solar system widget misled users to think that it is clickable and able to rotate. When clicking on the portal, the moving animation distracted users and made them unable to do the next step of the given task.

4.1.1.2. Feedback of Galleries section

This section and subsections do not have a clear explanation to make users understand what they can expect and do. Users pointed out that the section's layout is unorganized. The content is unnoticeable, which made them need to perform extra steps to reach the goal, for example, checking the previous month's or six-month-old information. The content carousel is unnoticeable because the arrows are overlapped with a "Feature of the moth" content. More importantly, users complained that the content is the wall of text and it made them lost interest to read it. The information in the VR Library subsection doesn't stand out to capture the attention of the users. Some parts of the contents do not show that this area is clickable. The result is users spent more than 3 minutes finishing the relevant tasks for example. Furthermore, users expressed this subsection should be more stand out from the Galleries section because they understood that this subsection is a highlight feature of this website from the banner on the homesite. The moving Solar system widget misled users to think that it is clickable and

able to rotate. When clicking on the portal, the moving animation distracted users and made them unable to do the next step of the given task.

4.1.1.3. Feedback of Feature section

This section surprised all participants with a mismatched header and content. They did not expect the feature section would contain tutorials of the features. They expected the feature section would contain the useable features. Furthermore, the unclear VR instruction made users unable to follow and complete the tasks.

4.1.1.4. Missed lead button

Users were confused with a reset button on the Treks portal screen. They thought this is a home button that will lead them to the homepage.

4.1.1.5. Cursor

Users did not know that some areas are clickable because the cursor confused them. For instance, the hand cursor means you can click on it but the cursor does not change on many clickable areas.

4.1.1.6. More or less information

Some of the users commented about the overwhelming information in the Galleries section. They suggested hiding some of it but still can access it later. We need to test this hypothesis further to confirm that this is a real issue or not.

4.2. Define

4.2.1. Prioritization Metrix

After understanding problems, the issues were prioritized with a two-dimension matrix. As mention, the criterion should always be taken from the project's general goals. In this case, the problems will be categorized based on the severity level from the designer's perspective. The two dimensions consist of Low to High scale of effort and value. Effort level represents the effort of the designer to solve the problem. The value represents how much the problem affects the website. A high value means a high impact on the website. The four areas in the matrix are

- *Low effort and High value* mean this problem uses only a minimum of effort to solve it but has significantly impacted the website. It must be solved first.
- *High value and high effort* mean this problem have a high impact but needs to spend a lot of afford to solve. This problem can be solved later in the project.

- *Low value and Low effort* mean this issue doesn't have a high impact on the website as well as less effort is required to fix the problem. This type of issue can be solved when the designer has time left during the process.
- *Low value and high effort* mean this problem has less or no impact on the usability of the website. Also, it is required a lot of effort to fix it. This problem can be ignored.

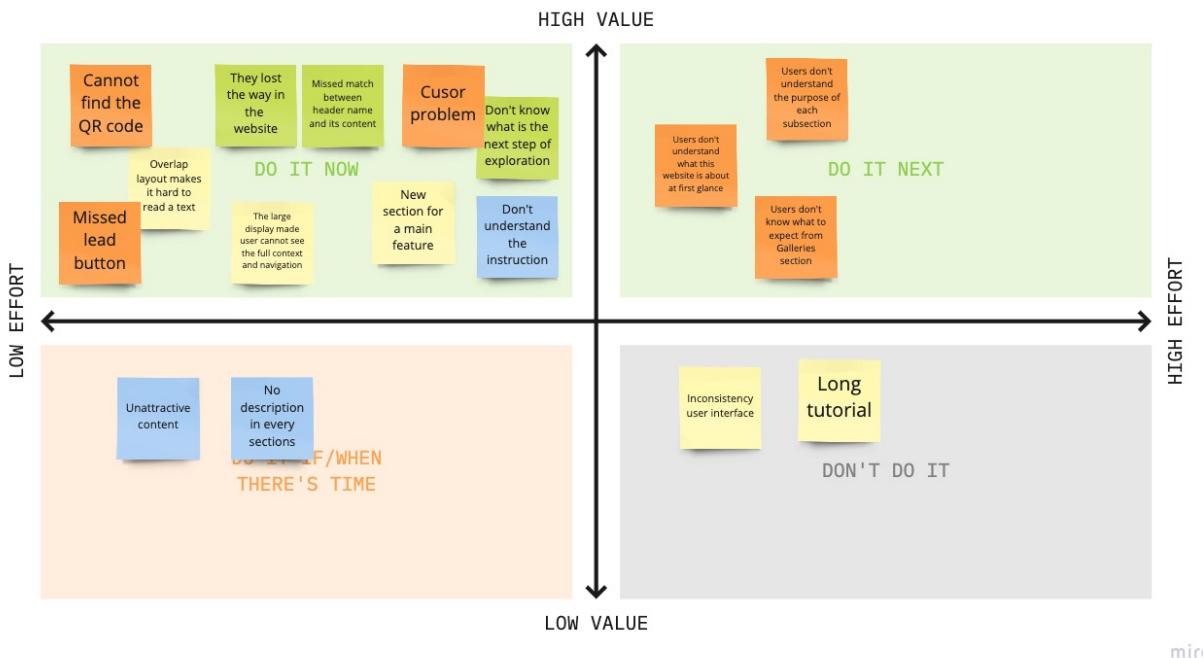


Fig.2 Prioritizing matrix.

From the problems that needed to be solved first, the design goals are:

- How to make the user understand the website concept and what it can do
- How to improve the Treks portal navigation to reduce excise and users' cognitive load
- How to improve the layout of the Galleries section so users can discover more highlighted information
- How the user can follow the VR transition instruction from the first step to the end in a shorter time
- Which word could be used for the section header and match with its content?

On the other hand, this project will focus more on solving the issues from "Do it now" and "Do it next". And if there is more time the problems on "Do it later" will be considered. However, the issues on "Don't do it" do not mean that they are not important. They could be in the "Do it now" area if we change the project's aim.

In addition, not only do these design goals need to be fixed but the designer has to always keep in mind that when designing the website, it has to be *easy and matched with the beginning user's mental model*.

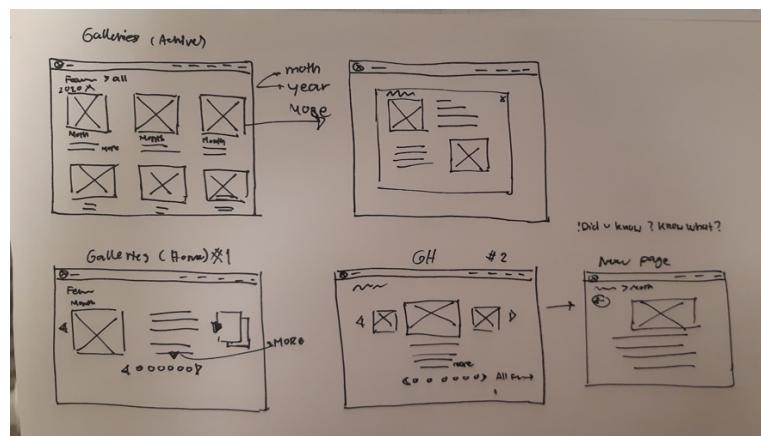
4.3. Ideate

4.3.1. Brainstorming and Sketch

After knowing which usability problems had to be fixed first, the designer started to brainstorm the potential design solution by researching the museum, art galleries and space education websites and reviewing the interaction design guideline book called “About face” by Alan Cooper.

The reason to research the museum, art galleries and space education websites (we will call these websites “*external websites*”) is the similarity of the amount of information and purpose of the website. Both websites would like to educate, present information in various forms (e.g., video, photo, text). By looking through and analyzing, the external website, there some common methods in organizing information and navigation.

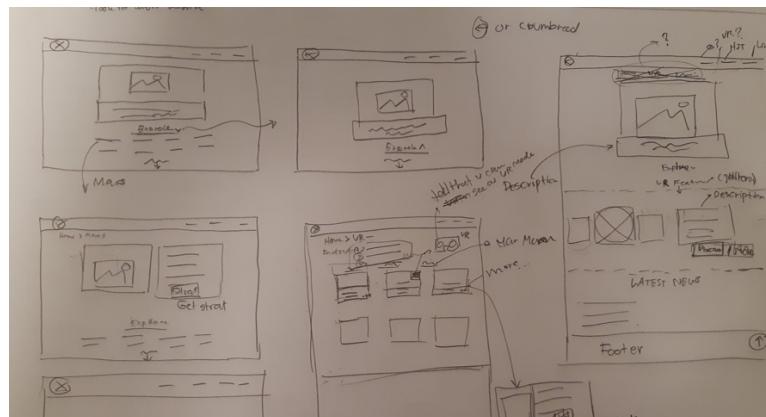
Content carousels: It is widely used by external websites as well as the Treks website. It was used to highlight “*the feature of the month*” in the Galleries section. However, with the current layout, it doesn’t look like a content carousel, as mentioned in section 2.1.2. The design ideas were brainstormed and sketched, for example, different layouts or sites of carousel, etc. Below are the different sketches of content carousels.



Sketch 1. The different forms of Content carousel.

