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NASA's Web Architecture and Content

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Abstract

This project was completed for the Office of Communications at NASA Headquarters to determine the current state of NASA's webspace. As per the Federal CIO, NASA currently supports 3092 website URLs. Our team randomly selected 312 websites from NASA's webspace and surveyed their responsible NASA employee for information about the website. With the survey data, our team developed personas from each of NASA's target audiences. Our team conducted user experience testing with these personas to observe the effectiveness of NASA's websites in serving their target audiences. This project resulted in data on the current state of NASA's webspace, the potential effectiveness of tested websites, and evidence that persona driven user testing could be a useful technique for NASA in the future.

Acknowledgements

Our team cannot express enough thanks to our sponsors at NASA - Kris Brown, Brian Dunbar, and Dan Woodard - for the support and guidance they provided us throughout our project. Our team would not have accomplished as much as we did without the support all of you have given us throughout our time at NASA HQ and making us feel welcomed.

We would also like to thank our project advisors: Fred Looft and Brigitte Servatius. For the guidance and assistance both of you have provided us with completing our report, our heartfelt thanks go out to both of you.

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Chapter 1: Introduction

The National Aeronautics and Space Agency (NASA) has a long history of sharing information on the internet, and has been developing websites since the early-90s. The majority of NASA's web traffic takes place on their larger, higher profile websites. These websites are aimed at several audiences. Many smaller websites also exist and these typically serve a singular target audience, such as teachers, researchers, or students.

NASA as a whole currently has at least 3092 websites. Some of these sites are outdated, in terms of design or content, due to their age, and a few have even been abandoned in the years following their creation. The main cause for so many websites existing, is the freedom that NASA employees are given with regards to website creation. As it stands currently, anyone within NASA with a budget and their manager's approval can have a new website created. This freedom is certainly not without merit, as it allows valuable information to easily be documented and shared with others quickly. However, many of these sites are largely disconnected from each other or only connected through a page dedicated to outgoing links. Given that site owners are not always notified when these links become outdated, even updated sites can be minefields of dead links, making system-wide maintenance is a nearly impossible goal.

In a number of cases, the archival or outright removal of an obsolete website would be the simplest solution, but often this doesn't happen because the website's existence is not documented. Furthermore, efforts to improve this situation are often inhibited by a lack of understanding of the current state of the webspace. Without clear evidence that these problems exist across the entire webspace, it is understandably hard to argue for an organization-wide process of dealing with them. This is not helped by the decentralized management of these sites. The resulting managerial processes and strategies differ across NASA's various locations, creating further obstacles to communication.

The Office of Communications (OCOM) at NASA Headquarters (HQ) has begun an effort to acquire this evidence and start increasingly important conversations about these problems. Our work on this project was an important first step to help OCOM with this, as our goal was to foster an initial understanding of their overall webspace. The information our team presented to OCOM, encompassing the target audiences, analytics, and update frequencies of many representative sites, served as some of the first concrete evidence they had on this front. Furthermore, both our data collection and user testing revealed sites that we documented as clear examples for OCOM to use when discussing the various negative effects of the current state of the overall webspace. On the most basic level, our work also allowed OCOM to see what practices for acquiring this evidence may or may not be useful, and adapt accordingly going forward.

In order to acquire a reasonable amount of data without examining all 3092 websites, we sampled 10% of the listed sites and collected the contact information for the NASA employees that were in charge of those sites. These employees were also surveyed to gather information on the intended target audiences and analytics services used on these sites, as well as other data points requested by OCOM itself. The responses to this survey were used to create personas that represented the target audiences of the sampled sites, which allowed us to do user testing to see how members of those audiences would use those sites when searching for relevant content. As a government agency, NASA has certain privacy restrictions with regard to interviewing the general public placed on it by the Paperwork Reduction Act (Information Collection / Paper Reduction Act, 1995). The usage of personas allowed our team and NASA to conduct this testing within the restrictions placed by both the Office of Budget and Management and WPI's Institutional Review Board. Finally, we compiled the results of these tests, the survey data, and observations about those sites into a deliverable that clearly conveyed the problems that are pervasive to the webspace as well as sites to look to as examples in avoiding those issues.

Chapter 2: Background

National Aeronautics and Space Administration

History

NASA is a federal agency devoted to advancing the fields of aeronautical and space research and development, and was formed in the early stages of the Cold War out of the National Advisory Committee for Aeronautics in response to the Soviet Union's successful launch of the *Sputnik 1* satellite in 1957 (NASA, 2015). The formation of NASA initiated the "Space Race" that culminated with the American Apollo missions and the manned landing on the moon by Apollo 11 in 1969. During this time, NASA launched 21 manned missions encompassing three space programs – Mercury, Gemini, and Apollo – as well as many unmanned missions (NASA, 2015). NASA has continued to conduct manned and unmanned spaceflight up to the present, with the most recent launches being the Curiosity rover mission to Mars and the New Horizon mission to Pluto.

Organization

NASA receives approximately 0.5% of the total federal budget for an estimated operating budget of $13.4 billion per year, and employs approximately 17,000 people (NASA 2015). There are 13 research centers and facilities spread across The United States working for NASA's administration. NASA's headquarters is located within Washington, D.C. and provides guidance for agency-wide directives and programs. NASA HQ is organized into five Mission Directorates: Aeronautics Research, Human Exploration and Operations, Science, Space Technology, and Mission Support. NASA HQ houses administrator staff offices including the Office of Communications.

Office of Communications

NASA's Office of Communications (OCOM) at NASA Headquarters has the responsibility of representing NASA to the public. This duty includes hosting and releasing media briefs, overseeing visitor centers, and producing and managing NASA's main websites (NASA Administrator 2010). OCOM works with other departments directly under the NASA Administrator and his staff, as shown in Figure 1.

Our team primarily worked with three NASA employees within OCOM management. Kris Brown managed public outreach for NASA Headquarters as the Deputy Associate Administrator for Public Outreach. Brian Dunbar was in charge of the web content and design for nasa.gov, as well as many more sites in the NASA webspace in his role as Internet Services Manager at NASA HQ. Finally, Dan Woodard, a Project Manager, also assisted us with our project at NASA HQ by providing insight from his own experiences with NASA politics and websites.

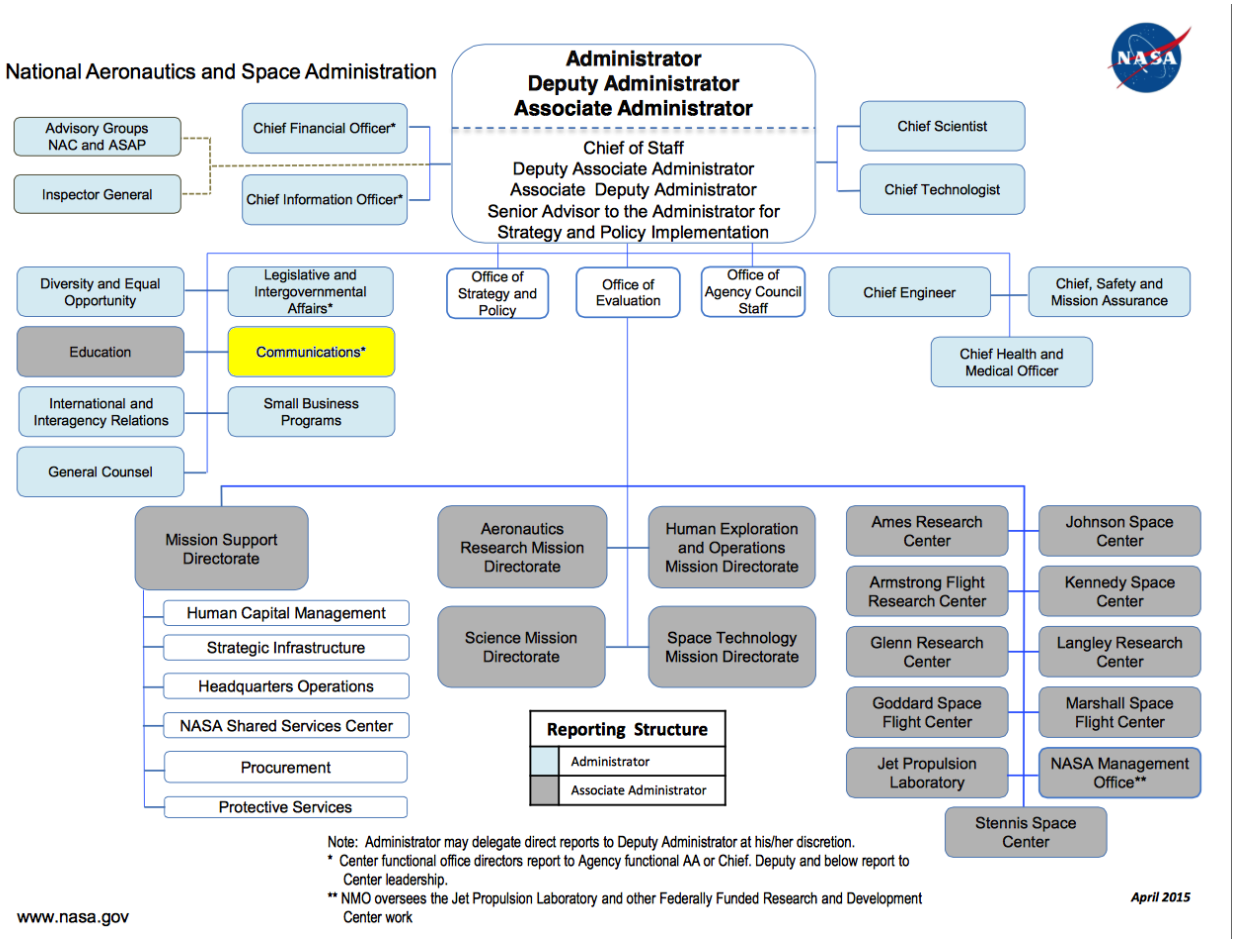

FIGURE 1: NASA HEADQUARTERS ORGANIZATIONAL CHART - COMMUNICATIONS HIGHLIGHTED

NASA's Websites

Understanding NASA's Webspace

The Office of Communications at NASA Headquarters is in charge of the general oversight of NASA's webspace, which currently consists of 3092 websites. Anyone within NASA that has the desire and budget to create a website can do so as long as they get approval from the manager of their department. As a result, OCOM only maintains observational power over websites currently existing within NASA's webspace.

While NASA has 3092 websites, when sorted by page hits the top 10 make up 67% of web traffic. It has large websites such as nasa.gov, climate.nasa.gov, and mars.nasa.gov that are designed to reach any audience that may visit them, and are very expansive with regards to their content. The majority of NASA's sites are aimed at specific audiences, and are much smaller and more specialized.

Characteristics of NASA Website Users

NASA's audience consists of the many users that access NASA websites. In the year of 2015, this audience has consisted of 167,767,410 users. In order to understand this large user-base, NASA has implemented Google Analytics to report on demographic information of their users.

While Google Analytics has many functionalities, Audience Reporting allows managers of websites to view age ranges and gender of their users. Google is able to report this information on users that have Google accounts, so not all users will have demographic data associated with them. For NASA's user data, Google Analytics has age ranges for 29.14% of users and gender information for 33.13% of users.

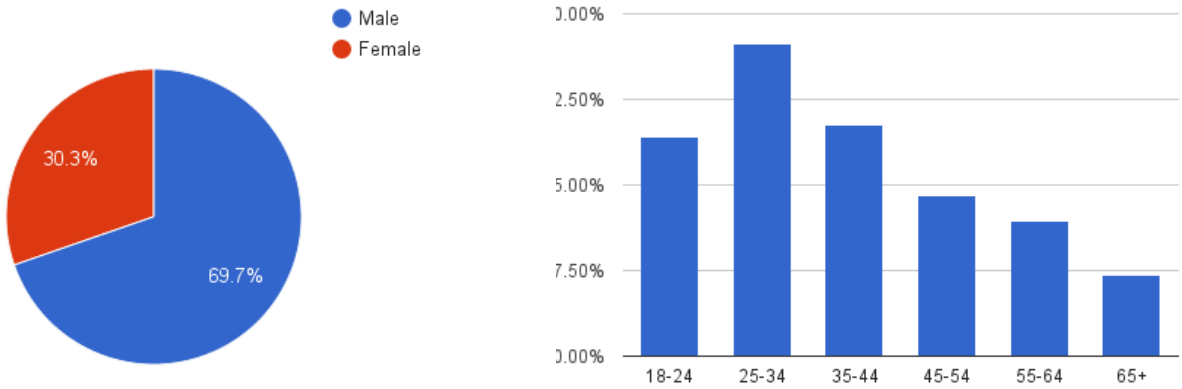

FIGURE 2: GENDER AND AGE OF USERS OF NASA'S WEBSPACE (GOOGLE ANALYTICS)

Along with keeping track of user demographics, NASA also uses user surveys to get an idea of the types of people that access their websites. Brian Dunbar has broken down NASA's audience into the following representative target audiences: General Public, K-12 Students, K-12 Teacher, NASA Employees, Aerospace Industry, and Researchers. These target audiences are applicable for content creation and website design and redesign, as well as understanding the current state of who NASA's websites are aimed at.

Understanding who NASA's websites are aimed at is the detail that NASA has the least information on, as their webspace has become so large. Looking again into which audiences NASA's top visited websites are aimed at nasa.gov is specifically targeted towards two of the six target audiences: students, educators; as well as the additional target audience of media. Because it is such a high traffic website, it must be able to cater to a large variety of audiences. This is the case for many of the high traffic websites. This is only the case for less than 90% of NASA's websites however, as the majority of NASA websites are aimed at an individual target audience.

Recent Changes

In 2013, NASA began to move towards a redesign of nasa.gov, documenting their changes with a blog post to the news and features section of nasa.gov. The reported renovation of nasa.gov was based on complaints about "clutter and the page being hard to navigate visually" as well as a demand for a greater focus on live events (Dunbar 2013). There was also a move towards integrating more multimedia content and social media connections to appeal to "the different preferences of social-media and web audiences" (Dunbar 2013).

The redesign involved removing navigation buttons in favor of a drop down topic menu, changing the method for navigating the main NASA website. Changes in the web programming required the web content to be moved to a new content-management system and content-delivery network. The change in management system resulted in the loss of some pages and related content that the web team promised to rebuild in the near future. The redesign was the start of a several year plan to overhaul the site, which had not received such an update since 2007.

This redesign continued in the summer of 2015, when another change to the design was released based on "extensive user feedback and testing" (Wilson 2015), and centered on clearing up more visual clutter and providing more support for different devices. The new design grouped content by relevance regardless of media type, and added a site-wide navigation bar as well as an additional bar when exploring the larger subsections of the site.

It is notable that despite how much this redesign improved navigability, this only happened to the main nasa.gov site. Due to the decentralized nature of web development within NASA, the improvements were not carried over to any of the other sites in NASA's webspace. Improving the other sites within NASA's webspace would require clear communication across all of the organizations within NASA whenever the main site is redesigned. Not making a universal effort to improve these sites make it harder for users to engage with sites that are moving increasingly further away from the design of nasa.gov. Furthermore, sites that do try to match the design still end up looking out of place when the nasa.gov design changes without them.

Website Analysis

Google Analytics

In order to determine the effect NASA's websites have on the general public, data must be collected from these sites and organized in a clean and efficient manner. One of the tools known for its ability to collect this data is Google Analytics. Google Analytics works by collecting site visitors' browser cookies and organizing them in a log file that is displayed through Google Analytics software, as seen in Figure 3. After this log file is generated by a visitor, it is then read

and interpreted by Google Analytics, put into a database, and formatted into lists and tables designed for clear presentation to the user.