Furthermore, some users skipped the instruction on how to transit to the VR mode and some could not follow every step. To reduce the excise, this could be formulated into graphical with text or reorganized the layout, etc. That might be easier for a user to spot on and follow each step. For the homesite, the users had a problem in understand what this website is for and what can they expected. Having a new description layout or improving the flow of selecting Treks portal to follow users’ mental model, etc. might solve these issues. As users mention to create a VR Library page separate from the Galleries section. Many designs were sketched to

brainstorm how it will look like. The problem with finding a QR code might need to think about how to make it obvious to the user. Many design solutions were sketches and can see it below.



Sketch 2. The different sketches of the interface

However, the problem that required technical help, for example, changing the cursor or showing the Treks portal on the same browser will not be the main focus of this ideation phase. But these problems already were known to the User Interface developers from JPL, and they explain these are technical issues that they will try to solve.

After sketching and considering many alternative solutions, these design solutions were moved on to the next stage:

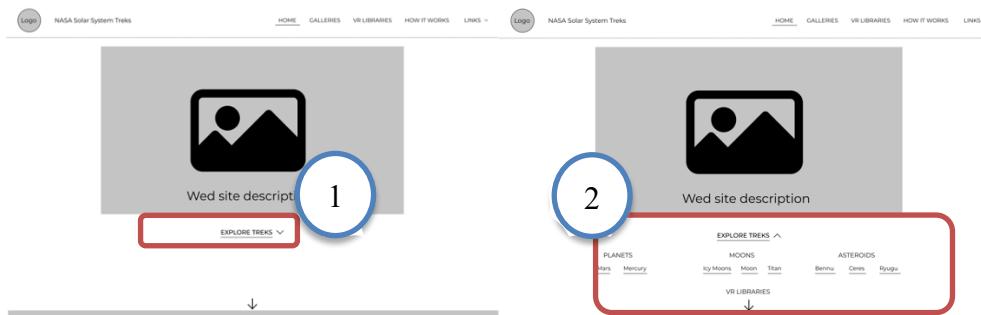
- The new navigation from homesite to Treks portal
 - Moving the Treks portal option to the middle of the screen, following users' mental model can reduce a cognitive load and excise
 - Separating the Treks portal detail, animation and button can navigate users to the Treks portal without spending too much time searching for the next step
 - Formulate call of action keyword from "Explore" to "Get started" on the Treks portal information
- The reorganize layout and navigation of the Galleries section
- Design a VR section and visualization that translated from the current VR instruction
- Reformulate the word on the navigation bar to match with users' mental model
 - From "Feature" to "How it works" on the Feature section

4.4. Prototype and Test

In this phase, it is an iteration process. Start by creating low – fi prototype from sketch, test, hi – fi prototype and then final evaluation to finalize the design solutions. The four design solutions were built to a low – fi prototype to determine their usability.

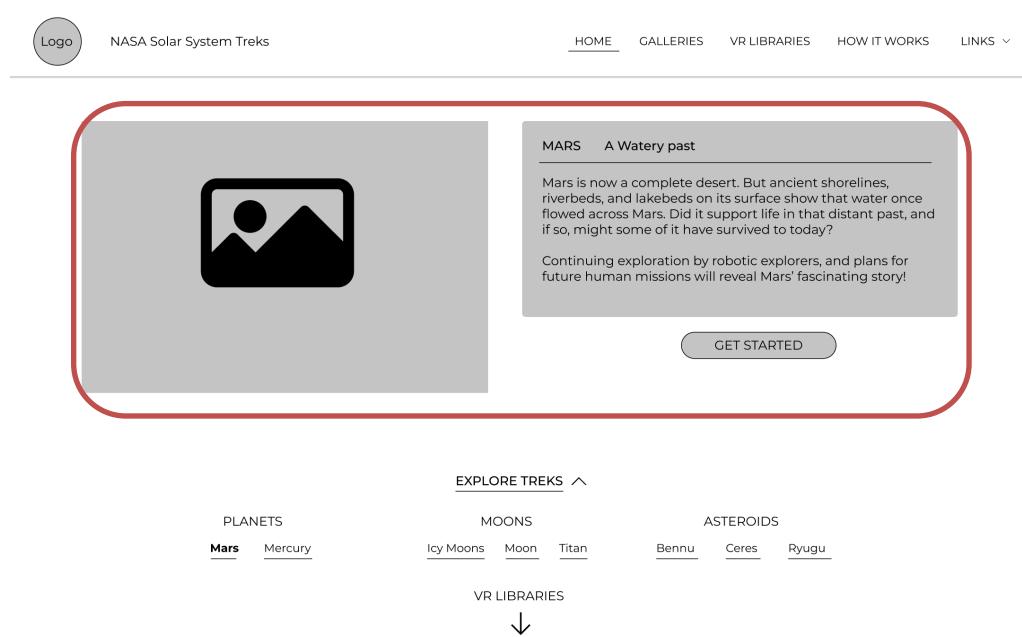
4.4.1. Low – Fidelity (Low – fi) prototype

4.4.1.1. Homesite and Treks portal information section



Screen 1. *Homesite and Treks portal options*

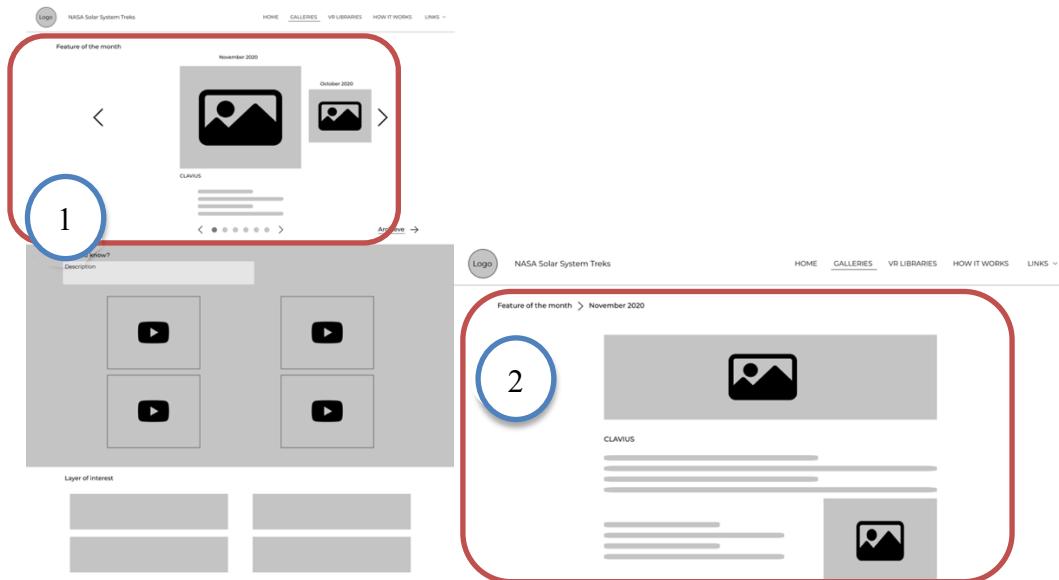
The Treks portal options were placed under the “Explore Treks” menu. It will appear in the middle of the screen after clicking “Explore Treks”.



Screen 2. *Treks portal information detail*

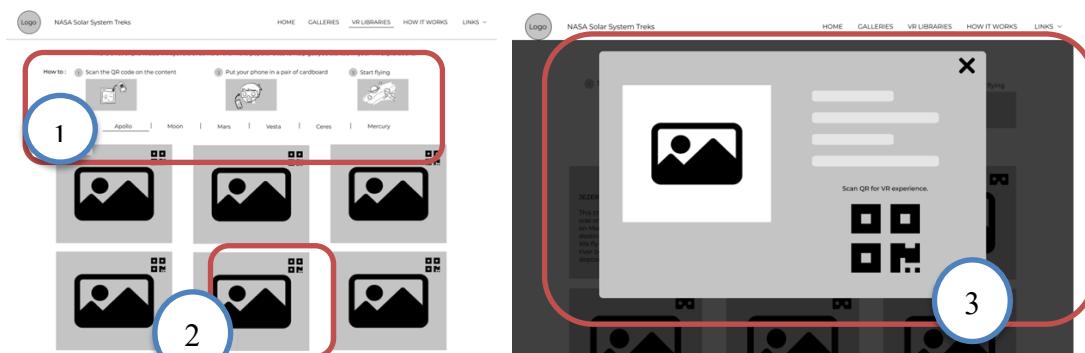
The Treks description, image, and animation were all placed separately to avoid overlapping. It was created to address the problem of reading text while watching an animation and to clarify the next step after selecting the Treks portal. The "Explore button" was designed to "Get started," not to be confused with the "Explore Treks."

4.4.1.2. Galleries section

Screen 3. *Galleries Section*

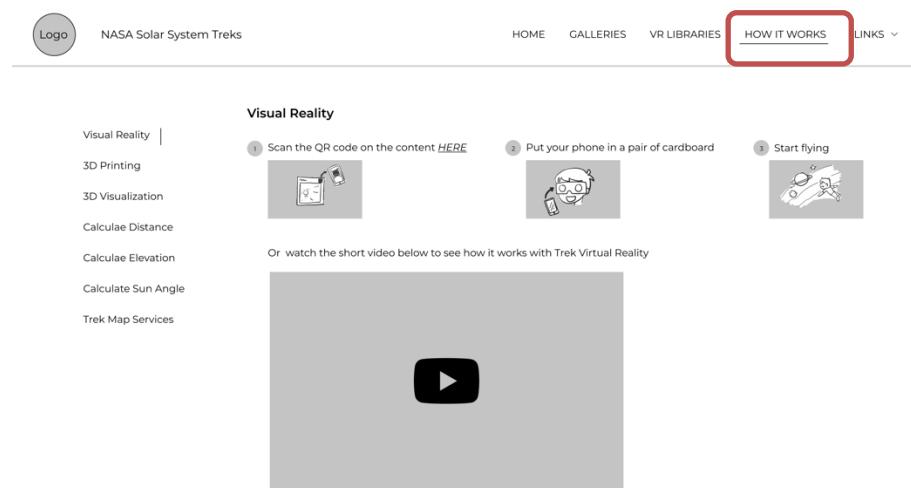
The problem of the picture size of “Feature of the month” subsection was solved by shrinking the picture and put only the short description below (1). The unnoticeable right and left arrows were made larger and placed beside the content. If a user is interested in the article, they can see more information in detail later. Also, there is a breadcrumb navigation to show where the users are (2). By showing the previous month's info next to the current one, tells the user that there is a next article to explore.

4.4.1.3. VR section

Screen 4. *VR Library Section*

While the other sections only were redesigned, this new section was created based on the feedback from users. The instruction was visualized from text into three graphic and text (1). Furthermore, the designer chose to place the QR icon to show where users can find the QR code (2). But the QR icon on the Flyover was intended to be too small to scan, the users had to click on it to see more info and the bigger version of the QR code (3)

4.4.1.4. Feature/ How it works



Screen 5. *How it works*

From the users' suggestions, this header name was changed from "Feature" to "How it works" to represent the content under this section and match users' mental models.

4.4.1.5. Low – fi prototype remote usability testing

To evaluate the design solutions, the remote usability evaluation was conducted with 3 new users. They are interaction design students. All the structure of the test was the same as the remote usability evaluation on Empathy. The zoom and prototype link was sent out. The users were asked to open the prototype and shared the screen before the session. In addition, they were informed consent to record the usability evaluation session. The recorded video will be stored on the local laptop. The designer is the only one who can access and watch the record. The record will be deleted after the project is approved from the examiner. After that, the designer explained the purpose of the test, and similar tasks were sent out. See Appendix A. The users were asked to complete the tasks while thinking aloud.

After the end of the usability testing, users were asked to rate this prototype from 1(Unsatisfied) – 5 (Satisfied), and some additional questions were brought up to gather their impressions and of the website. See the full feedbacks in Appendix C.

In addition, the feedbacks were summarized and analyzed. After comparing with the initial design goal, not all design solutions achieved the goal. The summary of the feedback to each design solution is listed below.

- *The new navigation from homesite to Treks portal* – This design solution received the lowest rating. The new navigation is significantly reduced time usage on the relevant tasks. However, the layout of the available Treks portals positions still confused. The

chosen text buttons (e.g., Get stared) weren't efficient enough to make users understand its purpose. It had to be formulated again.

- *The reorganized layout of the Galleries section* – This design solution received the second-lowest point. This change received both positive and negative feedback from the user. Users still did not understand the concept of the Galleries section. The redesign carousel is the better choice. But when users were asked to read a previous 6-month ago article, the mechanism for this design could not fulfill this task. The word “feature of the month” is confusing to some users. They preferred the word “Highlight”. The bread crumb is the right choice to show where users are during the session.
- *Design a VR section and visualization that translated from the current VR instruction* – This design solution received the highest score. The idea of translating the text instruction to illustration helps solve the confusing issue. Users easily spot the instruction and can follow them step by step. However, when it comes to scanning the QR code, they scanned the QR at the front page and didn't look inside the content. As mentioned, the design intended to use a small QR code, so the user needs to click on the Flyover to scan a QR code. This design decision led users in the wrong direction.
- *Reformulate the word on the navigation bar* – This design solution received the second-highest score. However, the word “Feature” to “How it works” received many positive feedbacks as it matches with the content itself and easier to understand.

The result shows that not all the issues were solved. Thus, the interaction design guidelines from Cooper should be considered in the next design. These new issues and the awaiting tasks from the matrix will be improved in the next prototype. Moreover, due to time constraints, the next prototype will be created into hi – fi prototype to develop a look and feel together with content.

4.4.2. Hi – Fidelity (Hi – fi) prototype

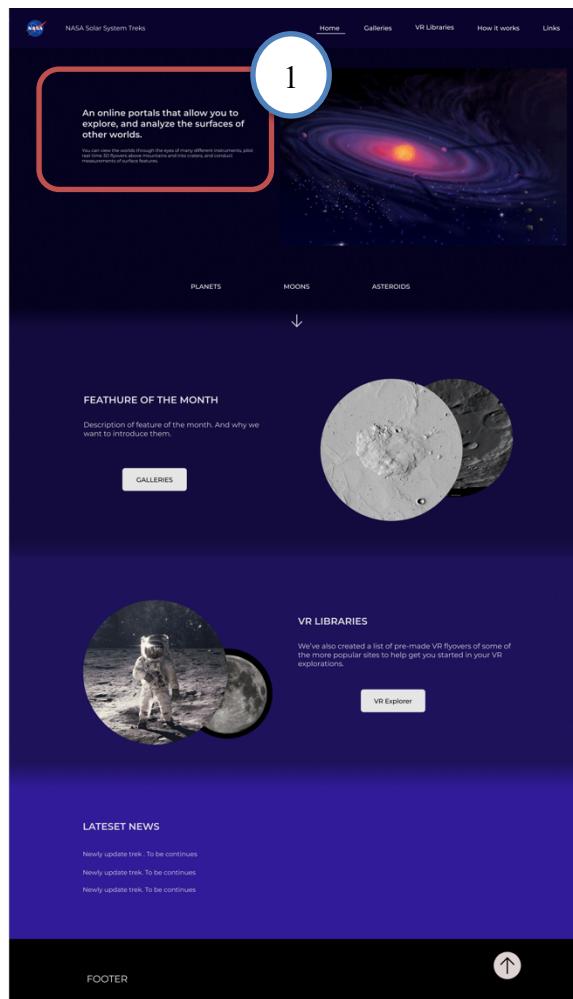
4.4.2.1. First iteration of hi – fi prototype

During the design phase, two high-fidelity prototype iterations were created. The first one was created to experiment and solve the issues for instance the color themes, component designs and fonts. It is to find a suitable design. The designer placed more content, text, and picture to determine the layout position, primary button and look & feel. The designer tried to follow the design pattern from the current website as much as possible for instance, using moving GIF to represent the animation of the planet or using the real content from the existing website, etc. The purpose of this setup is to let the user experience the same information and the feeling.

The first iteration mainly focused on translating the low-fi to hi-fi prototype as well as followed many design guidelines from Cooper et al. [18] for instance, eliminating navigation excise for users to achieve their goal successfully, the color contrast that can draw users' attention and they can perceive the information quickly, the position of the important component should be

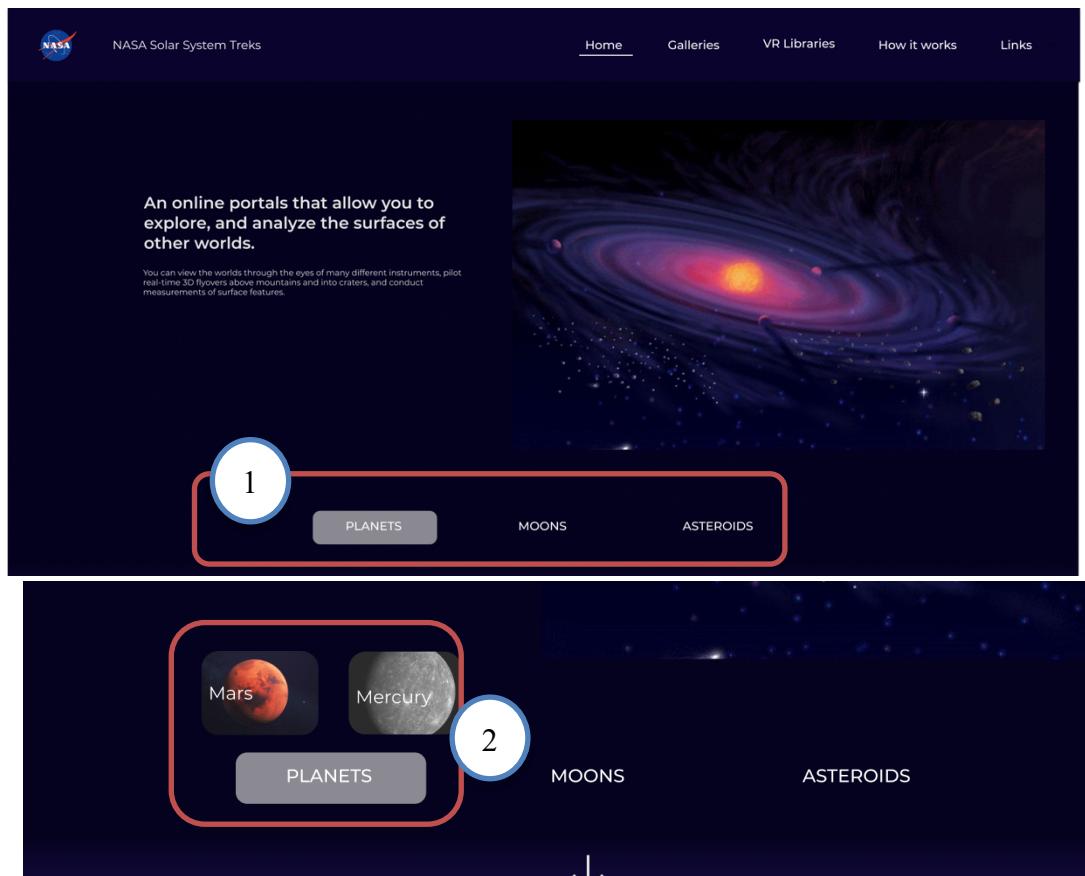
put at top-left, the text should be contrasted from the background and understandable, alignment and reading pattern create a logical path for a user to follow.