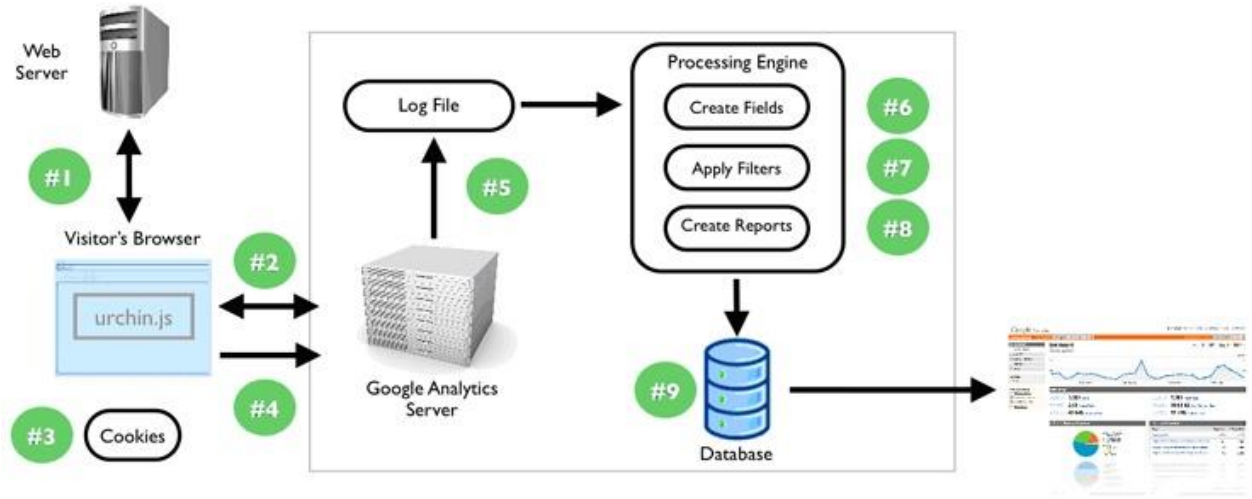

FIGURE 3: GOOGLE ANALYTICS PROCESSING FLOW (CUTRONI, 2007)

NASA's usage of Google Analytics consists primarily of Engagement Analysis. This type of high-level analysis, commonly used in the web development industry, focuses on answering questions such as: "how many visits did a site or page get?" or "how long does a visitor spend on the site?" (Zheng, 2014). For metrics such as page views, Google Analytics also allows events to be placed along a timeline below graphs, as shown in Figure 4. This functionality is highly used by NASA, as it lets them see how successful social media releases are at increasing website traffic.

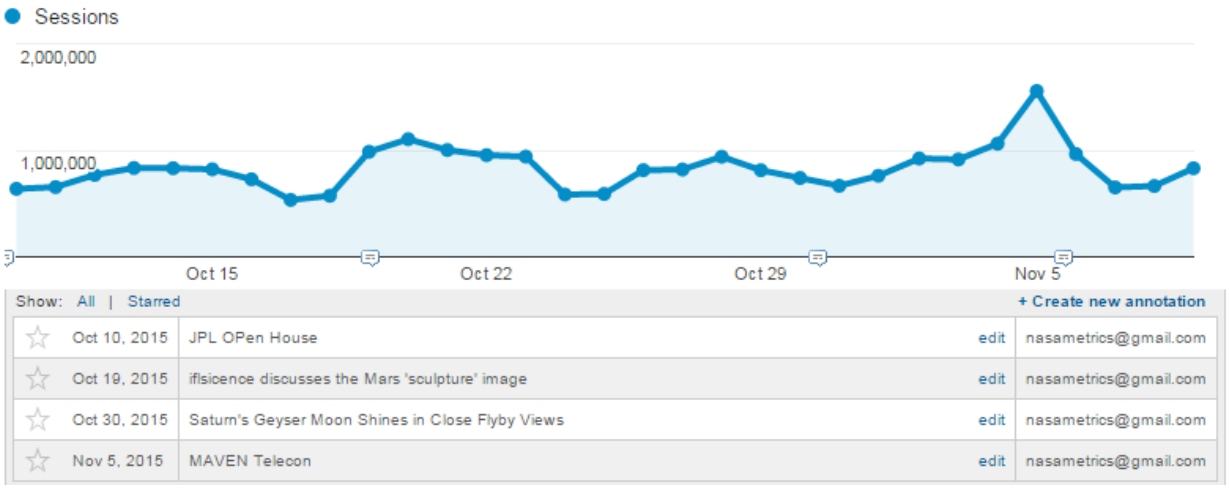

FIGURE 4: NUMBER OF SESSIONS OF NASA WEBSITE AS A FUNCTION OF TIME (GOOGLE ANALYTICS, 2015)

Figure 4 shows the number of sessions as a function of time for NASA's main website nasa.gov, along with annotations of specific events that happened in the timespan. For example, site views began to rise around October 10, 2015, which was around the time of the JPL Open House. Site views also spike on November 5, 2015, which was the same day as the MAVEN (Mars Atmosphere and Volatile Evolution mission) Teleconference. The MAVEN Teleconference was broadcast on NASA TV around the world to report on satellite data related to the Martian atmosphere (NASA, 2015). Since both events occurred at the same time as spikes in the NASA website traffic, one can reasonable associate the two as cause and effect. Similar trends between traffic spikes and NASA events allow analysts to predict past and future user traffic patterns.

With Google Analytics, developers can collect a wide variety of data from consenting sites, which can be categorized four ways, as shown in Table 1. Event Tracking, audience reporting, and site reporting are the three primary data types within these categories that Google Analytics formats into reports useful for web development teams within NASA.

TABLE 1: GOOGLE ANALYTICS FEATURES (GOOGLE, 2015)

Category	Data Type	Description
Data Collection & Management	Collection & Configuration of APIs	Measures how users interact with website content on any device or platform
	Event Tracking	Measures activities initiated by users, such as downloads, video plays, and ad clicks
Data Consolidation	Data Import	Allows for integration of data from other platforms measuring web traffic into Google Analytics
	Product Integrations	Allows for integration of products such as AdWords, AdSense, and Google Display Network, which measures user actions and best positions for web app locations
Data Analytics & Reporting	Acquisition Reporting	Measures advertising, campaign, and traffic source reports
	Audience Reporting	Measures the kind of people users are and other personal information that can be quantified
	Cohorts Reporting	Measures the most effective tactics on the website by reporting user retention
	Site Reporting	Measures the typical path a user takes through the website
Data Activation	Experiments	Allows for testing of different website design before the site goes live

Event tracking allows developers to track how users interact with their website by following user actions and extrapolating conclusions from the acquired data (Google, 2015). For

example, if a user clicks on the blue link more than the red link, a developer can determine that blue links may be more likely to be clicked.

Using audience reporting, developers can acquire data on the users themselves, including age, gender, and the average duration the user spends on a specific site. Developers can use this data to determine what kinds of sites appeal to certain demographics, which leads to developers designing their sites towards this data (Google, 2015).

Site reporting is an important tool developers can use to track users throughout their website in order to see the path they take through the site. This allows developers to determine what the overall goal of the user was on the website, if they found what they were looking for, and how many clicks it took the user to get there (Google, 2015). This allows developers to determine whether their site is optimized to allow users to find the information they are looking for quickly and efficiently.

Performance Metrics

Google Analytics tracks specific performance metrics that can be used to perform Engagement Analysis (which is largely what NASA uses Google Analytics for). Performance metrics are the measurements of a website's number of visits, unique visitors, and pages per visit (Table 2). Taking these performance metrics and comparing them to each other as well as to demographic information is an essential part of engagement analysis as it can uncover trends in how users act. One reason why Google Analytics has become particularly popular among website managers is because it provides a framework where one can compare the relationships between differing interactions and demographic data (Cutroni, 2007).

TABLE 2: IMPORTANT PERFORMANCE METRICS FOR WEBSITE ANALYSIS

Metric	Definition	Importance
Visits	"A visit is a single time that a person comes to a website, clicks around and views some pages, and then leaves" (Beasley, 2015)	The broad metric of visits doesn't provide much insight on its own. Visits are often separated into subcategories that provide more insight
Unique Visitors	The number of unique users that visit the website. This is tracked by device, so multiple users on one computer would be tracked as a single user, and a single user using multiple devices would be tracked as multiple users.	Unique visitors is a better metric than visits for comparing historical data and determining traffic trends.
Pages/Visit	The number of pages that a user goes to per visit.	This metric can be used to determine the depth with which users navigate the website.

Google Analytics also has tools for sorting and comparing performance metrics. One of the most flexible tools Google Analytics offers is Custom Reports, which allow users to create info pages that can be filtered to show how points of data relate to each other. Using custom reports, someone using Google Analytics could track how incoming traffic from social media outlets changes over time, or how long users from Facebook stay on the site compared to users that come to a website from a Google search.

Custom reports can also be coupled with segments to explore performance metrics for specific segments of the users. On the most basic level, segments allow filtering of user sessions based on demographics (age or gender), traffic source (Google, news sites, ads, etc.), and viewing technology (mobile phones or personal computers). It also allows filtering for sessions, such that one could look at performance metrics only for sessions where users visited more than 3 pages.

Usability

In addition to Google Analytics, another form of analyzing websites involves directly examining how users navigate and interact with webpages to determine the usability of a website. Usability is the "quality of a user's experience when interacting with products or

systems. Usability is about effectiveness, efficiency and the overall satisfaction of the user" (Usability Evaluation Basics, 2015). Factors that go into determining the usability of a website as defined on usability.gov are listed in Table 3. There are two types of usability data: quantitative and qualitative. Quantitative data includes the speed of use, number of user made mistakes, and user comprehension when using websites. Qualitative data includes the user's opinion of a website and the likelihood that they will return to the site or recommend it to another possible user.

TABLE 3: USABILITY FACTORS (USABILITY EVALUATION BASICS, 2015)

Factor	Description
Intuitive Design	Nearly effortless understanding of the architecture and navigation of the site
Ease of Learning	How fast a user who has never seen the user interface before can accomplish basic tasks
Efficiency of Use	How fast an experienced user can accomplish tasks
Memorability	If a user can remember enough of the site to use it effectively in future visits
Error Frequency	How often users make errors while using the site, how serious the errors are, and how users recover from the errors
Subjective Satisfaction	If the user likes using the site, would return to the site, and recommend the site to another user

A website's usability can be evaluated by performing user experience tests on a select group of users representing a sample of a website's complete user base. User experience tests, or UX tests, have test subjects complete a set of tasks using the information and tools available on a website, system, or application while observers watch, listen, take notes, and guide them through their test as necessary. These UX tests allow web developers to "identify any usability problems, collect qualitative and quantitative data and determine the participant's satisfaction" (Usability Testing, 2015) for the website. If the website's usability data does not meet the expectations of a web development team or website sponsor, then changes can be made to web content and architecture to improve user experience.

Personas

When examining the user experience of websites, developing personas is a way to collate collected data of multiple users in a way that reframes the information around a realistic human users. Personas are “fictional characters based on actual observed behaviors of real users” (Bustos 2011). This allows someone creating a website to consider what that character might use or need as a representative of a user group while operating from a realistic context rather than an abstract one.

Personas can be created by interviewing individual actual users and creating profiles based on commonalities among the users. In cases where it is not possible to interview users, an alternative way of developing personas is to use demographic, web survey, and analytics information and combine “existing bits of knowledge together into personas” (Spool 2007). These profiles contain narratives that specify the user’s desires for the websites as well as their motivation for that desire, and importantly also covers their behavior when using the websites in detail. This allows the persona’s creator to examine the true behavior of users, since “what people do and say can be entirely different things” (Bustos 2011), causing a contradiction in expected behavior. Further examination of these contradictions between expected user actions and actual experience is necessary in order to determine how to best adjust the website to benefit such users.

Chapter 3: Methodology

The goal of this project was to assist NASA in improving the quality of their webspace and to provide a report to NASA on the current status of their web presence. In order to create our report to NASA, we established a list of objectives that had to be accomplished within our time working with them. Objectives included:

- Acquire and assess initial project resources
- Gather information on NASA websites by surveying NASA employees
- Construct personas from data gathered on NASA websites
- Develop user experience tests for personas using sampled websites
- Perform user experience tests on test subjects
- Compile and analyze experiment results for a deliverable report

To address our objectives we used the schedule shown in Figure 5 and Appendix E. Figure 5 shows our predicted path through our project and dates our team aimed to complete each step. Throughout the project, the graphic was updated to reflect our progress through the project, and whether steps were completed on schedule, late, or in some cases, much earlier than expected.

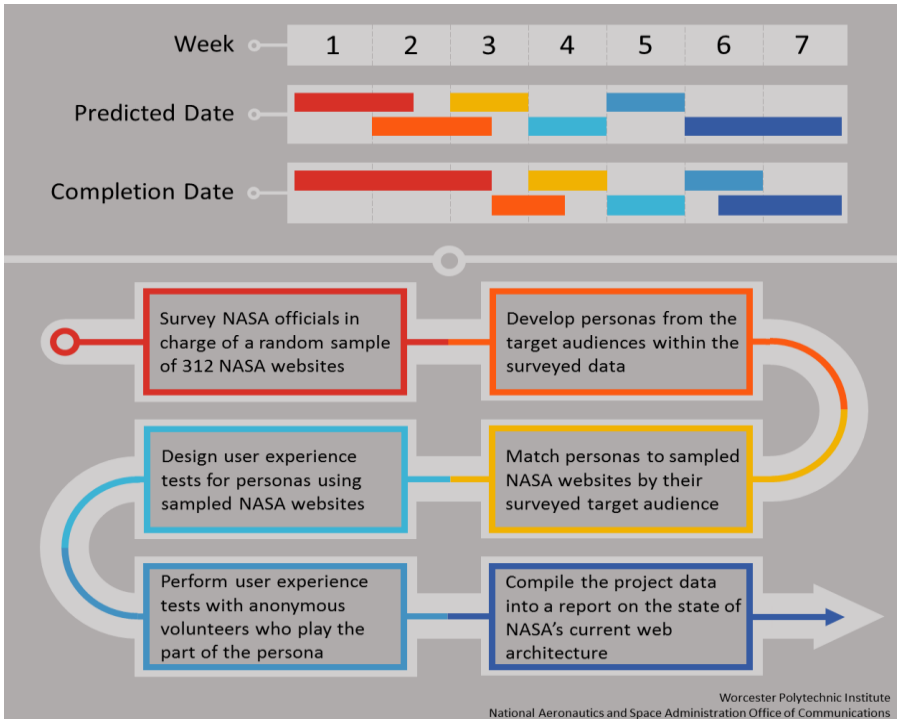

FIGURE 5: PROJECT TIMELINE AND WORKFLOW

Initial Planning

Obtained and Reviewed Site List

Upon arrival at NASA Headquarters, Brian Dunbar gave our team a document which contained the URLs (Uniform Resource Locator) for all of the NASA websites OCOM had knowledge of, as well as access to the Google Analytics software through which NASA websites were mandated to track web traffic. The list of 3092 URLs came with a questionnaire that Dunbar planned to fill with information gathered from each website's web manager. The information included:

- Website URL
- Manager
- Center
- Organization
- Contact Email
- Is this domain a public website?
- How frequently is the site updated?
- When was the last update?
- What contract supports your site?
- What quantitative metrics do you use?
- What qualitative metrics do you use?
- Who are your target audience(s)?
- What is your plan for including insights from metrics into improving your site?
- What would enable you to serve your target audience better?

Revised Questionnaire

The questionnaire provided by Brian Dunbar was the first draft for a data sheet meant to hold data on the websites in NASA's webspace that we constructed. We revised the questionnaire into this new data sheet by combining the original questions with tables for data gathered from Google Analytics. The revised data sheet categories can be found in Appendix B.

Explored Scope of Google Analytics Services

At this point, we used Google Analytics to gain some general information on NASA's webspace. We also wanted to determine how feasible the ideas that we had for Google Analytics were. Initially, we focused on gathering engagement metrics. We started by sorting all of NASA's tracked websites by their traffic. For the top 15 websites, we looked at their average visit durations and number of pages per visit to get an idea of how engaged visitors were. While this information was generally interesting, there were no specific trends that could be useful to

our study. We then looked at general traffic patterns, volume of traffic across NASA's webspace, and how people of different age ranges used NASA websites.