4.4.2.1.1. Homesite and Treks portal information



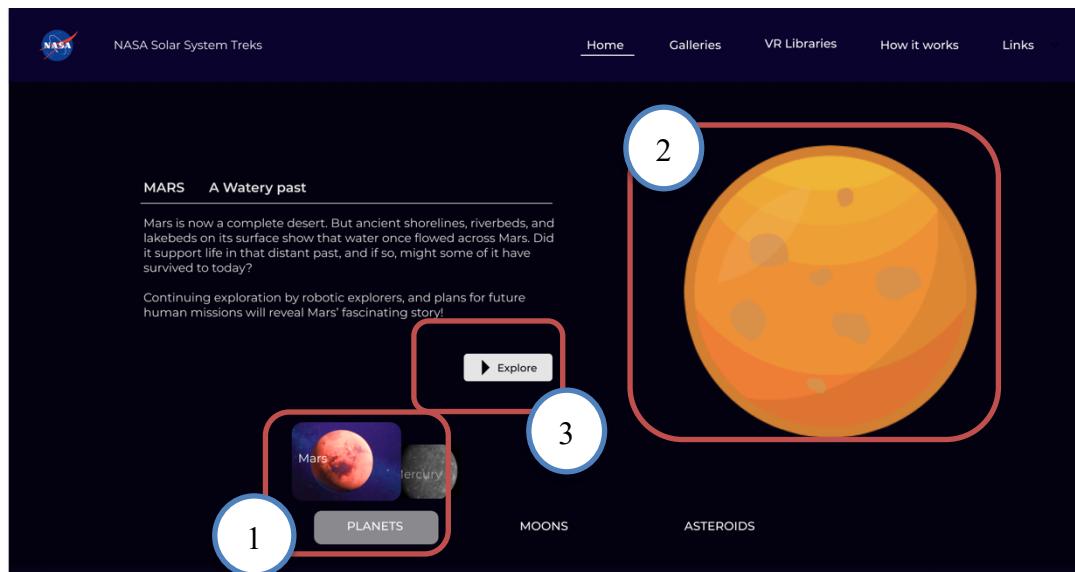
Screen 6. *Homesite*

The description of the website was placed on the left, separate from the widget. The intention is the description will be the first thing that a user sees(1), so he/she will understand the website's purpose immediately. The main section will present the main banner on the homesite, so the user can see what can be expected from the website. Each banner has its own description.



Screen 7. Choosing the Treks portal

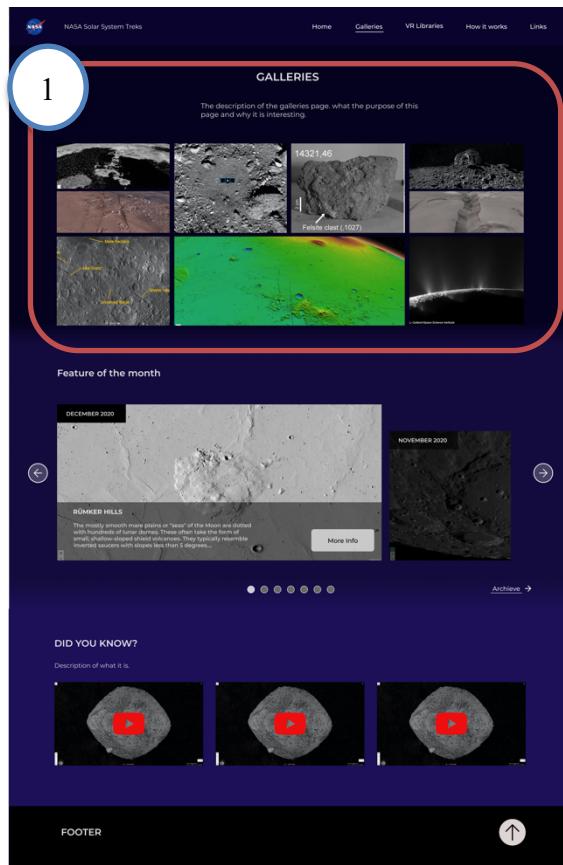
The exploring sequence was changed. This design intends to show all portal options. A user can see them immediately instead of clicking exploring Treks, then the main portal to access the full options (1). A user can hover over the main portal and the choices were placed horizontally along with the button (2). It is for the user to get easier access and reduce the number of clicks. By presenting the option together with the picture, it will make the content looks more interesting.



Screen 8. *The Treks portals information detail*

When a user chose the Treks portal, the choice will be enlarged to highlight the chosen portal (1). The Mars gif was placed on the right site as the moving animation (2), so a user will get the concept of having an animation at the right center of the website. The “Explore Treks” button was removed. The “Explore” button remained the same but it was redesigned by placing an arrow icon next to the text to nudge the user to press it (3), and the button was placed under the Treks detail. Hence, the user will understand what they need to do next.

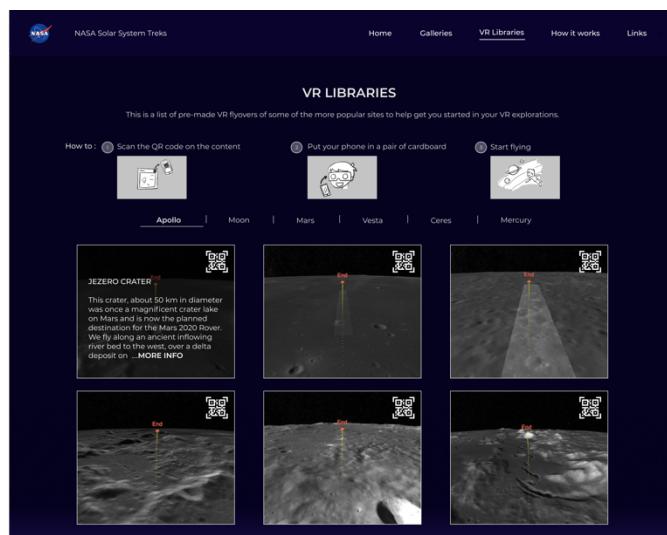
4.4.2.1.2. Galleries



Screen 9. *Galleries* section

After researching how the galleries or art museums' websites present their information, the idea of using a collage was chosen (1). The purpose is to present different photos to raise the curiosity and understanding of the Galleries section.

4.4.2.1.3. VR Library



Screen 10. *VR Library* section

The header was placed at the top center of the page and the short description under so the user will understand what this section is for and know where they are. The “more info” aims to encourage a user to discover more information in the Flyover.

4.4.2.2. First iteration: hi – fi prototype remote usability testing

This prototype was tested with 3 new users and UI developers from JPL. For the 3 new users, all the structure of the test was the same as the remote usability evaluation on the low – fi prototype. The Zoom and prototype link was sent out. The users were asked to open the prototype and shared the screen before the session. In addition, they were asked for permission for this usability evaluation. After that, the designer explained the purpose of the test and similar tasks were sent out. See Appendix A. The users were asked to complete the tasks while thinking aloud.

After the end of the usability testing, users were asked to rate this prototype from 1(Unsatisfied) – 5 (Satisfied) and some additional questions were brought up to gather their impressions and of the website. See the full feedbacks in Appendix D.

However, for the developers from JPL, they were asked to give overall feedback for the design because they are the expert of their own website by comparing the usage time will not have that much affection for the design. The purpose of the overall feedback is to check that the design solutions do not lose the goal of the original website or focus on the wrong direction. In addition, after summarizing and analyzing the feedback from 3 users as well as comparing it with the initial design goal, some improvements had to be refined. The look and feel received very positive feedback. The layout is easier to follow. The word changing from “Feature of the month” to “Highlight” match more with users’ mental models. However, the user still skipped the website explanation. They still hadn’t understood what the galleries section is about and what they can expect from this section and subsections. These issues had to be improved in the next iteration.

Furthermore, after receiving the feedback from JPL, there was a huge change in the design. The option to email the QR code needs to be kept in the case that a user is on the homesite on his or her mobile device. The VR Library is not the focus of this website. They do not want the VR content to stand out more than other Galleries content. This means that the VR section must be removed and placed under the Galleries section.

4.4.2.3. Second iteration of hi – fi prototype

The second iteration has a more focus on refining the hi – fi prototype, putting the description and fixing the issues according to JPL feedback. Mostly the visual design, content and layout were improved, for instance, divided the purpose of the website and what it can do in the separate layout, so the user can perceive the information in an instant, put a clear description on every section – subsections and pictures, etc.

The new design solution of the Galleries section was purposed. Based on the feedback from two usability tastings, users do not know what they can expect from this section. The new design solution will be related to navigation because well-designed navigation can be a powerful tool for informing users about what is accessible to them and how it relates to their goals. [18, pp 273]

4.4.2.4. Second iteration: test and feedback session

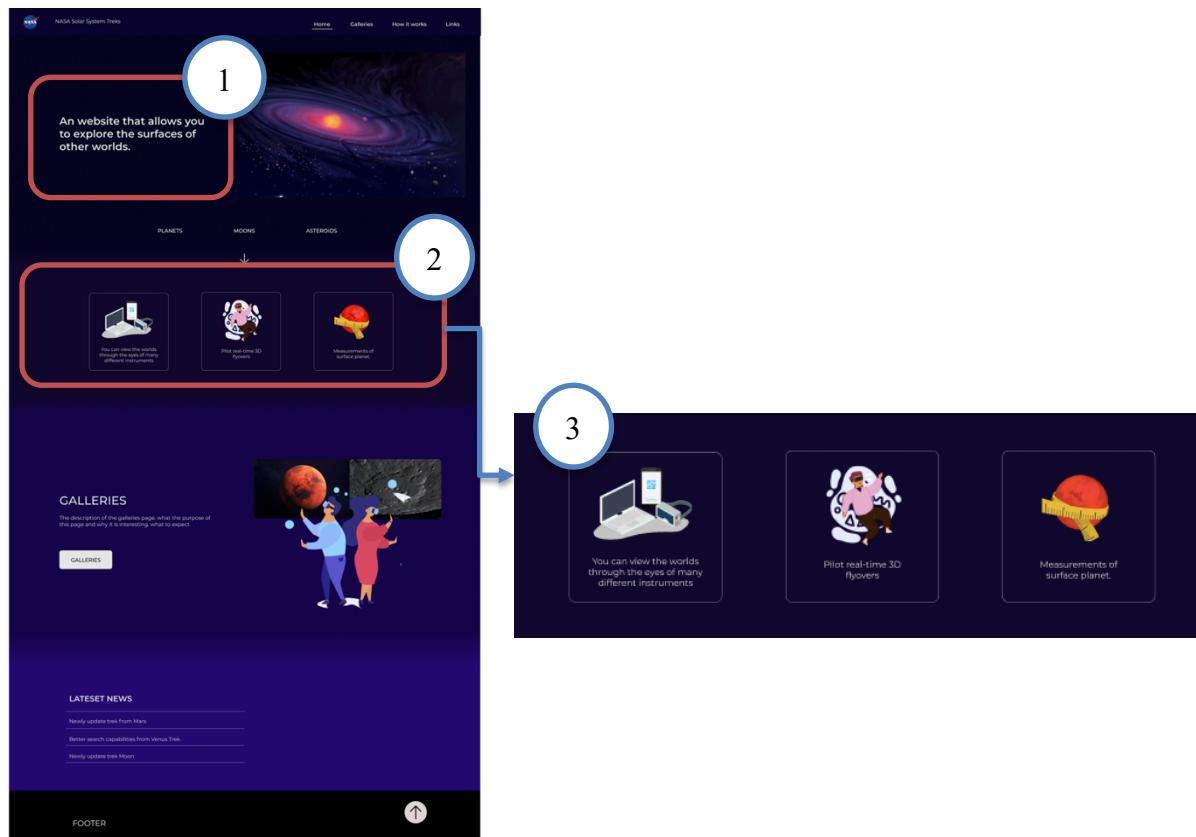
In this second iteration, the hi – fi prototype was sent to JPL for feedback. Then, the feedback meeting was set. During the meeting, the designer answered the question brought up by JPL. The overall feedback is positive. They like the idea of visualizing a part of the website's description to graphics. It was a good decision to test the vocabulary between the word "Highlight" and "Feature of the month". The photo library section can be developed its concept further. It could be presented with various media, not only pictures. The explanation of the email is good to have so the user will understand why they need to send the link via email.

The next chapter will explain what the final design solutions are after 3 iterations as well as the design decision.

5. The design solutions

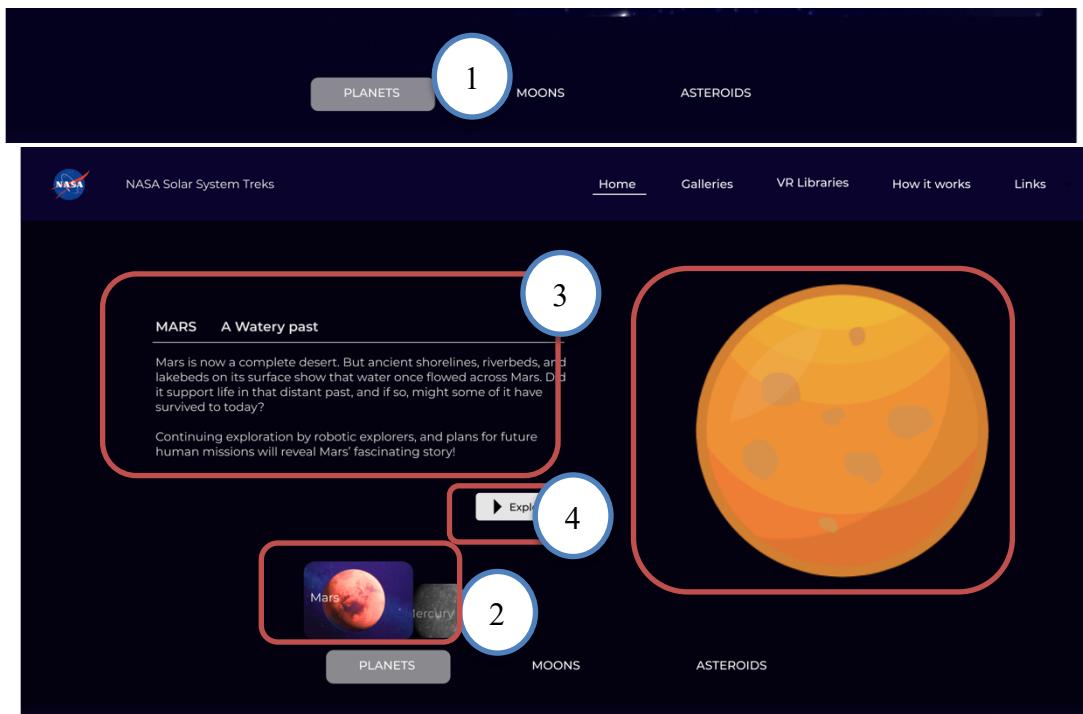
From the first remote usability evaluation on the Empathy phase to the previous hi – fi prototype, the design solutions were refined and finalized. They will be explained in the following section.

5.1. Homesite and Treks portal information



Screen 11. *Homesite*

The participant behavior shows that they scrolled through the whole page at a fast pace. The website has to provide precise and brief information for users to create their mental model in a short time. For them to quickly understand the concept and see the text clearly, the text needs to be contrasted from the background and write in brief and clear to convey the meaning. [18, pp 410] The description was divided into two parts (1). The overall concept of the website and (2). What user can do on the website. From Cooper, the most important element should be put on the top-left of the homepage [18, pp. 409], in this case, it is the introduction of the website. The content related to the function of the website was divided into three parts and match each of them with a graphic. (3) This will help users to quickly understand what this website can do and what they can expect. Using the white color for the text, make it stands out from the background.

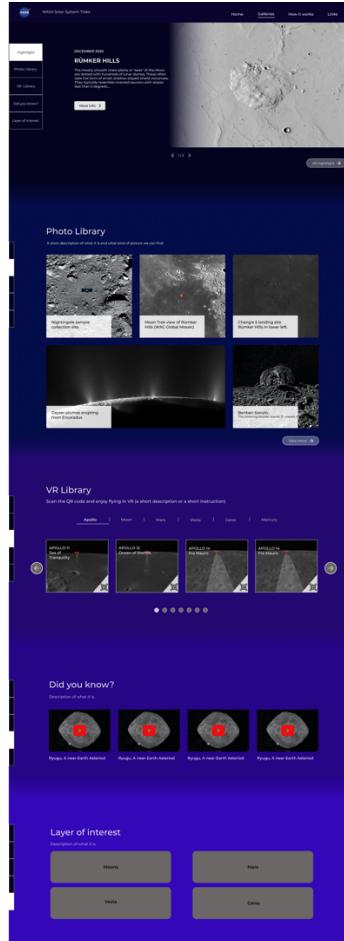


Screen 12. *Choosing the Treks portal and Treks portal information*

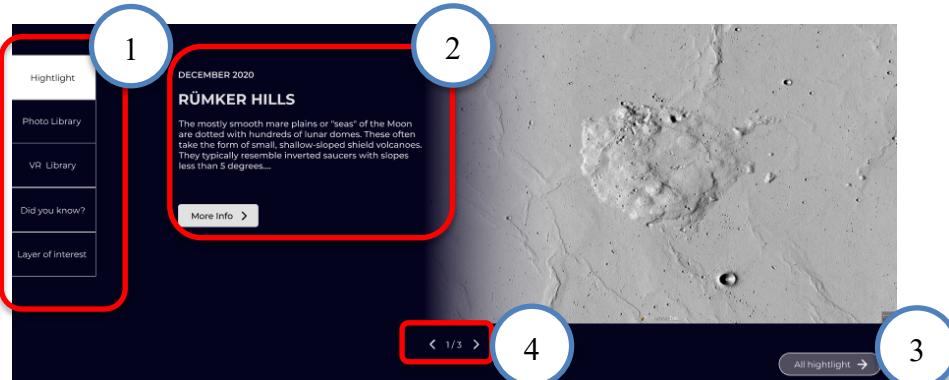
Reaching the tools or information fast and easy without obstacles, is the common goal in every stage of user. (See section 2.3) From feedback, the user complained about both the layout and the time they spent accessing Treks portal. Showing all the main portals on the middle of the screen instructs users what they can expect. (1) By enlarging the chosen portal (2) together with the header (3) tells the user where they currently are. The most important info on this page is the Treks detail has to be located in the top – left as mentioned previously. (3) The primary button color is in contrast to the background, so users can easily spot on.