Once we had gotten an initial analytical view of NASA's webspace, we explored how custom reports and segmentation could be used later in the project. Our idea for combining the two was to create segments for each of the target audiences, allowing us to focus on users that were likely within these audiences. Then we could create a custom report for each target audience that would show us more information about their traffic patterns. To develop repeatable steps for this process, we first created a preliminary segment for college students. We filtered for both certain age ranges and users within the field of higher education using the filters that Google provided. This narrowed down the traffic data to 2% of the overall traffic.

Website Data Collection

Randomly Sampled NASA Websites

After collecting the resources we required for starting our project, our team randomly selecting approximately 10% of the websites in the NASA webspace. We were able to gather a random list of websites by organizing the complete list of NASA websites alphabetically and selecting every tenth website. Performing this sampling method, our team created a sample of 312 websites for use in our project. We then documented these websites in the data sheet we had constructed from Brian Dunbar's questionnaire.

Collected Contact Information

For each of these 312 websites, our team visited the website's homepage to gather the names for the NASA Official in charge of the website, the site editor, manager, webmaster, and curator. We also recorded the email for the NASA official if their name was listed on the homepage. This information was then added to the row for that sampled website in the data sheet.

Surveyed Employees In Charge of Sampled Sites

Created Contact List and Acquired Missing E-mails

Once we gathered our random sample of websites from NASA's webspace, we assembled a list of the employees in charge of those websites along with their contact information. If information on the official was missing from the website, we found their email and current work status at id.nasa.gov, NASA's internal directory. In the case where we could not discern the NASA Official for that website or they had already left NASA, we instead used the site manager, webmaster, or curator in that order of precedence. This list of contacts could then be used to keep track of who we were expecting answers from for each sampled site.

Created Google Form and Reviewed it with Sponsors

After compiling a list of all the NASA employees in charge of a site, our team worked to develop a way to contact all of the employees quickly and efficiently. With the assistance of Brian Dunbar, we settled on asking them the following multiple-choice and open-ended questions:

- What is the URL of the site you are filling this out for?
- Who is this site's primary target audience?
- Who are the site's secondary target audience(s), if any?
- How often is this site updated?
- What contract supports this site?
- Are there any quantitative metrics used on this site?
- Are there any qualitative metrics used on this site?

If the NASA employee filling out the survey responded to the last question with a no, then their form responses were submitted. If the responder answered with a yes, he was then taken to a second page with the following two questions:

- What qualitative metrics do you use on this site?
- How do you include insights from metrics when improving this site?

The questions about the primary target audience, site updates, and existence of qualitative metrics were multiple choice with the restriction of only choosing one option. The questions regarding secondary target audiences and quantitative metrics were also multiple choice, but allowed employees to select multiple options. All other questions had the employee write in their own answer, though this was also an option for the multiple choice questions if needed. After development of the Google Form was completed, our team sent the survey to Dunbar for distribution among the employees on the list, asking them to complete the survey within one week.

Reviewed Input

As employees submitted answers to the survey, we reviewed the answers and made note of who had completed the survey for which websites. Several of the employees responsible for multiple sites did not initially submit answers for more than one of them. In some cases, an employee answered for a website that was not in the sample. These answers were almost always either a more popular website that employee was in charge of. Some of these cases were also clearly a more general website relating to the sampled one. After some cases that required follow up contact had accumulated, we got in touch with Brian Dunbar so he could reach back out to people accordingly.

Called Unresponsive Employees

One week after sending out the survey, our team used id.nasa.gov to collect the phone numbers for employees who had not responded so we could reach out to them by phone. This list was split equally into 5 parts and divided amongst our team and Brian Dunbar. Calling employees visibly raised our response rate and in doing so helped to make our data collection more representative of the overall webspace.

Added Information to Data Sheet

Upon retrieval, review, and organization of the data received from the employees in charge of websites, our team worked to move the data from the generated Google Form response spreadsheet into our master data spreadsheet. This allowed us to frontload some of the work for analyzing the data later on. By moving this information from one spreadsheet to the other now, our data was already compiled into one spreadsheet that could be easily viewed on one screen, allowing for comparisons and correlations between the data to be readily created.

Persona Development

Created Persona Criteria

While collecting data on the NASA webspace, our project team received a list of target audiences from Brian Dunbar that was largely representative of NASA's audience. Using this list, we worked on developing the target audiences into personas. A target audience is the general group of people for which a website's content is meant to provide the most useful information and interactive content.

In our research, our project team found pre-constructed methods for developing personas using target audiences and Google Analytics data. Information provided by usability.gov allowed our project team to develop our own criteria for persona development. We used our criteria as a template for each persona, allowing us to create personas that satisfactorily matched the target audiences of NASA websites.

Constructed Personas

After collecting data on our sample of NASA's websites, our project team assessed which of NASA's target audiences for their websites were most represented among the random sample. From the survey sent to NASA employees about the websites they managed, we were able to gather the intended target audience for the websites in our random sample.

Our team needed to further develop these target audiences into personas. From the survey data, we were able to find the target audiences for various sites, and determined demographics, including age and gender, by using Google Analytics on each of these sites. With

this data, we constructed personas that represented a specific type of user among the target audience.

Developing unique personas allowed us to create an objective depiction of a typical individual within a target audience. Each persona reflected a representative narrative of a fictional user from a group that was used in further analysis of the website. These narratives include a fictional description of the persona's background and motivations, which were developed by our team using the resources associated with the relevant user group. The narrative also covers the end goal of the user, as well as what their standard behavior for approaching a website was in different situations.

Segments

Initially we wanted to approach usability from two sides: user testing and google analytics. In order to do this we needed to be able to identify traffic patterns for our personas. We used segmentation to filter the data further within Google Analytics. Segments allow Google Analytics to filter traffic based on metrics such as age or interest category. While creating segments, we realized that the large diversity in users that visit NASA's websites didn't allow us to create filters in Google Analytics that ensured we could identify all traffic relating to our personas. For example, our segment for the Researcher persona was filtered by an older age range, and for people that Google identified as being interested in the field of Higher Education. Though this was a reasonable assumption of what the average researcher would be, it drastically narrowed down the analytics data to the point that it was clear that it was not capturing the majority of researchers visiting NASA's webspace.

Although the limitations in segment filters meant that we couldn't directly make observations for our personas, it did allow us to narrow down the sessions within Google Analytics to less than 1% of all traffic. We believed that narrowing down the users to this percentage would still allow us to identify some form of traffic patterns for a subsection of people with similar interests, which satisfied our initial intentions behind segmentation and goal page development, and so we moved forward with this in mind.

Identify Goal Pages

After creating the segments, we worked to define goal pages for each segment. These goal pages were to be based on navigation trends for each segment. Our criteria for goal pages were web pages that contained definitive information that the relevant persona would reasonably be looking for and were the last page in a session. These two factors would suggest that a user navigated to the page and found the information they were looking for, thus making their session a successful session. By filtering sessions for a specific segment, we could sort the pages within a website by exit rate, and determine from the content of the page if it would

make a good exit page. Once we identified goal pages, we could understand how people navigate to those pages to identify trends that would suggest users of the same target audience as the persona were looking for that information. In this way we hoped to be able to identify users looking for information, and compare that number to the number of users who found the information.

We intended to use custom reports in Google Analytics to identify users seeking these pages that did not reach the information, as well as users seeking this information that did find it. This ratio would allow us to determine if the website was designed in a way that allowed users to easily find information that they sought. However, once we started to explore websites using segments and goal pages, we came to the conclusion that beyond our struggles to develop reliable segments, there was too much navigation data for us to reasonably sort through, and user sessions were also typically no more than a few pages. This made it extremely difficult to identify any conclusive navigation patterns from Google Analytics data within our time constraints.

User Experience Testing

Designed User Experience Tests

Selected Sites for Tests Based on Personas

Previously during persona development, our team compiled the data gathered from the NASA employee survey and organized our sampled list of NASA websites by their reported primary target audience. We checked the websites listed in each category of our list to see if the websites would work well for testing. A website was disqualified from the potential testing pool if the website was malfunctioning, a redirect, private, or lacking in information. From the remaining list of viable websites we chose four websites in each target audience category, with the exception of the Aerospace Industry category, which had six due to the lack of content on several of the websites. These websites were used for further testing and test question development. Each set of websites was gathered from the list of possible candidates by selecting the first four valid websites in the target audience category. If we felt that we couldn't create useful test questions from a website, we selected the next website in the list.

Designed User Experience Test Questions

Our team then devised a set of testing scenarios for each persona with the intended goal of observing direct user interaction and experience with NASA websites. For each persona, we devised 8 tasks, with there generally being two tasks for each site selected for that persona. Each scenario we developed was based on the goals and motivations that we set for the personas. For each of the personas, we created a test worksheet on Google Forms. Each page of this worksheet consisted of two separate questionnaire sections. The first focused around

performing the specific tasks that we deemed appropriate for the motivations of said persona regarding information that the persona wanted to find on the given site.

The second section contained a series of questions regarding the subject's qualitative experience as the persona using that website. These questions addressed how the user felt about the site's navigation and appearance, as well as whether they would return to the website later. Qualitative questions about their experience with a website used a Likert scale, with the option to answer with strongly disagree, disagree, neutral, agree, or strongly agree. The qualitative experience questions were generalized so that they could be used in every worksheet for each website, providing a basis for comparison across the tests. Each worksheet was designed to be completed within an hour of testing.

Conducted User Experience Test Sessions

Our team then looked for participants who would be able to act out these scenarios as the designated persona by asking for volunteers from our fellow IQP students, who volunteered to be tested and signed up for a testing block over our five day testing period. Each persona was randomly assigned to 5 participants, with a participant being assigned 2 personas by drawing the personas from a hat, to ensure the random distribution of personas among volunteers. For each assigned persona, participants were asked to participate in a test where they would assume the role of that persona. Each test session was intended to be an hour long, and consisted of the participant filling out that persona's worksheet. These tests were conducted individually with a member of our team supervising each participant.

To avoid collecting any personal information of participants, each participant was given an identifying code to connect their first and second test in our records when they signed up. Before each test, the volunteer was given the biography of the persona they would be assuming, and the supervisor instructed them to both avoid the search bars on sites and to stay away from outgoing websites. The volunteers were told to ask any questions they had about their persona or the test itself, but that the test administrator could not help with answering the UX test questions. This process was explained to all participants clearly before they began, including that their browsing session would be recorded for our later review by a screen capturing software. The software used was ActivePresenter for the two supervisors who used Windows computers, and QuickTime Player for the two supervisors who used Macs. This software only captured the screen, and did not use any external audio or video recording devices, in order to protect the identity of our volunteers. All testing was done using Chrome as the web browser in order to avoid any possible differences between how browsers displayed the tested websites.

As each participant had a testing session for each of their two personas, there was a restriction that their second test would be held 24 hours after the start of their first test to

avoid the first persona from influencing the results of the second. To accommodate this, the testing was held over the course of several days. Four tests could be held per hour, with each member of our team supervising one participant each during that time. Participants were randomly split into four roughly equal groups, Groups A, B, C, and D. Group A had their first tests on the first day, followed by their second test at the same time on the second day. Group B then started by following the end of Group A's second tests, with their second tests being held at the same times on the third day. On the third day, Group C's tests were held when Group A's were, continuing with this pattern until Group D's second test concluded on the fifth day. This staggered testing schedule allowed both our team and the participants to accommodate the tests without it getting in the way of our other work.

After the participants finished the tasks for each site, they answered questions designed to obtain qualitative ratings of their experiences. With these answers, our team could investigate how each persona represented in the interviews was currently served by NASA's websites. Screen captured sessions were reviewed after testing by their supervisors to document task completion times, the number of pages visited during each task, and the successful completion of each task. Task completion times were determined by timing how long it took a tester to complete a task, starting from when they began searching the website and ending when they input their answer into the google form. The number of pages visited during a task was determined by counting the total webpages visited during the task by the tester, including the homepage of the website. The success rate of a task was determined by assigning a value of 0, 0.5, or 1 to the answer given by a tester. A 0 meant they either could not find the answer and moved on to a different task, or they gave an incorrect answer. A 0.5 meant that they found an answer to a task, but it was found in a different part of the website and only provided a partially correct version of the answer. A 1 meant that the answer given by the tester for a task was correct, and this sometimes included answers found elsewhere on the website if it was reasonable for the persona to have used that instead. Using this additional amount of data, our team was able to suggest how pursuing user experience testing in the future could provide more information about NASA websites

Perform Analysis

Compile Data for further NASA Use

After completion of the UX tests, our team compiled all the data and information we had collected over the previous weeks into a package centered on the personas we developed. Each persona's profile was collated with the relevant survey responses, as well as the site information that informed its creation. Additionally, each has the UX test results for that persona following the profile, as well as our comments on how the responses followed or differed from expectations. This package was primarily intended to provide NASA with documentation regarding the work we conducted. We believed that our work would give them

a starting point if they wished to conduct further research or analysis based upon the personas we developed. We additionally provided NASA with the data sheet we had constructed to hold our sample data and survey responses, as well as another sheet containing the erroneous responses for websites that were not actually in the sample.

Conclusions

By following our plan to complete our project, our team aimed to improve NASA's awareness of their web presence while also helping them plan for further growth. Our team initially determined the scope of the NASA webspace by selecting approximately 10% of the agency's websites and surveying the employees in charge of those websites to learn more about the target audiences for our persona development. With this data about the websites, our team was able to create personas - fictitious users that represent a website's target audience - in order to use them for user experience testing. By using personas, our classmates could be used to test these target audiences, which allowed for much more flexibility in how we structured and ran our UX tests. With the data from these tests, our team was able to provide valuable information to NASA on the current state of their webspace, and recommendations to improve it in the future.

Chapter 4: Results and Analysis

Included in this chapter is our team's results from each step of our project. This section includes information from our random sample data sheet, survey responses from NASA employees, results of persona development, and results from user experience tests. Included with this information is the narrative of how these tasks were completed.

Website Data Collection

Randomly Sampled 312 Sites

While gathering this data from the various websites, our team found many URLs that redirected users' browsers to another site or broken pages. As shown in Figure 6, we determined there to be 25 URLs that redirected and 65 broken pages within our list of sampled URLs.

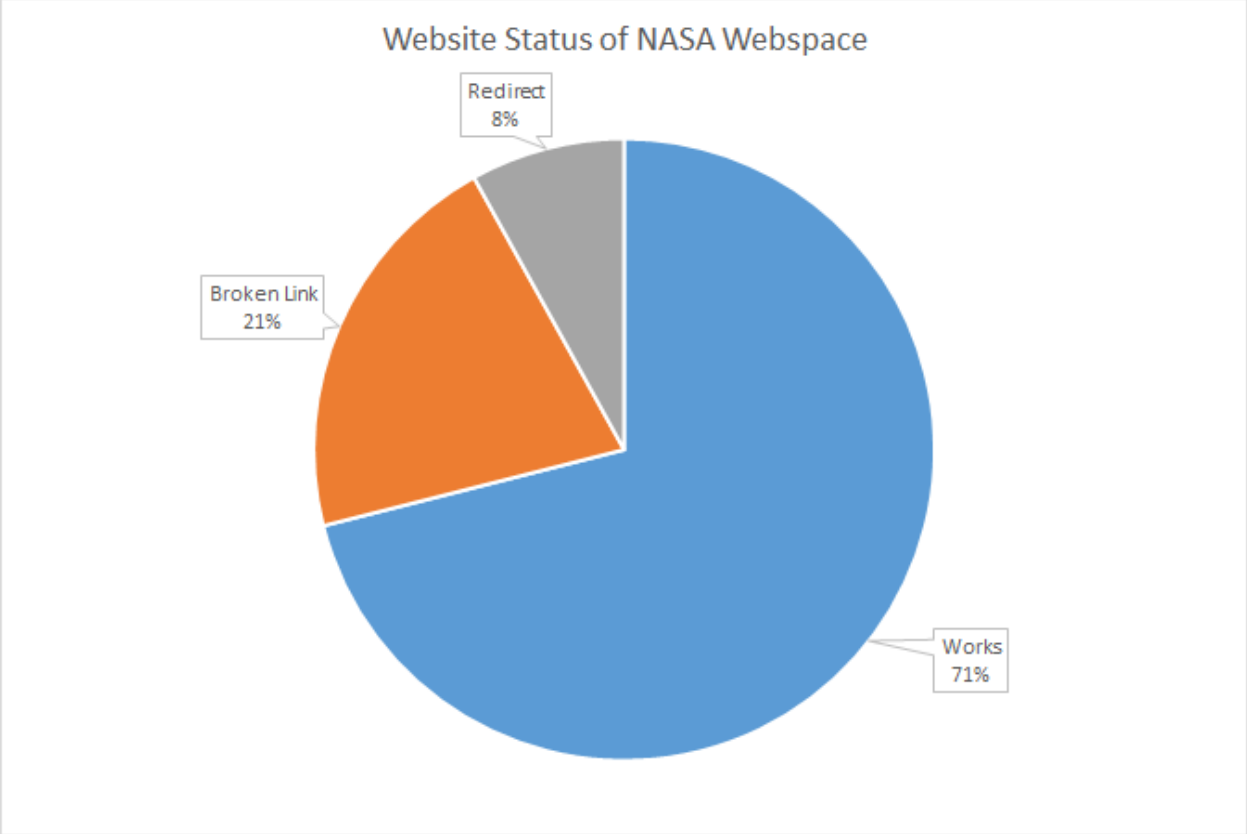

FIGURE 6: LINK CHARACTERISTICS FOR SELECTED NASA WEBSPACE

Surveyed Employees In Charge of Sampled Sites

Of the 312 randomly sampled sites, 215 had names of the employees responsible for the site. From these sites, as well as NASA's internal directory, we collected the contact information for 169 unique NASA employees. Most of these employees were in charge of one website, but some handled multiple sites. The remaining 97 websites either didn't have contact information listed, or were error pages, restricted internal sites, or redirects.

Added Information to Website Data Sheet

After following up with employees who didn't respond to the survey and waiting for responses, by the time we decided to move forward survey data had been collected for 135 of the 312 sites. We then created a data sheet with the results of the survey so we could compile our findings into figures. As seen in Figures 7, 8, and 9 we found the target audiences of each site, the frequency that the site was updated, and if any quantitative metrics are used on these sites, respectively.

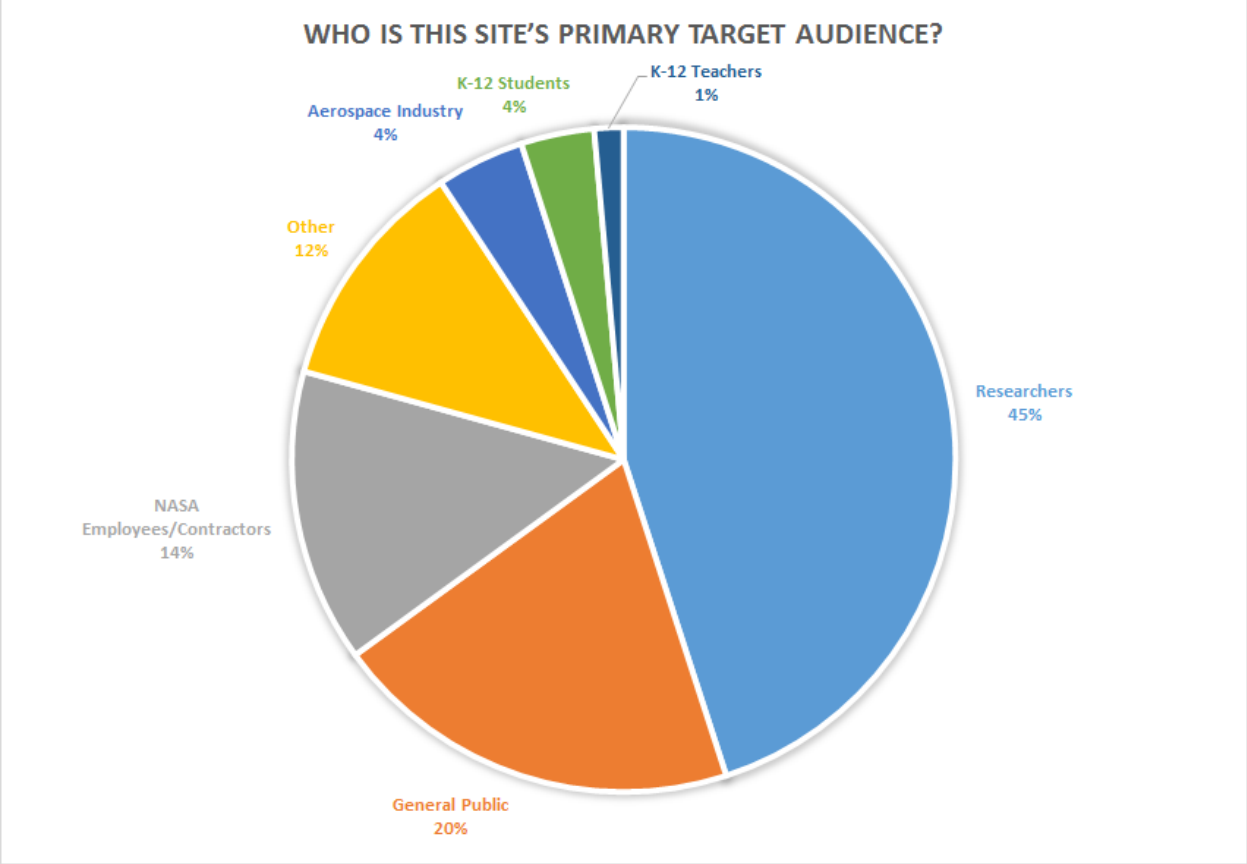

FIGURE 7: WHO ARE NASA'S WEBSITES' TARGET AUDIENCES?

Figure 7 shows the resulting responses when we asked responsible employees for their website's primary target audience. As we wanted to get a singular primary target audience, the question was formatted as a multiple choice. However, there were many responses that were input using the "Other" option that did not align with our expectations. For example, one response received was "JPL Personnel" for the primary target audience. While this was not a target audience we provided, we decided that this would reasonably fall into the NASA Employee target audience. Several other cases existed which were similar to this, and by refining some of these open ended responses into the predefined categories, our team was able to clean up our data and shrink the size of the Other section, clarifying the information that the data provides.

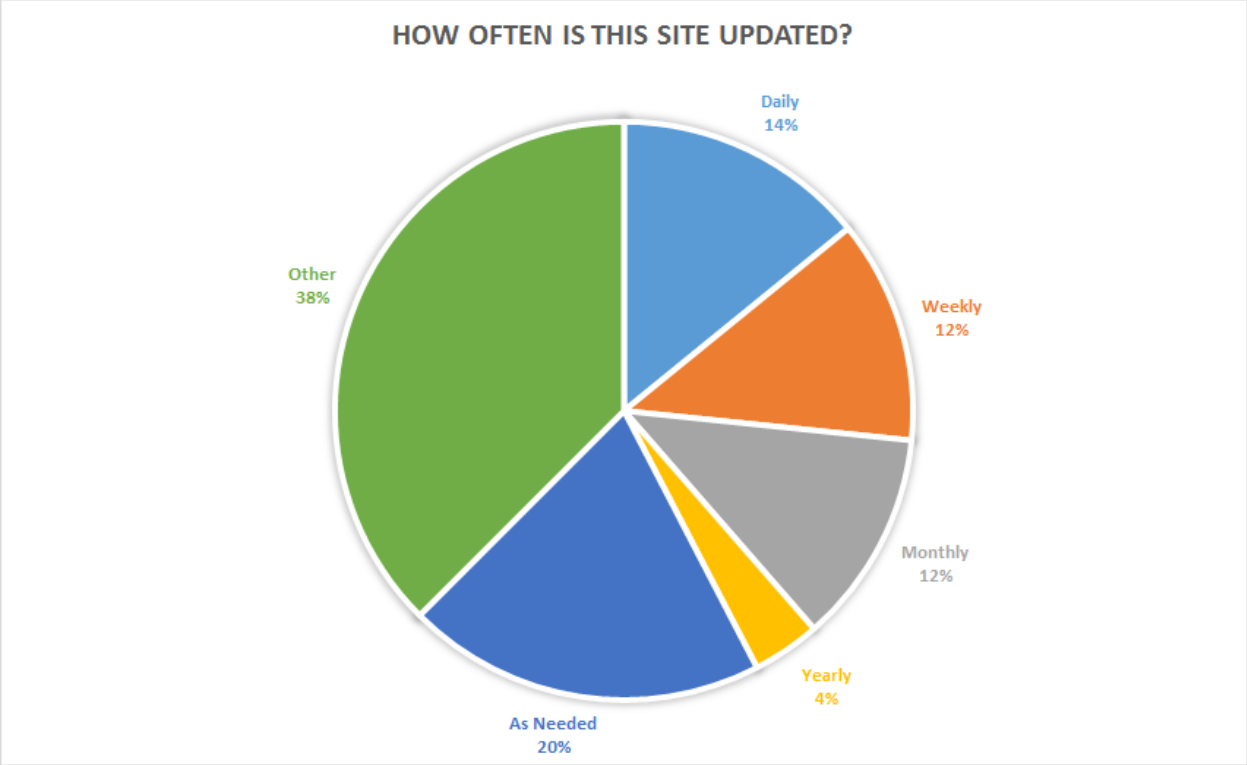

FIGURE 8: HOW OFTEN IS THIS SITE UPDATED?

Figure 8 shows the responses from website managers on how often their websites were updated. The possible answers for this question were daily, weekly, monthly, and other. We added the categories "as needed" and "yearly" upon reviewing the results and finding that answers that fit in these categories appeared multiple times among the results submitted in the "Other" field.

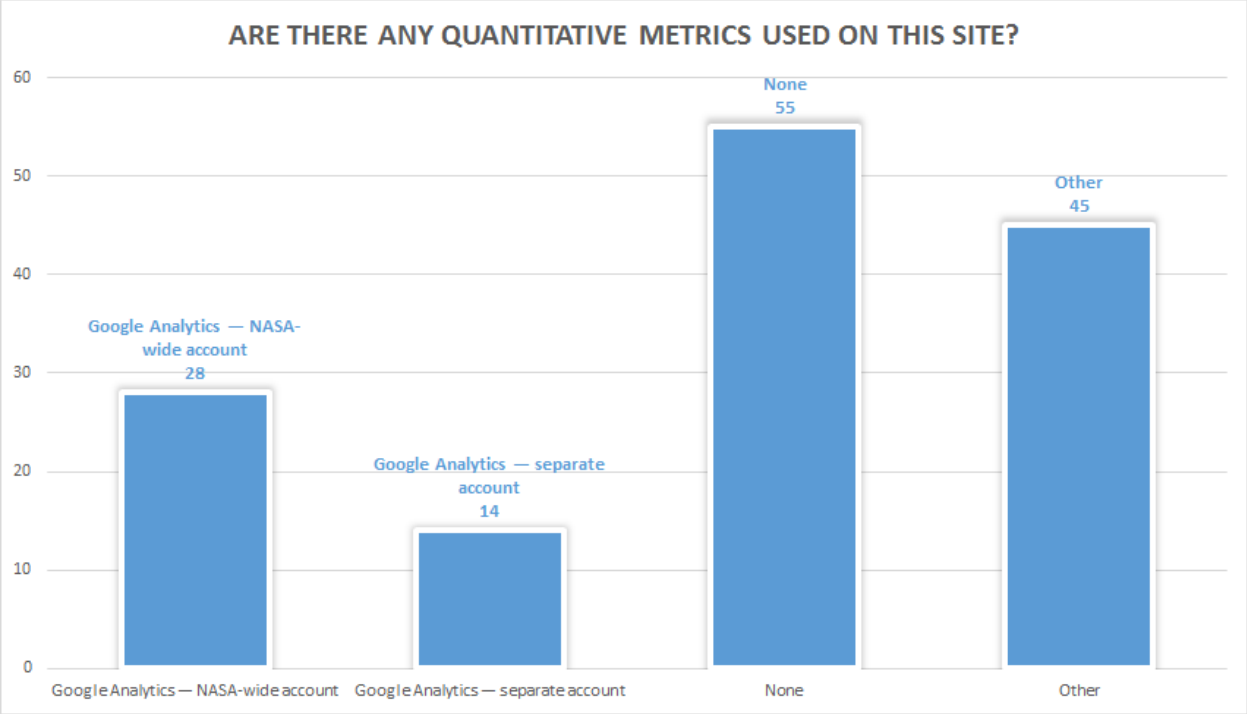

FIGURE 9: ARE THERE ANY QUANTITATIVE METRICS USED ON THIS SITE?

Figure 9 shows the results from website managers when asked whether their website uses any form of analytics software to track quantitative metrics. It is an Office of Management and Budget policy for every government website to have Google Analytics implemented with the government-wide Google Analytics account, but the results of the survey show that only 28 websites in our sample are using the government wide Google Analytics account. 55 of the websites in our sample don't have any web analytics implemented.

Persona Development

Our Persona development criteria consisted of questions about a user's characteristics (Appendix B). These questions were organized into four categories: personal, professional, technical, and motivational. These biographical questions helped shape the persona into a realistic representation of a target audience (Appendix B).

After creating the persona criteria, we created personas with the help of the responses from our employee survey. For each persona we chose a name corresponding to the target audience it represented, such as Student Sam for the K-12 Student persona.

To determine the age of each persona, our team chose an age that would fulfill the educational and work experience qualifications previously determined in persona development. For example, we determined that the Researcher persona should be 39 years old because we

previously determined the researcher had a PhD in astronomy and 11 years of research experience. In order to fulfill these qualifications, the researcher persona would have to be 39 at least. We determined that the gender of the persona would have no effect on the performance of testers using it, so we arbitrarily assigned gender.

The work experience and professional background for our personas were determined based on the expectations of the target audience they were derived from. For example, an Aerospace Industry persona had a job related to aerospace engineering, the K-12 Teacher was a teacher, and the General Public worked in retail because of the low qualifications needed to have the position.

We determined the highest level of education required for the professional background of each persona and used it accordingly. For the general public we gave them a high school diploma because of their retail work, and for researchers we gave them a PhD because of the research work they were conducting.

We determined the technical requirements of the persona by determining which materials were available to the average person within each target audience. For example, a K-12 student would have a home or school computer and a Researcher would have academic software and computers at their disposal.

This allowed our team to create a persona representative of the actual people who use the website. We constructed persona biographies consisting of a background, goals, and challenges from the persona characteristics to be used by participants in UX testing (Appendix C).

User Experience Testing

Listed in this section are the websites we used in our user experience tests for each persona that we developed earlier in the project. We selected four websites per persona, with the exception of the Aerospace Industry persona where we selected 6 websites out of necessity.

General Public

1. science.larc.nasa.gov
2. www.giss.nasa.gov
3. eclipse.gsfc.nasa.gov
4. saturn.jpl.nasa.gov

K-12 Student

1. cosmictimes.gsfc.nasa.gov
2. globalastro.gsfc.nasa.gov
3. mwmw.gsfc.nasa.gov

4. spaceplace.nasa.gov

K-12 Teacher

1. mars.nasa.gov
2. solarsystem.nasa.gov
3. jwst.nasa.gov
4. spaceplace.nasa.gov

Researcher

1. earthdata.nasa.gov
2. nasirf.wff.nasa.gov
3. www-mipl.jpl.nasa.gov/mipex.html
4. atrain.gsfc.nasa.gov

NASA Employee

1. ammos.jpl.nasa.gov
2. code250.gsfc.nasa.gov
3. fvncep.gsfc.nasa.gov
4. oce.jpl.nasa.gov

Aerospace Industry

1. trajectory.grc.nasa.gov
2. rtaps.grc.nasa.gov
3. dst.jpl.nasa.gov
4. nsidedlab.jpl.nasa.gov
5. jsc-aircraft-ops.jsc.nasa.gov
6. turbmodels.larc.nasa.gov

Once we selected the web sites we intended to use for UX testing, we explored each website to find information that would fit within a persona's goals. From that information, we developed user experience test tasks. An example task for the K-12 Student UX test was to find the instructions on making star cookies, while a task for the Aerospace Industry UX test was to find information on RTAPS regulations. After the tasks were created, the most efficient paths from the homepage of the task's website to the webpage with the task's answer were recorded for future reference during the analysis of the UX test results (Appendix D).