Based on feedback from the remote usability on the Empathy phase, the user complained about the difficulty in reading a text and notice the “Explore” button on moving animation. This design solution is reorganizing all the layout and placed the components separately which results in increasing the readability on this page and also the efficiency of the website.

5.2. Galleries section



Screen 13. *Galleries*



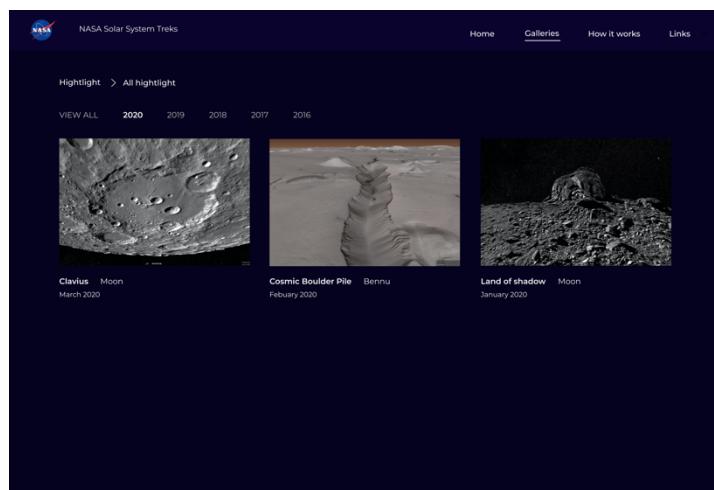
Screen 14. *Highlight subsection*

As mentioned before, navigation can be a powerful tool for informing users about what is accessible and what they can expect. To make it easier for users to form a good mental model of how the website is arranged, aim to keep the navigation space as flat and compact as necessary. [18, pp. 575] By having this simple navigation when entering the “Galleries” section will inform the user where they currently are and what they can do on this section. (1) The complaints about the wall of text on this highlight subsection were solved by showing brief information only for rising curiosity and creating an understanding of the story. If users want

to know more, they can click on the “More info” button. The different text sizes are used to distinguish the level of hierarchy. [18, pp. 413] As Cooper explained “The most important elements could be larger, and smaller for the less one”. In this case, the name of the highlight is the most important, followed by the month and its content. (2)

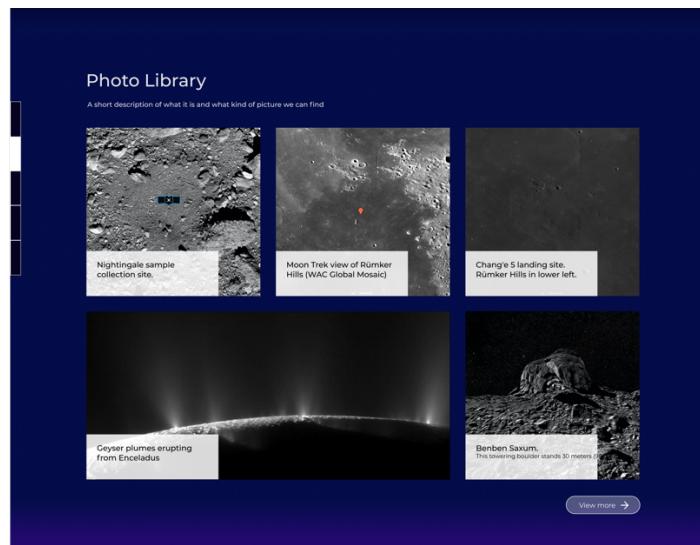
The primary action on a page should have a higher visual weight and stand out from the rest of the page. It should be the most visible button.[24] In this case, the primary button is the “More info” button which was designed with a bigger size and high contrast color. On the other hand, the secondary button is the “All highlight” button with less contrast color and smaller button size.

The design solutions for the Content carousels have a page number and arrows below the thumbnail to inform the user that there is more content next from this and how many. The arrows will be easier to spot in this design compare to the current website.



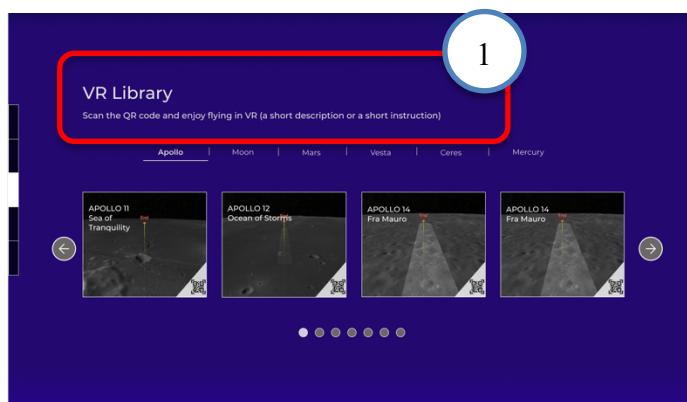
Screen 15. *All highlight*

After clicking “All highlight” on the previous page, it will lead a user to discover more information on all highlights of the website. The information was categorized according to the published year. By grouping the information, it is easier for a user to browse the information. With the breadcrumb navigation, a user easily recognizes where they are.

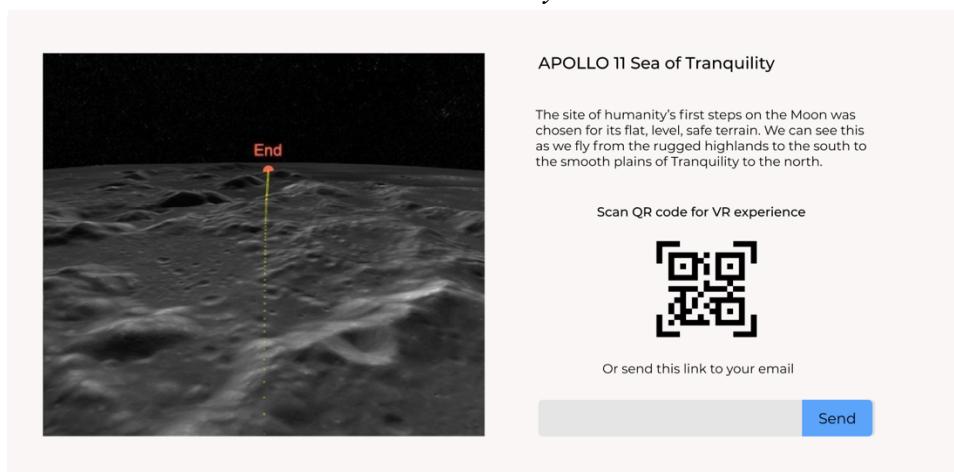


Screen 16. Photo Library subsection

This subsection intends to show the visitor more interesting photos from Treks or missions.



Screen 17. VR Library subsection



Screen 18. VR content

After the clarification from JPL, the VR Library section and banner was removed from the homesite and main section. It was put back to the Galleries section. The tutorial was formulated

to a brief version (1) (Screen 17) to save space. The email textbox in the VR content was put back but with a short description to clarify what it is about (Screen 18).

6. Discussion

This chapter provides an overview of the process, as well as the insights and lessons learned.

6.1. Remote Usability evaluation

During the session, the user and facilitator must have a good internet connection, microphone, speaker, and laptop. Losing connection during the session might affect the testing result and user emotion. The microphone and speaker have to be in the good condition for communication during the test. Furthermore, the laptop should be able to run the prototype and a video conferencing program in order to for this test to be successful.

6.2. Limitation of time

During the empathy and define phase, the designer discovered many usability issues from many parts of the website. However, with the scope of time and the goal, some issues had to be discarded from this project.

6.3. More understanding behind the design of the website

If the designer had more understanding of the reason behind the design of every component, the huge change on the first iteration on hi – fi prototype might not happen. The designer cannot take out the original design component based on the usability testing data. He/She needs to understand what the purpose behind that is and make it better according to the feedback.

7. Conclusion

The result of conducting remote usability testing method on the Empathy phase is the discovering of navigation and layout issues. Many parts of the website are full of a wall of text, confusing explanations, and a lack of description. The navigation leads to surprising turns and events. The design process was applied to define critical problems and explore possible solutions. Prototypes helped to validate the assumption and design decision. The design solutions were iterated and tested until final design solutions were selected. However, this website still has many areas that must be developed further.