Executed User Experience Test Sessions

The user experience tests were executed over a five day period, in which 30 total tests were administered to volunteers from other IQP teams staying in Washington DC. The graphs included in this section show the average test time, number of page visits, and success rate for each task in each UX test. We also included a graph for each UX test that shows the average qualitative scores for each website as answered by testers. For the qualitative score graphs, the questions referenced are as follows:

TABLE 4: SUBJECTIVE QUESTION KEY FOR UX TESTING

Question Number	Extended Question
1	I was easily able to find the information I needed
2	Navigating through this website was clear and easy
3	I enjoyed the visual design and style of the webpages on this website
4	I would return to this website in the future to find more information
5	I would recommend this website to someone else if they are looking for the same information

These qualitative score graphs visualize the Likert scale answers given by users for each website in their test. For example, if the graph shows that a website received a 1 for a qualitative question, then the testers answered on average with strongly disagree. If the graph shows that a website received a 5 for a qualitative question, then the testers answered on average with strongly agree. Other scores between 1 and 5 match the Likert scale responses accordingly.

General Public - General George

We conducted 5 UX tests for the General Public persona with 5 volunteers. For each UX test, the volunteers were required to visit four different websites and perform two different tasks, resulting in eight total tasks for the entire UX test. Tasks in the General Public UX test had users search for the location of information on various topics across many different sciences (Appendix D). From the 5 UX tests we conducted, we gathered the average completion time, number of page visits, and success rates for each task in the test. Due to technical issues with a google form submission, volunteer D1's test times and page visits are included in this data, but not the successfulness of their responses. We also included the averaged answers to the five qualitative questions for each website.

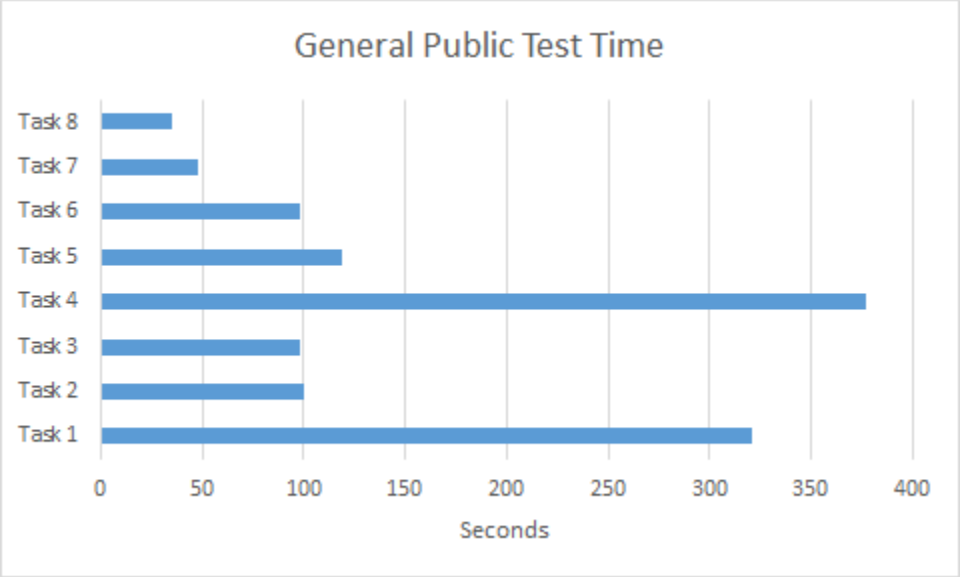

FIGURE 10: TEST TIME PER TASK OF GENERAL PUBLIC UX TEST

Figure 10 shows the average time taken by testers to complete each task in the General Public UX test. From this graph, it can be seen that testers took the longest time to complete Task 1 and Task 4, at 321 seconds and 377 seconds respectively. These test times stand as outliers compared to the test times of the other tasks for the General Public test. These outliers could have resulted from an issue with the navigation system of science.larc.nasa.gov and giss.nasa.gov, the way information required to answer Task 1 and 4 is displayed on the websites, or with the way we wrote the task.

Figure 10 also shows that testers took the least amount of time to complete Task 7 and Task 8, at 30 seconds and 23.9 seconds respectively. Testers completed these two tasks 70 seconds faster than the average time required for Tasks 2, 3, 5, and 7. These two tasks were associated with website 4, saturn.jpl.nasa.gov, which means that either it is very effective in displaying information to users or we made these tasks much easier to complete than the other tasks in the test.

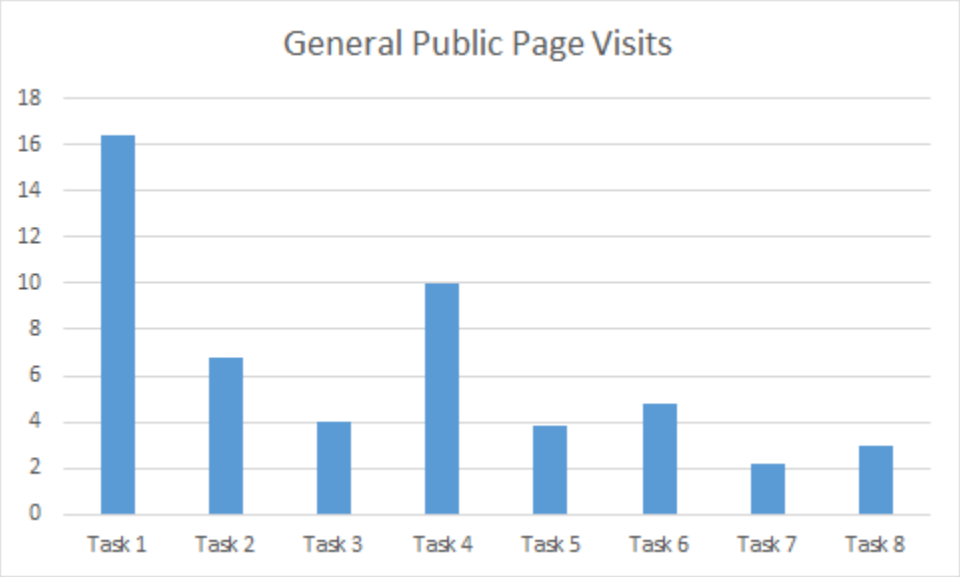

FIGURE 11: NUMBER OF PAGE VISITS PER TASK OF GENERAL PUBLIC UX TEST

Figure 11 shows the average number of page visits taken by testers for each task in the General Public UX Test. As seen in the figure, testers visited the most websites to complete Task 1 and Task 4, at 16.4 pages and 10 pages respectively. We found that the most efficient path for completing these two tasks was 3 pages, which means that testers had to visit 5 times as many webpages for Task 1 and 3 times as many webpages for Task 4. Our testers had never visited these websites before, so we had no expectation that they would take the most efficient path. However, having users complete their goals as efficiently as possible is a factor of good usability and shows the effectiveness of a website's navigation and content. Completing these two tasks by having to visit so many webpages implies that there is a problem with the navigation on websites 1 and 2.

Alternatively, testers completed Task 7 in two page visits and Task 8 in three page visits, matching the most efficient paths for these tasks. These results imply that the navigation on website 4, saturn.jpl.nasa.gov, effectively displays the distribution of content across the website for users. However, we could have inadvertently designed the tasks for this website to be less difficult than the others. Considering Task 7 could be answered with one page visit on website 4 and the answers for Tasks 1 and 4 are found within text heavy research sections of websites 1 and 2, the ease of Tasks 7 and 8 more than likely explain their resulting data.

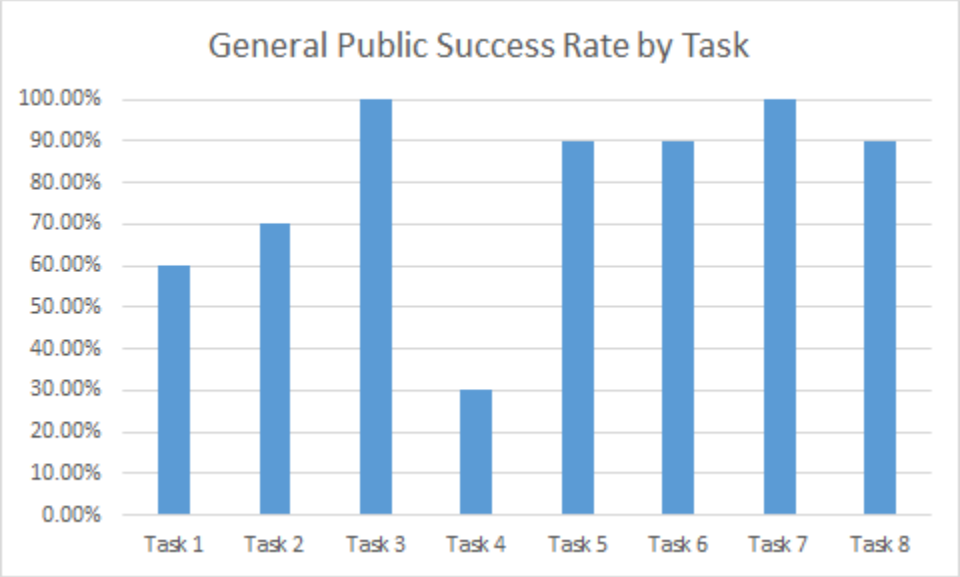

FIGURE 12: SUCCESS RATE PER TASK OF GENERAL PUBLIC UX TEST

Figure 12 shows the average success rate of each task, which was calculated by comparing the answers given by the testers to the correct answers determined when the UX tests were designed. The three critical points in this figure are the minimum scores for Tasks 1, 2 and 4, the maximum scores for Tasks 3 and 7, and the difference in success between Tasks 3 and 4.

Complementing the resulting test times and page visits for Tasks 1 and 4, testers only found the answer to their questions 60% of the time for Task 1 and 30% of the time for Task 4. Since Task 2 also had a relatively low success rate there was an issue with how website 1, science.larc.nasa.gov, displayed information to users. For Task 1, two testers answered correctly, two testers gave partial answers, and one tester failed the task. For Task 2, three testers answered correctly, one tester gave a partial answer, and one tester gave an incorrect answer. At best, only half of the testers could provide a correct answer to a task for science.larc.nasa.gov which challenges the idea that the website is successfully serving its target audience.

Since the tasks for www.giss.nasa.gov had testers produce results at both the maximum and minimum success rates, the source of failure most likely lies with Task 4. Right before we began performing tests with our volunteers, we reviewed this task and found that it failed to provide the user with a specific enough goal. Therefore, we changed Task 4 to a new question asking “How does NASA validate the measurements of aerosols taken by satellites?” The problem was that the answer for this new question was on the same article, *Seeing Through the Smoky Pall: Observations from a Grim Indonesian Fire Season*. This article was primarily focused

on the smoke produced by fires in Indonesia and not satellites measuring aerosols. The answer for Task 4 can be found in a paragraph quoting a NASA employee about their opinion of the Indonesian fires half-way through the article. If a tester was correctly navigating webpages as the General Public persona, t they would have not searched thoroughly through this article for the answer to this task.

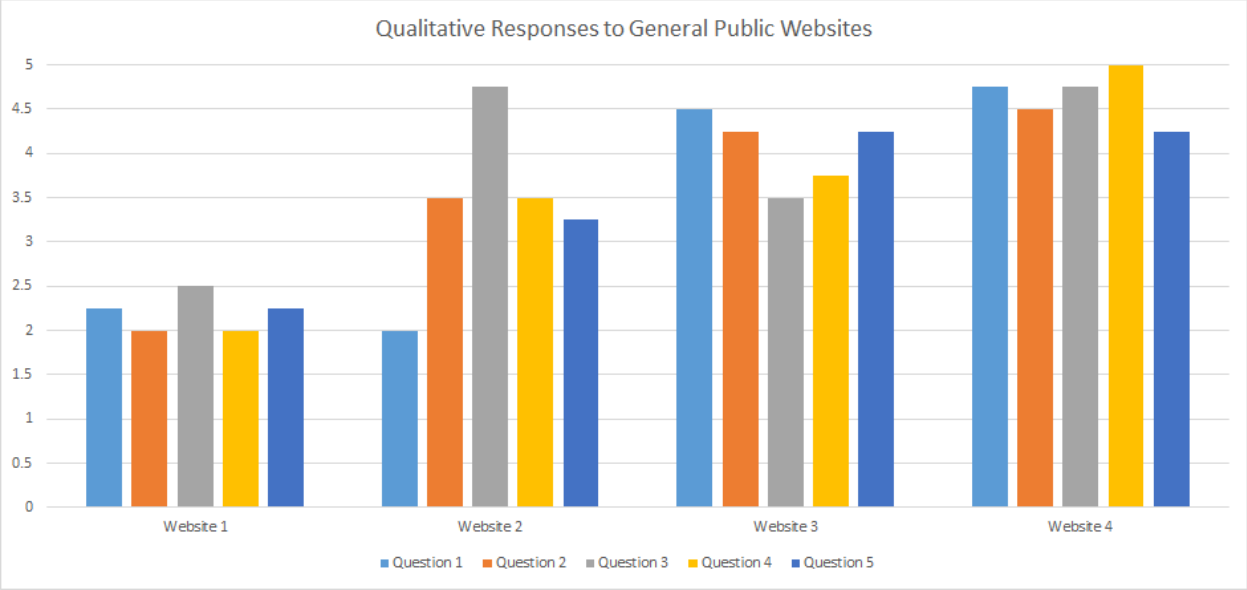

FIGURE 13: QUALITATIVE RESPONSES PER WEBSITE OF GENERAL PUBLIC UX TEST

In Figure 13, the scores given by each tester for qualitative questions on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

As seen in Figure 13, website 1, science.larc.nasa.gov, received the lowest qualitative score of all four websites with an average answer of disagree across all qualitative questions. This means that the testers felt that they could not find information easily or navigate the website and would not return to the website or recommend it to a colleague. They were neutral about the visual design of the webpages within the website.

For website 2, giss.nasa.gov, testers responded positively to the visual design of the website giving on average an answer of strongly agree. However, they felt indifferent on the navigation and concept of future use of the website. They responded negatively when asked if they could find information on the website, and this is likely due to the difficulty of Task 4. Interestingly, even if they could not find the information they required they still had a positive impression of the website.

For website 3, eclipse.gsfc.nasa.gov, testers gave overall positive responses to qualitative questions responding with an average answer of agree. They had the most positive reaction to questions about finding information and recommending the website and felt only slightly less positive towards the visual design of the website. Considering testers had little trouble with tasks on this website, these responses are reasonable.

For website 4, saturn.jpl.nasa.gov, testers gave overwhelmingly positive responses to qualitative questions responding with an average answer of strongly agree. The tasks for this website were completed much faster than the other tasks which could point to the testers not having enough time to analyze the website or that the website sufficiently served their needs.

With our quantitative and qualitative data on our testers' performances analyzed, we can examine how these pieces of data interact with each other and reveal the total usability of the four NASA websites tested by the General Public UX test.

The short test times, low page visits, high success rates and good qualitative scores of websites 3 and 4 show that testers had a good experience during their visit to these websites. Therefore, we can infer from the lower scores of the other two tested websites that websites 3 and 4 effectively serve the General Public as a target audience.

The low success rates, high test times, low success rates, and poor qualitative scores of website 1 show that testers had a poor experience during their visit to this website. Therefore, we can infer that compared to websites 3 and 4, website 1 does not effectively serve the General Public. This is due to the consistently poor performance given by testers for Task 1 and the average performance given for Task 2.

The results for website 2 are inconclusive due to the good results of Task 3 and the poor results of Task 4. Due to the difficulty of Task 4, further UX tests would need to be performed on giss.nasa.gov to conclusively say whether the website effectively serves the General Public or not.

Our General Public UX tests were meant to test whether or not NASA websites intended to serve the General Public were doing so effectively. Of the four websites tested, two showed that they were effectively serving the General Public, one showed that it was not effectively serving the General Public, and one produced skewed results because of a poorly constructed task. Whether or not these results show an effective webspace for the General Public is subjective to anyone in charge of NASA's websites.

K-12 Student - Student Sam

We conducted 5 UX tests for the K-12 Student persona with 5 volunteers. For each UX test, the volunteers were required to visit four different websites to perform two different tasks, resulting in eight total tasks for the entire UX test. Tasks in the K-12 Student UX test had

users search for the location of information on various topics relating to students and educational material (Appendix D). From the responses to these 8 tasks, we gathered the average completion time, page visits, and success rates for each task in the test. We also recorded the average for answers to the five qualitative questions for each website.

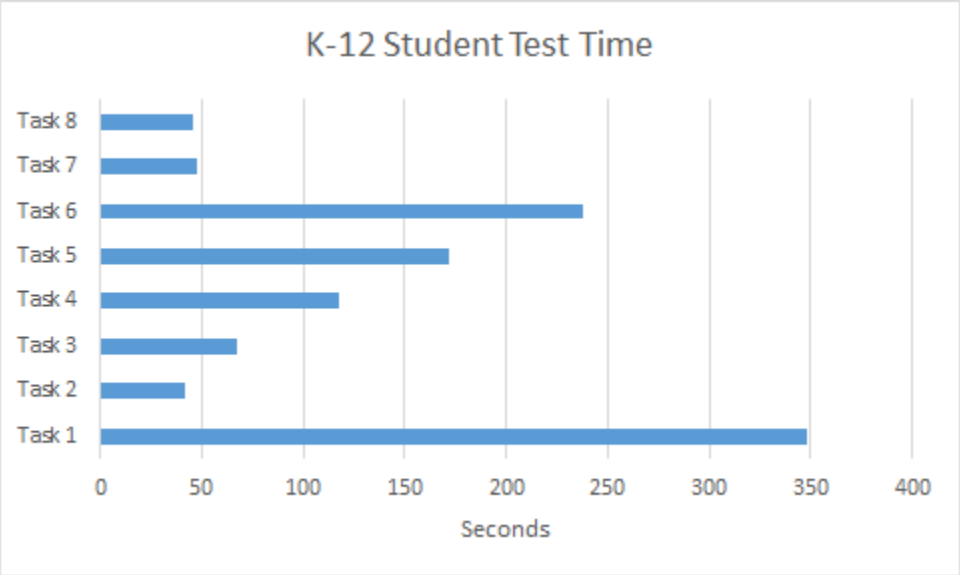

FIGURE 14: TEST TIME PER TASK OF K-12 STUDENT UX TEST

Figure 14 shows the average time to complete each task in the K-12 Student UX test. From this graph, it can be seen that testers took the longest time to complete Task 1, at 348 seconds, and completed Task 2 in the shortest time, at 42 seconds. These test times stand out compared to the average test times of the other tasks for the K-12 Student test, as they are the most dramatic change on the same website than other tasks. These outliers could have resulted from an issue in the navigation strategy of website 1, cosmictimes.gsfc.nasa.gov, the way a picture of a new Universe or the death year of Albert Einstein is displayed on the website, or with the presentation of the task for the test. However, as both tasks were completed on the same website, cosmictimes.gsfc.nasa.gov, participants may have also found the answer to Task 2 while looking for the answer to Task 1, which allowed them to quickly find it again once they answered Task 1.

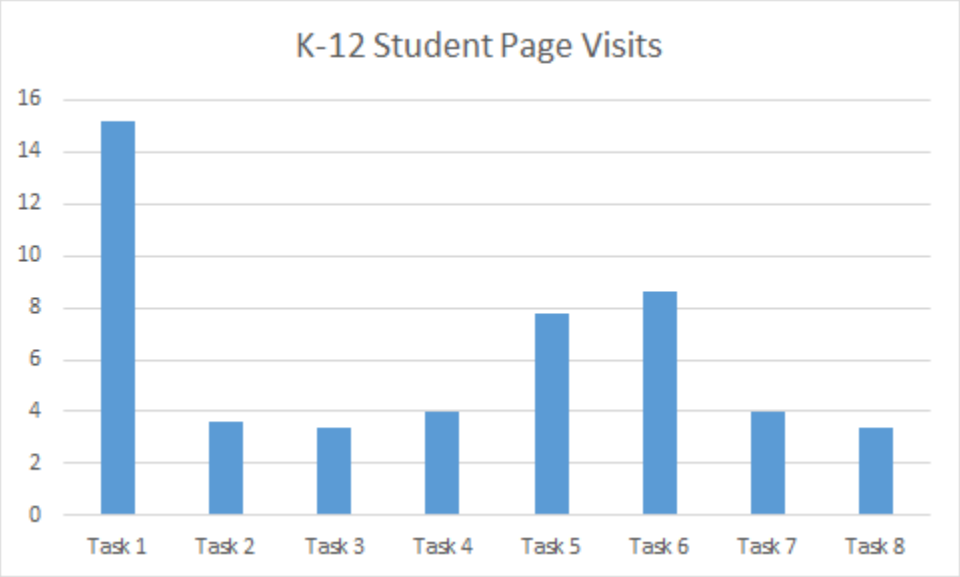

FIGURE 15: NUMBER OF PAGE VISITS PER TASK OF K-12 STUDENT UX TEST

Figure 15 shows the average number of page visits taken by volunteers for each task of the K-12 Student persona. From this graph, it can be seen that testers visited the most pages during Task 1 at 15.2 pages and the least amount of pages during Task 2 at 3.6 pages. These page visits stand out compared to the other tasks of the K-12 Student test, as it is the most dramatic change of visits on the same website. This can indicate volunteers were able to find the information to complete Task 2 much easier than in Task 1, or can also be attributed to a confusing test question. A third cause of this change could also be that volunteers found the answer to Task 2 before completing Task 1, and therefore knew where to look after completing Task 1.

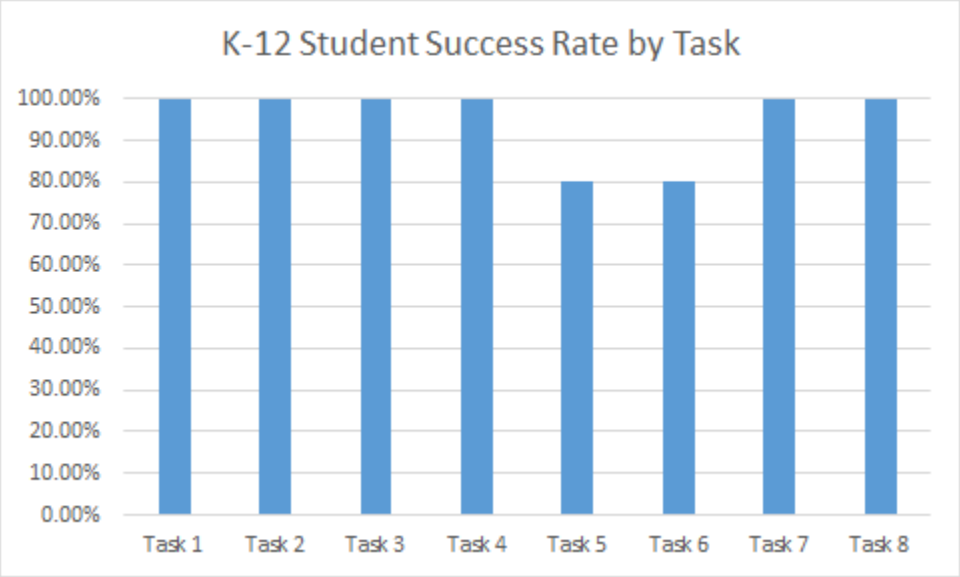

FIGURE 16: SUCCESS RATE PER TASK OF K-12 STUDENT UX TEST

In Figure 16, the graph shows the overall success rates of volunteers for each task of the K-12 Student UX test. As shown in the graph, all volunteers were able to successfully find the correct information on every task except Task 5 and Task 6. Task 5 and Task 6 were both completed on website 3, mwmw.gsfc.nasa.gov, which could indicate the website is hard to navigate or the information is hard to navigate. It could also indicate that the UX test questions were confusing to the tester, and was not able to answer the question.

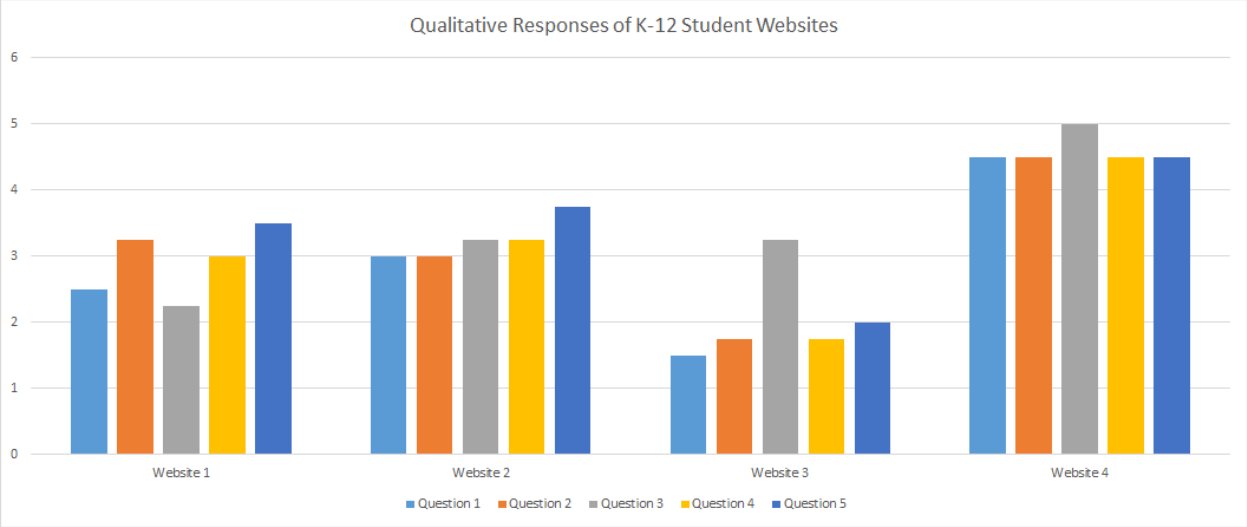

FIGURE 17: QUALITATIVE RESPONSES PER WEBSITE OF K-12 STUDENT UX TEST

In Figure 17, the subjective scores gathered from each volunteer on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

As seen in Figure 17, website 1, cosmictimes.gsfc.nasa.gov, received an average qualitative score over all questions by testers, with a neutral average answer. These results show that testers did not feel strongly about the website in a negative or positive way. The lowest score this site received involved the design of the site, which was rated just above disagree on the 1-5 scale designed in the question.

As seen in Figure 17, website 2, globalastro.gsfc.nasa.gov, received an average qualitative score over all questions by testers, with a neutral average answer. These results show that testers did not feel strongly about the website in a negative or positive way. The highest score this site received involved whether the tester would recommend this site to a friend, which received just below the rating for agreement on the 1-5 scale designed in the question.

As seen in Figure 17, website 3, mwmw.gsfc.nasa.gov, received the lowest overall qualitative score over all questions except for question 3, with an average answer of disagree. This means that the testers felt that they could not find information and navigate the website easily and would not return to the website or recommend it to a colleague, while participants were neutral about the design of the website.

As seen in Figure 17, website 4, spaceplace.nasa.gov, received the highest overall qualitative score over all questions, with an average response between agree and strongly agree. This means that testers felt they were able to find information and navigate the website and would return to the website and recommend others to it. Testers also strongly agreed with the design of the website.

Our K-12 Student UX tests were meant to test whether or not NASA websites intended to serve K-12 Students were doing so effectively. Of the four websites tested, one showed that it was effectively serving K-12 Students, two showed that it was mediocre at serving K-12 Students, and one showed that it was not effectively serving K-12 Students. Whether or not these results show an effective webspace for the K-12 Students is subjective to anyone in charge of NASA's websites.

K-12 Teacher - Teacher Tom

We conducted 5 UX tests for the K-12 Teacher persona with 5 volunteers. For each UX test, the volunteers were required to visit four different websites to perform two different tasks, resulting in eight total tasks for the entire UX test. Tasks in the K-12 Teacher UX test had

users search for the location of information on various topics relating to teachers and educational materials (Appendix D). From the responses to these 8 tasks, we gathered the average completion time, page visits, and success rates for each task in the test. We also recorded the average for answers to the five qualitative questions for each website.

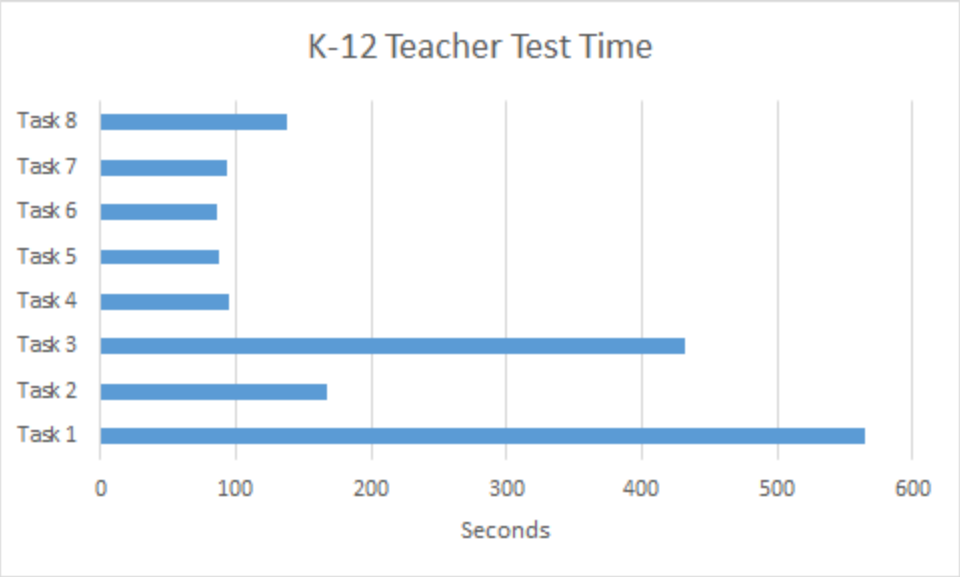

FIGURE 18: TEST TIME PER TASK OF K-12 TEACHER UX TEST

Figure 18 shows the average time to complete each task in the K-12 Teacher UX test. From this graph, we see that testers completed each task in a similar amount of time with about 30 seconds of deviation, except for Task 1 which took 564 seconds and Task 3 which took 289 seconds. Across five tests administered for the K-12 Teacher persona, the average time to complete Task 1 was more than five times the average of Tasks 4 - 8 with a minimum completion time of 102 seconds and a maximum completion time of 1492 seconds. The average time to complete Task 3 was more than four times the average of Tasks 4 - 8 with a minimum completion time of 60 seconds and a maximum completion time of 848 seconds. However, it is important to note that the tester who finished Task 3 in 60 seconds found a 404 page not found error on the webpage where he expected to find the answer causing him to move on to Task 4. The next shortest time to complete Task 3 was 345 seconds. These points of interest in Figure 18 show that testers had to spend a much larger amount of time on websites 1 and 2 to find the answer to their Tasks.