8. Future work

This project only focuses on the small area of the website. The next step for this project would be creating a design system, doing more user research, designing a mobile version and improving copywriting. The explanation in each of them can be seen below.

8.1. Design system

The design system is a design standard of the digital product. It has many benefits when it comes to expand the product or use as a guideline for a development. The system is composed of tangibles and non-tangibles elements such as tools for designers and developers, patterns, components, guidelines, etc. However, there is no design system as a design standard to follow in this project. The JPL team and a future designer might face a UI consistency problem in the future.

8.2. User research

The website is designed for three different types of users. It is very challenging to design for all-in-one website because there are different needs for each target. This project is only focused on one target of a user from three main target groups. Also, there are many categories of the target user. To design a website that fulfills the user expectation, the team needs to conduct more user research.

8.3. Mobile version

There is a mobile and desktop version of this website. However, this project did not focus on improving the mobile version and chose to only improve the desktop one. For the future work this project should focus on a mobile-first design to create a design that suits for both platforms.

8.4. Copywriting

The designer discovered that the copywriting issues are one of the most mentioned problems from the feedback for instance, the text is too long and complexed to read, the instruction is too hard to understand and follow, etc. Hence, it needs to be reformulated and made more interesting and easier for the reader to understand and follow.

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Appendix A

The usability testing script and question task

Questions	Scenario	Tasks
Homesite		
Which area is clickable, and which is not?	A new user visits a website for the first time and wants to learn about this website through its first homepage.	<ul style="list-style-type: none"> • Look through the entire homepage • Explain what this website is about. • Please answer which area is clickable and which is not. • If you don't understand something please ask. • If you have any struggles please raise the issue.
Homesite, Treks portal and Feature section		
Is there any problem with the website's navigation?	First You want to explore the Mars trek and want to try a calculation tool after that you want to go back to the homepage.	First task <ul style="list-style-type: none"> • Explore Mars Trek • Please read the instructions. • Please find a calculation tool. • Go back to the homepage.
Any misused button?		
Instruction is unclear/ doesn't serve its purpose/ too long?	Second The user wants to explore VR features and wants to know how to do it.	Second task <ul style="list-style-type: none"> • Find the VR feature • Can you explain how it works, step by step <ul style="list-style-type: none"> ◦ Find the QR code ◦ Find Video explanation

Galleries section		
How do you feel about the content info?	Users want to explore what galleries are.	<ul style="list-style-type: none"> • Go to Galleries page • Look at the entire website and express how you feel. • Can you find “Feature of the month” • Explain which area is clickable • If you discover a QR code, can you explain what it is? • What is your understanding of “Galleries” before exploring.
Some areas seem unclickable.		
What is their understanding of “Galleries”?		

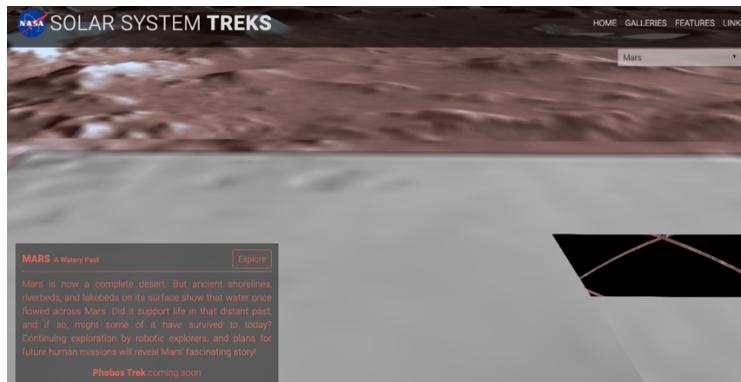
Appendix B

The feedback from the remote usability evaluation on Empathy



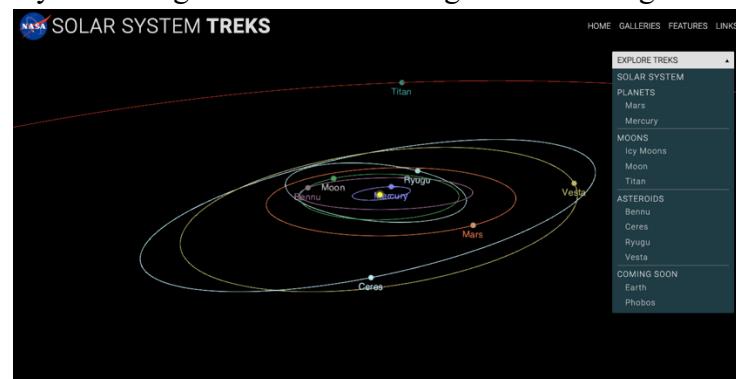
Screen 18. Homesite

- Every user tried to interact with the Solar system widget because the animation they saw and misunderstood that they click and move the widget in different direction.
- Users did not know what this web portal is about and what they can do.
- Users did not notice the feature of the month banner. They thought that this is only showed picture.
- Users understood that the VR Library is one of the highlight features of this website. They suggested to have its own section.



Screen 19. *A trek description.*

9. Users are confused after clicking “Exploring treks” and choosing “Mars”. They thought that they only needed to watch an animation. They did not know what is the next step until I needed to guide them to click the “Explore” button again. Figure 2.1
10. Users had a difficulty in reading a text on the moving animation. Figure 2.1

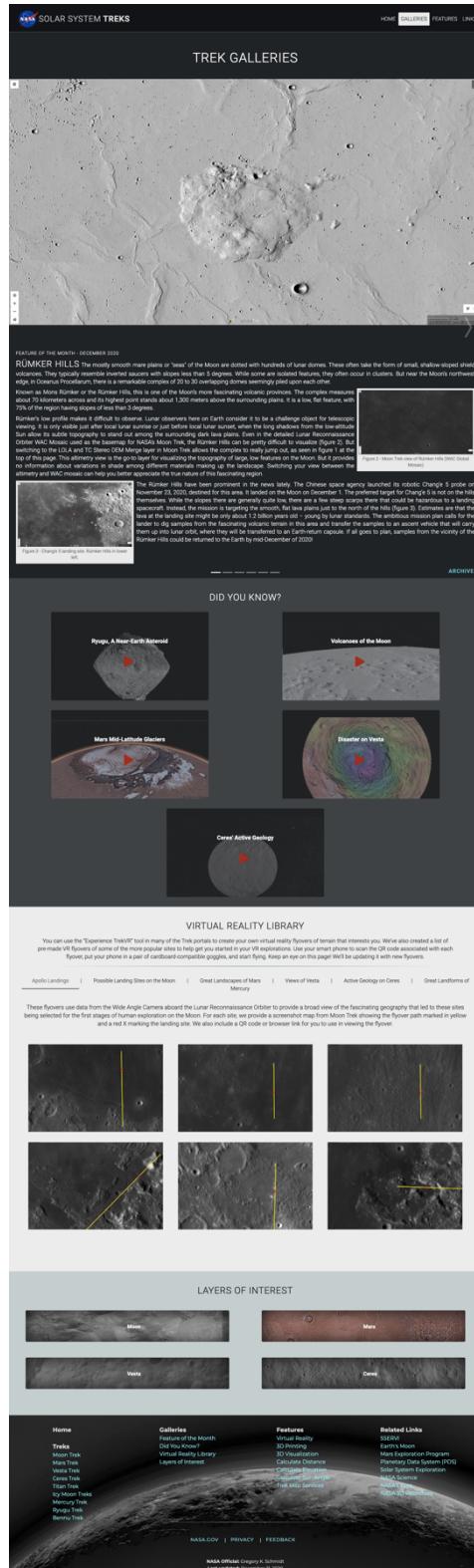


Screen 20. *The available trek portals*

- They expected the planets options would appear at the middle of screen instead of the the top right. Figure 2.2
- They though the “Latest news” banner is clickable because the text showed the border when they mouse overed it.
- The participants were confused and frustrated when they could not find a way to the homepage. They randomly clicked or guessed which button might be the way to go to the homepage. Mostly they will click “Nasa logo” in the "Hamburger menu" because their mental model tells this is a usual way to go back to the homepage. Then they see the Mar treks at the bottom of the page and accidentally hover the animated object. It made them think this might bring them back which they were very surprised that it actually opened a new tab for a new website.

- They lose interest to follow all of the instructions. They thought it was too long and overwhelming information. They had the same answer that they will forget most of the instructions after going to the next step.
- They prefer to know only the must know feature in the Trek portal and understand how it works.
- They cannot find “*the calculate tool*” as I asked them to find it.
- They assumed that the content under “hamburger menu” is all about the general information, not the place for the calculation tool.