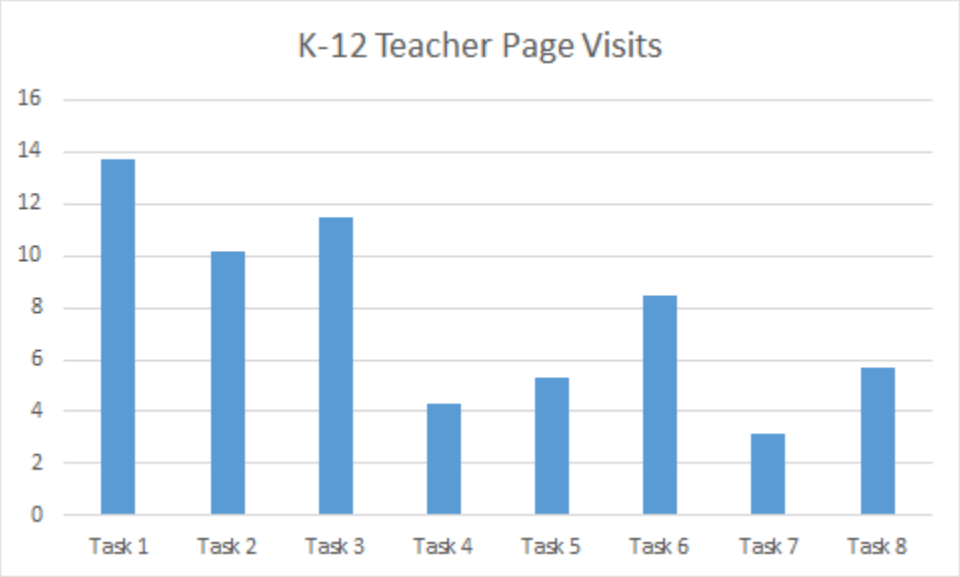

FIGURE 19: NUMBER OF PAGE VISITS PER TASK OF K-12 TEACHER UX TEST

Figure 19 shows the average number of page visits taken by testers for each task. For Tasks 4, 5, 7, and 8, testers found an answer to the tasks either within one or two pages of the most efficient path to that task's correct answer. Testers were able to find an answer for Task 6 within an average of eight page visits which is double the most efficient path of four page visits. Considering our testers were new users for each of these tested websites and had no prior knowledge of how to navigate them, visiting within the range of double the most efficient path is reasonable. Problems with completing tasks can be seen in Tasks 1, 2, and 3 where testers took 4 or more times as many page visits as the most efficient path to find an answer to the given task. The most efficient path for Task 1 was 3 pages visits, for Task 2 it was one page visit, and for Task 3 it was 2 page visits. Since Task 1 and 2 are answered using website 1, mars.nasa.gov, there was an issue with testers having to find information on the website. The difference in page visits between Task 3 and 4 show that either the answer for Task 3 was difficult to find on the website or Task 4 was very easy to answer. Since Task 3 only required two page visits to find the correct answer, there was clearly an issue with the navigation of website 3, solarsystem.nasa.gov.

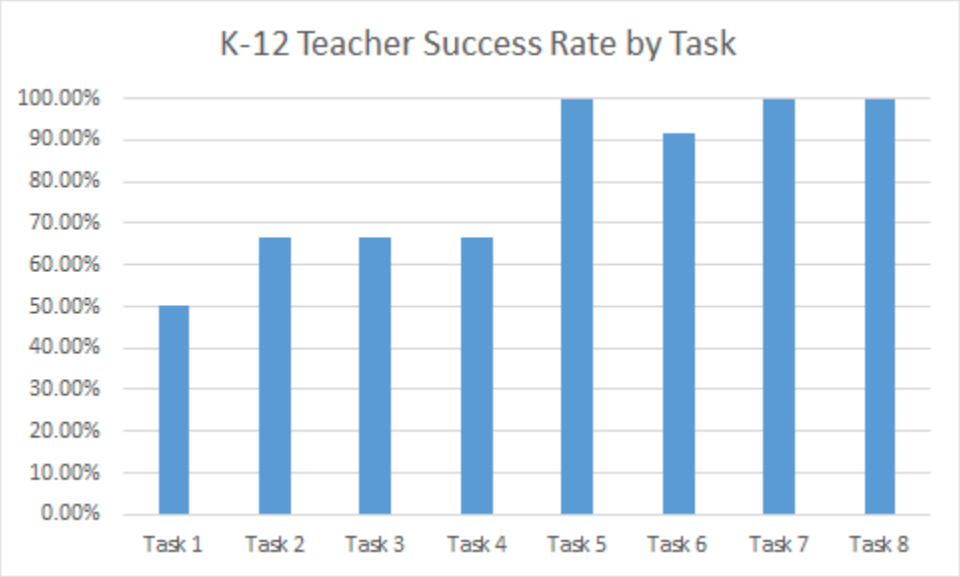

FIGURE 20: SUCCESS RATE PER TASK OF K-12 TEACHER UX TEST

Figure 20 shows the average success rate of each task, which was calculated by comparing the answers given by the testers to the correct answers determined when the UX tests were designed. From this graph we see that Tasks 1 - 4 had a success rate of less than 70% while Tasks 5 - 8 had a success rate of higher than 90%. Testers for website 4, spaceplace.nasa.gov, produced perfect success rates for Task 7 and 8 showing that website 4 either clearly displayed information, had a strong navigation system or the tasks were easy to complete compared to other tasks. Testers for website 3, jwst.nasa.gov, had a near perfect success rate except for one tester who received partial credit for one answer. These results imply that the two websites were effectively portraying information for users. For the other tasks, three out of five testers for Tasks 2, 3 and 4 gave correct answers while the other two gave incorrect answers or could not find an answer. For Task 1, two testers gave a correct answer and three gave an incorrect answer or could not find an answer. These results show that websites 1 and 2 must have had an issue with their display of information on webpages or navigation which resulted in testers not being able to find the information they required.

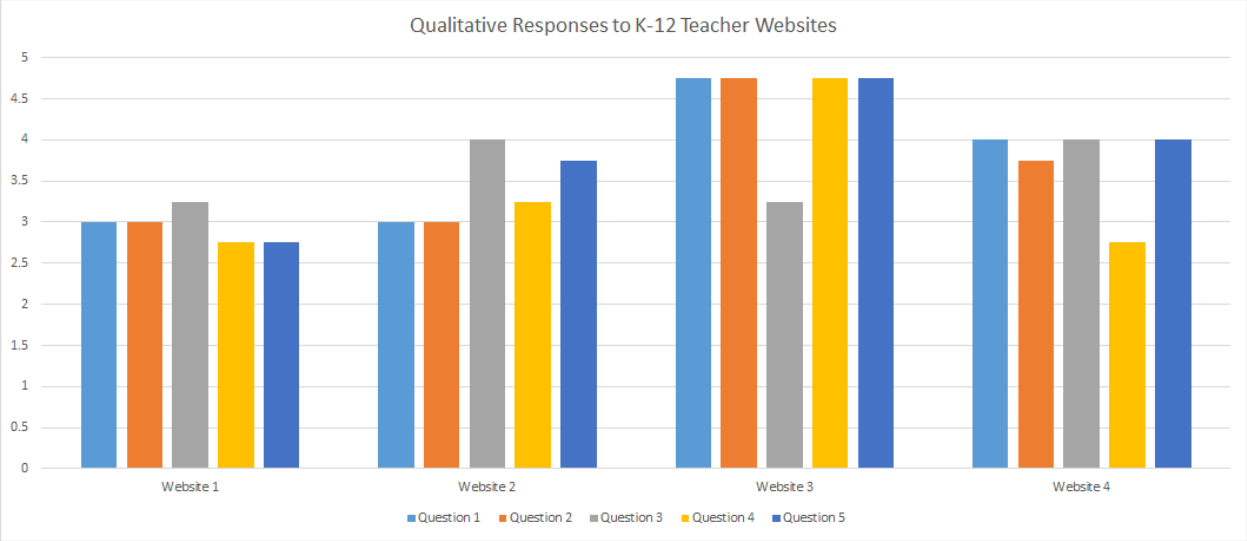

FIGURE 21: QUALITATIVE RESPONSES TO K-12 TEACHER WEBSITES

In Figure 21, the subjective scores gathered from each volunteer on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

As seen in Figure 21, website 1 and 2 received the lowest qualitative scores from testers with an average answer of neutral for each qualitative question. Website 1, mars.nasa.gov, maintained a consistent average score of neutral when testers were asked about its visual design, navigation, and their intentions for using it in the future. Testers were also neutral about the navigation and future use of website 2, solarsystem.nasa.gov, except that they answered agree when asked if they enjoyed the visual design of the webpages in the website and if they would recommend the website to their colleagues.

For website 3, jwst.nasa.gov, testers responded positively when asked about their opinions of the website, giving an average answer of strongly agree. The only exception was when they answered neutral when they were asked if they enjoyed the visual design of the webpages in the website. Compared to the responses for the other websites, website 3 left a very good impression on the testers which could lead to future use and an increase in the website's user base.

For website 4, spaceplace.nasa.gov, testers responded positively by answering on average with agree to qualitative questions about their subjective opinion of the website. The only variation in the testers' answers was that they responded with neutral when they were asked if they would use the website in the future. Considering this website was meant to serve

K-12 Teachers who primarily visit NASA websites for teaching materials, a neutral answer would imply that a user found the teaching materials on the website to be inadequate for their needs.

With our quantitative and qualitative data on our testers' performances analyzed, we can analyze how these pieces of data interact with each other and reveal the total usability of the four NASA websites tested by the K-12 Teacher UX test. The poor quantitative and qualitative results of websites 1 and 2 imply that they were not effectively serving their target audience of K-12 Teachers. The strong performance of testers when using websites 3 and 4 and the websites' positive qualitative scores imply that these websites were effectively serving their target audience of K-12 Teachers. Therefore, half of the website targeting K-12 Teachers within our testing sample are effectively serving their target audience and half are not serving them well. Conclusions on how well our sample size represents NASA webspace as a whole is dependent on NASA's subjective view of our results.

Researcher - Researcher Rob

We conducted 5 UX tests for the Researcher persona with 5 volunteers. For each UX test, the volunteers were required to visit four different websites to perform two different tasks. Originally, there were eight tasks in the test; however, the path to find the information on Task 1 changed between the design of the UX tests and the execution of the tests, so the task was not counted in the results, resulting in seven total UX tasks for each test. Similarly, a second change implemented during the testing period significantly affected the ability of volunteer D1 to complete Task 2, so their data was not included for that task. Tasks in the Researcher UX test had users search for the location of information on various topics relating to data from scientific missions and satellites (Appendix D). From the responses to these 8 tasks, we gathered the average completion time, page visits, and success rates for each task in the test. We also recorded the average for answers to the five qualitative questions for each website.

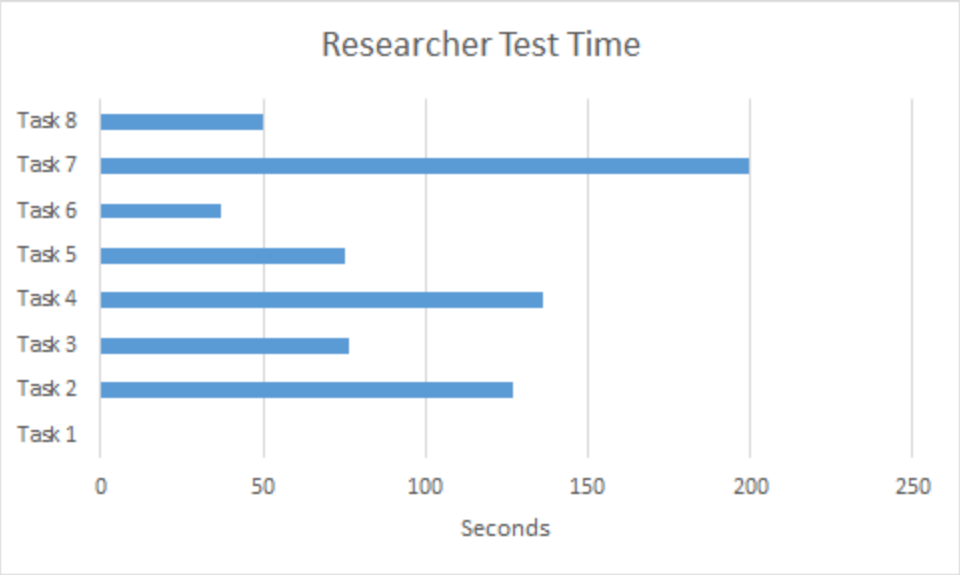

FIGURE 22: TEST TIME PER TASK OF RESEARCHER UX TEST

Figure 22 shows the average time to complete each task in the Researcher UX test. By splitting the tasks up into their respective websites, the graph shows which websites took the longest to find information on. For the first website, earthdata.nasa.gov, Task 2 took an average of 127 seconds to complete. This can indicate a website that is difficult to navigate, information that is hard to locate, or UX test questions that are confusing.

On the second website, nasirf.wff.nasa.gov, Task 3 and Task 4 took 77 seconds and 136 seconds, respectively. This shows that the second task on the website took longer than the first task on the website. This can indicate that users can find the navigation setup of the page difficult to understand the more time that is spent on the site. This also may indicate that the information for Task 3 was easier to find that the information for Task 4. This can also indicate that wording of Task 4 was more confusing that the wording of Task 3.

On the third website, www-mipl.jpl.nasa.gov/mipex.html, Task 5 and Task 6 took 75 seconds and 35 seconds, respectively. This can indicate that users begin to understand the navigation setup of the page the more time that is spent on the site. This can also indicate that the information for Task 6 was easier to find than the information for Task 5. This can also indicate that the wording of Task 5 was more confusing than the wording of Task 6.

On the fourth website, atrain.gsfc.nasa.gov, Task 7 and Task 8 took 200 seconds and 50 seconds, respectively. This can indicate that users begin to understand the navigation setup of the page the more time that is spent on the site. This can also indicate that the information for Task 8 was easier to find than the information for Task 7. This can also indicate that the wording of Task 7 was more confusing that the wording of Task 8.

FIGURE 23: NUMBER OF PAGE VISITS PER TASK OF RESEARCHER UX TEST

Figure 23 shows the average number of page visits taken by volunteers for each task. By splitting the tasks up into their respective websites, the graph shows which website took the most amount of page visits to complete a task. For the first website, earthdata.nasa.gov, Task 2 took an average of 4.67 pages to complete. As the most efficient path to find this information is 3 pages, this shows that testers, without any prior knowledge of the site, were able to find information with an average of only 1.67 pages over the most efficient path. This can indicate that the navigation of the site serves researchers well. This can also indicate that the wording of the task question was clear and concise.

On the second website, nasirf.wff.nasa.gov, Task 3 and Task 4 took an average of 4.5 pages and 9 pages to complete the tasks, respectively. This can indicate that spending more time on the website does not improve a user's understanding of the navigation of the website. This can also indicate that the information to complete Task 4 was harder to find than the information to complete Task 3. This can also indicate that the wording of Task 4 was more confusing that the wording of Task 3 during the UX test.

On the third website, www-mipl.jpl.nasa.gov/mipex.html, Task 5 and Task 6 took an average of 4 pages and 3.75 pages to complete the tasks, respectively. This can indicate that users became more comfortable with the navigation of the site as time went on, and can also indicate that the information to complete Task 6 was easier to find than the information to complete Task 5. This can also indicate that the wording of Task 5 was more confusing than the wording of Task 6.

On the fourth website, atrain.gsfc.nasa.gov, Task 7 and Task 8 took an average of 5.5 pages and 4 pages to complete the tasks, respectively. This can indicate that users became more comfortable with the navigation of the site as time went on, and can also indicate that the information to complete Task 8 was easier to find than the information to complete Task 7. This can also indicate that the wording of Task 7 was more confusing than the wording of Task 8.