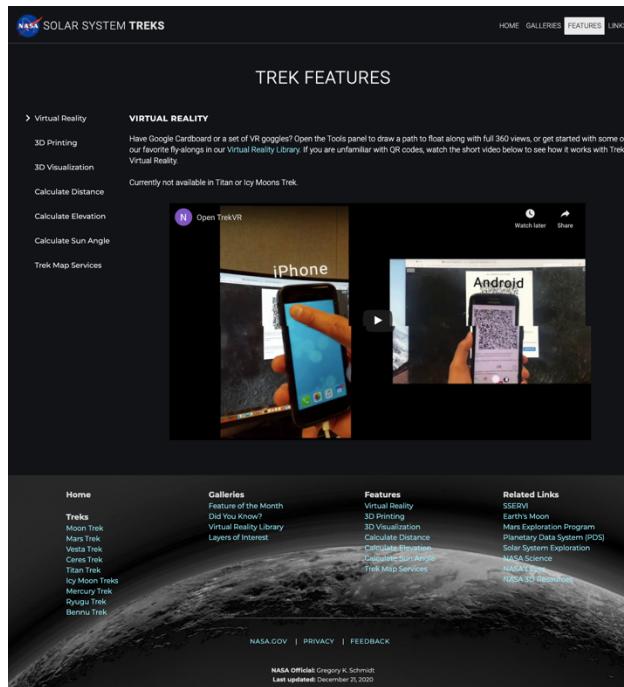
Galleries section



Screen 21. *Galleries Section*

- From our participants' perspectives, "Galleries" is a place that contains only pictures and descriptions. They don't understand why VR Library are at the middle of the page. It is not related to galleries and it is the main feature that should be dedicated to a whole page for it.
- Their first comment on the "Galleries" page is that the content is unattractive. It is a wall of text that made them lose interest immediately.
- They mistook that the buttons on the picture are clickable which are not. Those are the part of the screen capture.
- They couldn't spot the arrow under the picture but can go to another article by clicking the slide at the button of the article page. However, They were annoyed with this section because they needed to scroll up whenever they went to the next article due to the picture and information not being the same level and the section always adjusted the space according to the content to make them question this part.
- They pointed out that they did not know where the "feature of the month" is located. They kept clicking a "feature of the month" under the "Galleries" menu bar. They spend more time searching for it. Some of them discovered the QR code, but they do not know what it is for.
- They spend a long time finding the VR instruction. They did not understand how to find the QR code and they needed to go back and forth between "feature page" and "VR Library" to find a QR code.
- They pointed out that they spent too much searching QR code because they did not know that the picture in the VR Library section is clickable and contains QR code inside.
- They did not understand what the "what did you know?" "layer of interest" are.
- They felt lost on the website.

Feature section



Screen 22. Feature Section

- When they wanted to find the VR feature, they expected that this page would include all of the information or some content that could be viewed in VR mode.
- The video does not explain how to find the QR code
- On the other hand, this page only contains “How it works” which they think the menu bar should be changed to prevent confusion.
- They did not notice the text above the video is an instruction. On the other hand, the instruction is also unclear for them to follow.
- The video demo is way too long.
- They don't like that they need to switch between the instruction and the VR Library or the trek portal.

Appendix C

The result of the remote usability evaluation with low – fi prototype

Homesite

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
Is it easy for a user to find the way to explore Mars?	- I am confused why I didn't use "Continue..." instead of "Get started"	- It is easy to know what to do next and back to homepage - I like that you use get started and have a picture on the left and short description on the right - She suggested the underline on explore seem like it will lead her to new page, not more option. - She expected that if she click the arrow again the homepage will be back to default stage.	- The Carousel might be a better choice in choosing planet etc.. - Understand what he needs to do next after exploring - Clicked the NASA logo in Hamburger menu	3,4,3 = 3.3

Galleries

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
Do they have any confused with a new feature of the month design?	- I think the Feature of the month shouldn't be the first things you	-I thought the Carousel contain the	-I think the layout still feel a bit off	4,4,4 = 4

Between word "Highlight" and "Fotm" which they prefer?	see. Maybe second? I think about the gallery's museum. I expected to see only a picture and description first.	entire year information. -It is easy to understand that when I click on the content, I can see more information of November content.	-I don't understand the feature of the month means. Highlight?	
Do they know where they are right now?				
Can they search for more information on the feature of the month?	-I love bread crumb It is much easier to know where I am right now			
Is a carousel the better presentation for the data?		-I like bread crumb, I know where I am.		

VR Library

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
Can they follow VR instruction?	<p>It is easy to find and unsderstnad the instruction</p> <ul style="list-style-type: none"> - I like it bbecause it is easy to find QR code - I like the concept of having the illustration of instuction - I think it needs to make it clearer that you can click to see more information of the Flyover and that I need to scan QR code in the content, not outside. 	<p>-I like the instruction illustration</p> <ul style="list-style-type: none"> - It easy to spot the instruction - I know instantly where to find the QR code 	<p>- I love the instruction illustration</p>	4.5,4,4 = 4.2

Appendix D

First iteration: The result of the remote usability evaluation with hi – fi prototype

Homesite

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
How does user feel for this page?	-In genally it looks good - I really like the theme color	-I like the color -The arrow is too close the line. thought that the arrow is part of it - Can you make those choices to be more clickable, stick out more than an arrow	-I really like it -I like the color! - I like that I only need to hover and then the choices appear.	4,4,4 = 4
Is it easy for a user to find the way to explore Mars?				
Do they have any confusion what they need to do next?	- I suggested that make the pic to full screen and maybe move those choices.			

Galleries

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
Do they have any confused with a new feature of the month design? Between word “Highlight” and “Fotm” which they prefer?	- I think the Feature of the month shouldn't be the first things you see. Maybe second? think about the gallery's museum. I	-I expected to click on the dot - The navigation is very clear - the picture collage might need to be a same color. - It is too much	-She clicked on the pic before arrow -I don't know what Feature of the month is and I don't know it is under galleries -I expected to see a whole year first and choose a month later. -I don't know what to expected	4,4,3 = 3.9
Do they know where they are right now?	I expected to see only a picture and description first.	text on the feature od December detail.		
Can they search for more	-I love bread crumb It is much			

information on the feature of the month?	easier to know where I am right now -I prefer “Highlight”	- You should reorganize the detail page. -I prefer “Highlight”	in Galleries, maybe need a description? -I like the word “Highlight” more	
Is a carousel the better presentation for the data?				

VR Library

Questions	Answer 1	Answer 2	Answer 3	Satisfaction Rate
Can they follow VR instruction?	<ul style="list-style-type: none"> -Navigation is very code - The qr code is noticeable - This is much clearer than an existing one - I like the instruction 	<ul style="list-style-type: none"> -I like the instruction illustration - It easy to spot the instruction - I know instantly where to find the QR code 	<ul style="list-style-type: none"> - She likes it that we guide her directly - She immediately understand what to do and follow it - She thought that she can scan the QR code immediately, dont have to click on Flyover. - She like that she only click on Flyover once and can see all of the information 	5,5,5 = 5

First iteration: The result of the remote usability evaluation with hi – fi prototype**Feedback from JPL**

- Overall, the changes are agreeable - introductory text over graphic, showing the available Trek portals horizontally along the bottom, and fixed placement of Trek portal information to the left-center of the graphic.
- One thing to keep in mind is that we would like to allow more functionality of the Solar System widget, such as being able to choose the flight path and viewing angles, thus we might want to showcase the widget more in the
- I only just realized that this represents a Trek portal. For perhaps this reason, we want to keep the Trek title that immediately identifies which Trek portal a user is in. Your report indicates that the animated object to the left of the Trek title (along the center-bottom) is unclear, so what if we were to have that animated object somewhere on the homesite/homepage to create the association of the animated object to the homesite?
- I feel further discussion would also benefit us about accessing Trek tools and capabilities from a Trek portal (having a button be immediately visible from the default view versus having a link or links in the Menu).
- I kept wondering why the VR Library was made into its own section in both your prototypes, and I realized that I may have placed unintentional emphasis on the VR Libraries simply with how much space it occupies in the homesite (in the Galleries and as a banner on the front page). If this is so, we need to actually de-emphasize the VR Libraries so that it does not stand out more than the other Galleries contents. However, this is my guess, and I would appreciate hearing your thoughts on why you made the VR Libraries its own section.
- I agree on renaming the Features section; however, further discussion as to what specifically should be had with the project's UI/UX team.
- Similarly, the Galleries section and its contents would benefit greatly from being renamed to less confusing and more descriptive terms, also to be discussed with the project's UI/UX team.
- The Galleries contents would also benefit from different presentations, namely to not emphasize one (such as the VR Library) over the other (such as the Layers of Interest), but also to present all items cleanly and with less effort to the user.
- The collection of images near the top, while interesting, maybe too confusing and without context. We would like to table this aspect
- I agree about shrinking the size of the FotM images and carousel and think it would be cleaner to truncate the text and have individual pages for each FotM. Furthermore, an individual page could have links to related or adjacent FotMs or perhaps show the Archive listing in a condensed, vertical format.
- I also agree about having descriptions for each subsection here.
- While immediately showing a QR code might help the user to understand, we will have to find another way, because these QR codes get very complex due to the amount of information they hold within. Thus, the QR codes need to be at least a certain size, and unfortunately, the size required would not allow them to be overlaid in a small corner of the flyover screenshot.
- I've noticed that you have replaced the image of the bird's-eye view with the image of the lateral view. I am curious to see how much this alone helps users to better understand these VR flyovers!
- While your proposed change is cleaner, we need to keep the option to email the QR code in the case that a user is on the homesite on his or her mobile device. However, maybe we can achieve a similar effect by making the instructional text smaller in size and rearranging those elements

- The simple, 1-2-3 steps at the top for the VR Libraries is a nice touch!