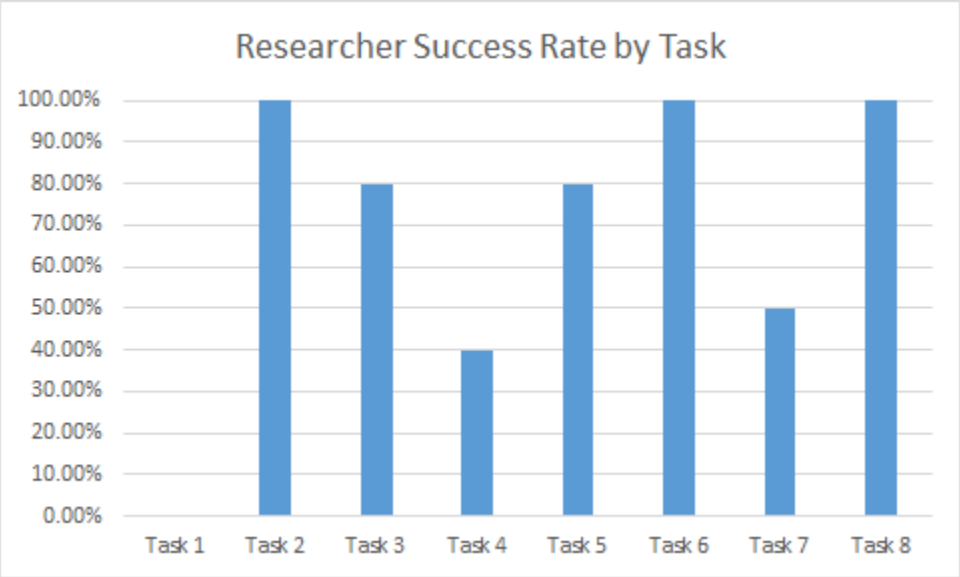

FIGURE 24: SUCCESS RATE PER TASK OF RESEARCHER UX TEST

Figure 24 shows the average success rate of each task, which was calculated by comparing the answers given by the testers to the correct answers determined when the UX tests were designed. On website one, earthdata.nasa.gov, Task 2 was completed with a 100% accuracy by participants. This indicates that the navigation of the site and that the information was easy to find. This can also indicate that the task question was clear and concise.

On the second website, nasirf.wff.nasa.gov, Task 3 and Task 4 were completed with an 80% and 40% completion rate, respectively. This can indicate that staying on a site longer did not improve a testers understanding of the navigation of the site. This can also indicate that the information was hard to find on the website. This can also indicate that the task questions confused the tester, resulting in an incorrect answer.

On the third website, www-mipl.jpl.nasa.gov/mipex.html, Task 5 and Task 6 were completed with an 80% and 100% completion rate, respectively. This can indicate that the tester's understanding of the navigation on the site improved with the amount of time they spent on the site. This can also indicate that the information to answer Task 6 was easier to find

than the information to answer Task 5. This can also indicate that the wording of Task 5 was more confusing to the tester than the wording of Task 6, resulting in an incorrect answer.

On the fourth website, atrain.gsfc.nasa.gov, Task 7 and Task 8 were completed with a 50% and 100% completion rate, respectively. This can indicate that staying on the site longer helped improve tester's ability to navigate the site. This can also indicate that it was easier to find the information to solve Task 8 than to find the information to solve Task 7.

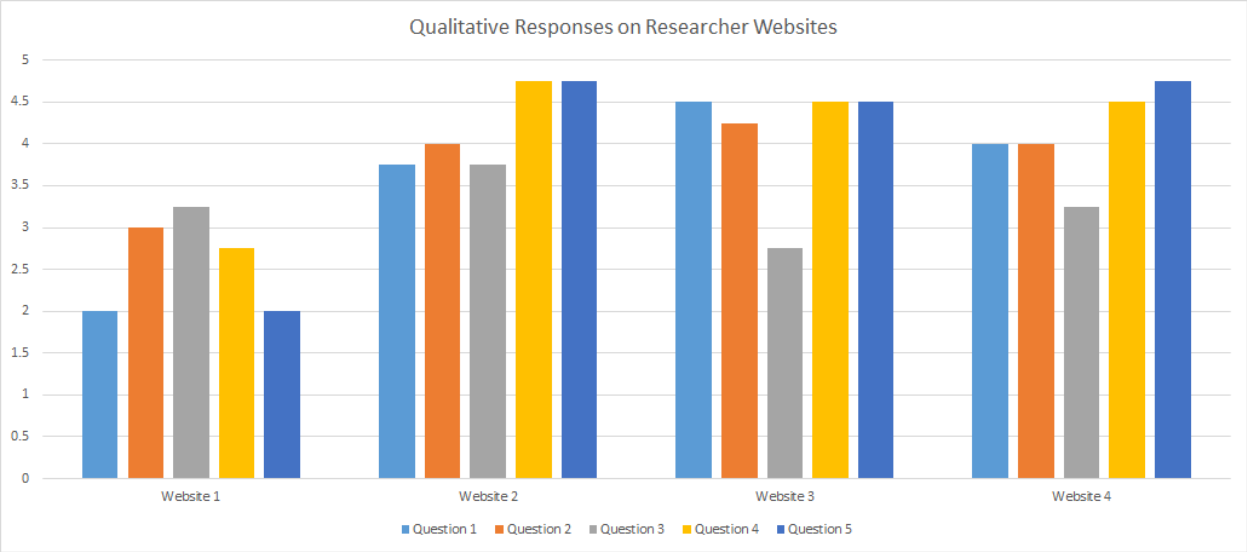

FIGURE 25: QUALITATIVE RESPONSES ON RESEARCHER WEBSITES

In Figure 25, the subjective scores gathered from each volunteer on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

The first website, earthdata.nasa.gov, received the lowest score from testers when asked how easy it was for them to find the data they needed, with testers saying they disagreed with the first question. Testers also said they would not recommend this site to someone else if they were looking for the same information. It is also worth to note that this website had a broken task that was not included in the quantitative results, due to a change in path after the test was designed. This website also received neutral responses for the other qualitative questions asked about the site.

The second website, nasirf.wff.nasa.gov, received a very high qualitative score by users, with the lowest score being users agreeing with the design of the website. This shows that testers enjoyed using the website, and would return to the website for more information, as well as refer the website to others looking for similar information.

The third website, www-mipl.jpl.nasa.gov/mipex.html, received high scores from users on all questions other than about the design of the website. Users reported that they felt neutral about the design of the site, but would still return to the site, and recommend it to others, to find the required information.

The fourth website, atrain.gsfc.nasa.gov, received high scores from users on all questions. The lowest score on this website referred to the design of the website, where users felt neutral about the site design. Users were still able to find the information easily and would return to the site and recommend it to others for more information.

With our quantitative and qualitative data on our testers' performances analyzed, we can analyze how these pieces of data interact with each other and reveal the total usability of the four NASA websites tested by the Researcher UX test. Of the four websites tested, three showed that they were effectively serving Researchers, and one showed it was not effectively serving Researchers, which could be due to a poorly constructed task. Whether or not these results show an effective webspace for Researchers is subjective to anyone in charge of NASA's websites.

Aerospace Industry - Aero Alexis

We conducted 5 UX tests for the Aerospace Industry persona with 5 volunteers. Due to a corrupted capture, we could only record times and page visits for 4 UX Tests. For each UX test, the volunteers were required to visit six different websites to perform one to two different tasks, resulting in eight total tasks for the entire UX test. Tasks in the Aerospace Industry UX test had users search for the location of information on various topics relating to aerospace regulations and programs (Appendix D). From the responses to these 8 tasks, we gathered the average completion time, number of page visits, and success rates for each task in the test. We also recorded the averages of the answers to the five qualitative questions for each website.

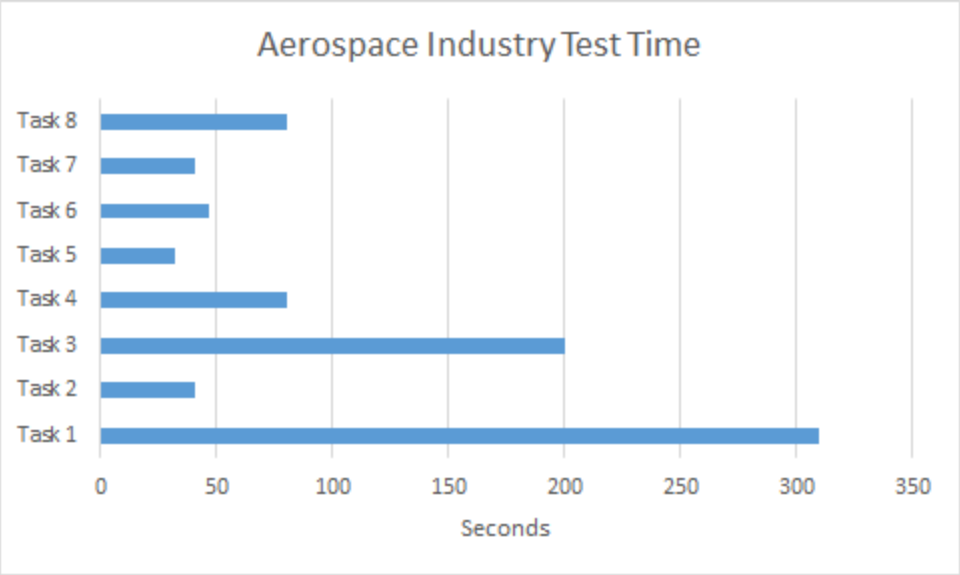

FIGURE 26: AVERAGE TEST TIME PER TASK OF AEROSPACE INDUSTRY UX TEST

Figure 26 shows the average time to complete each task in the Aerospace Industry UX test. From this graph, it can be seen that testers took the longest time on average to complete Task 1 and Task 3, at 309.75 seconds and 200 seconds respectively. These test times stand out as outliers compared to the average test times of the other tasks for the Aerospace Industry test, which are all under 100 seconds. Task 1's test time in particular is notable, as it differs largely from the average time for the other task on the same website. This outlier likely came from the volunteers not specifically being told that the task's solution was a paper, causing them to look through the other sections of trajectory.gsc.nasa.gov first and then have to search through all the papers listed on the site till they found the proper one, whereas Task 2 had a clearer solution. Task 3's status as an outlier most likely stemmed from volunteers not knowing that Federal Acquisition Regulations would be related to procurement, which led to them to not looking at the Procurement References page on rtaps.grc.nasa.gov at first, while an actual member of the aerospace industry may have known better.

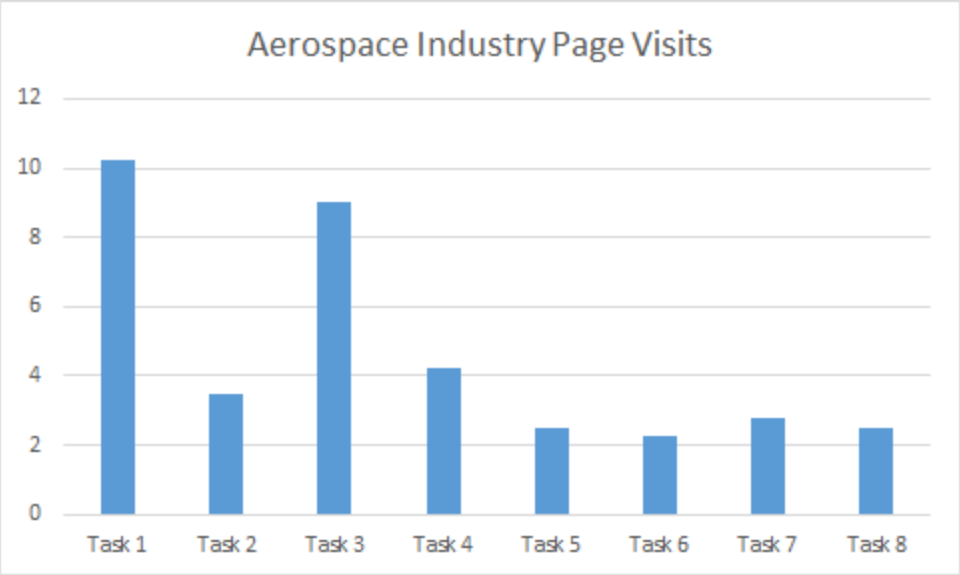

FIGURE 27: PAGE VISITS PER TASK OF AEROSPACE INDUSTRY UX TEST

Figure 27 shows the average number of page visits taken by volunteers for each task of the Aerospace Industry persona. From this graph, it can be seen that testers visited the most pages during Task 1 and Task 3 at 10.25 pages and 9 pages on average respectively despite both having a most efficient path of 2 pages. Both stand out compared to the other tasks of the Aerospace Industry test, given that none of the other tasks took more than Task 4's 4.25 on average, and Task 2 was less than that at 3.5 pages on average despite being the same site as Task 1. It is likely that Task 1's increased number of page visits stems from clicking through multiple papers on trajectory.gsc.nasa.gov before finding the correct one, as there were numerous other papers with topics relating to electric propulsion or solar power. Task 3's increased number of page visits most likely is tied to the lack of knowledge about terms mentioned previously, as it increased the amount of browsing through unrelated sections.

In comparison, all the other task's average number of page visits were very close to the most efficient path, with the greatest deviation from it being Task 4's difference of only 1.25 pages. These results can be interpreted to mean that the relevant websites were effectively structured for users to find the information we asked them for. Alternatively, given that Task 2 and Task 4 had a most efficient path of 3 pages and the other four tasks had a most efficient path of 2 pages, it may be that the tasks designed for this persona did not consistently require the testers to go deep enough into these websites to reveal potential issues with navigation.

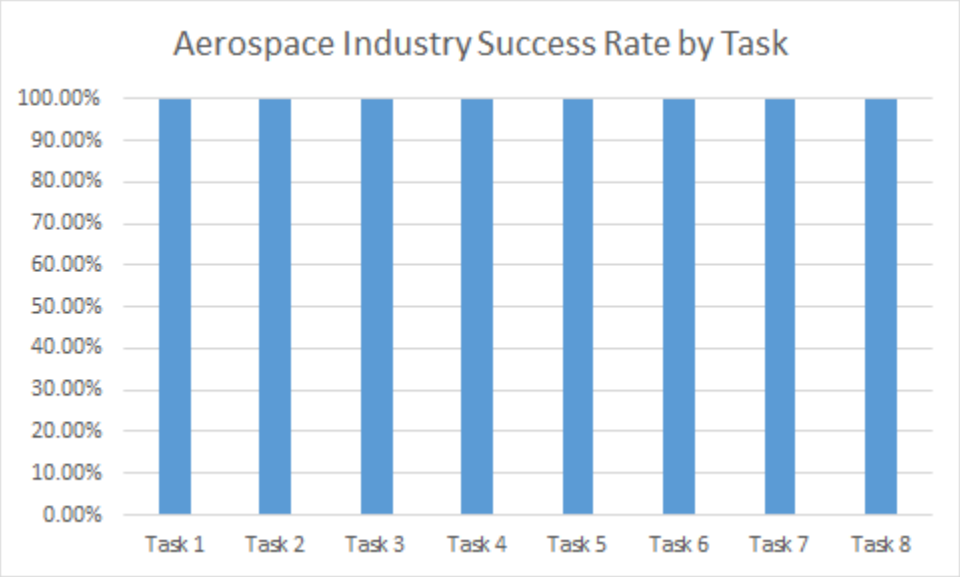

FIGURE 28: SUCCESS RATE PER TASK OF AEROSPACE INDUSTRY UX TEST

Figure 28, shows the average success rates for each task of the Aerospace Industry UX test. As shown in the graph, all volunteers were able to successfully find the correct information on every task. This shows that despite the lengths of time it took for some volunteers to find the information for some tasks, they eventually did find the correct information. Given the probable sources of confusion on Task 1, this indicates that despite the increased amount of browsing, the wording on both the task and the website was clear enough that the testers reached a reasonable answer. Additionally, due to six websites being required for this test due to how small some of them were, this likely affected the difficulty of the questions. For example, both Task 7 and 8 were very easy for volunteers to answer, given that their solutions were only a single page away from jsc-aircraft-ops.jsc.nasa.gov and turbmodels.larc.nasa.gov respectively. Both websites are almost entirely text with no complicated site navigation and had very obvious routes to the solutions, meaning that those tasks were possibly too easy. However, the fact that we had to choose more websites due to their simplicity also indicates that websites with this target audience may be simpler in general, and therefore this lower difficulty was a proper representation of using similar websites.

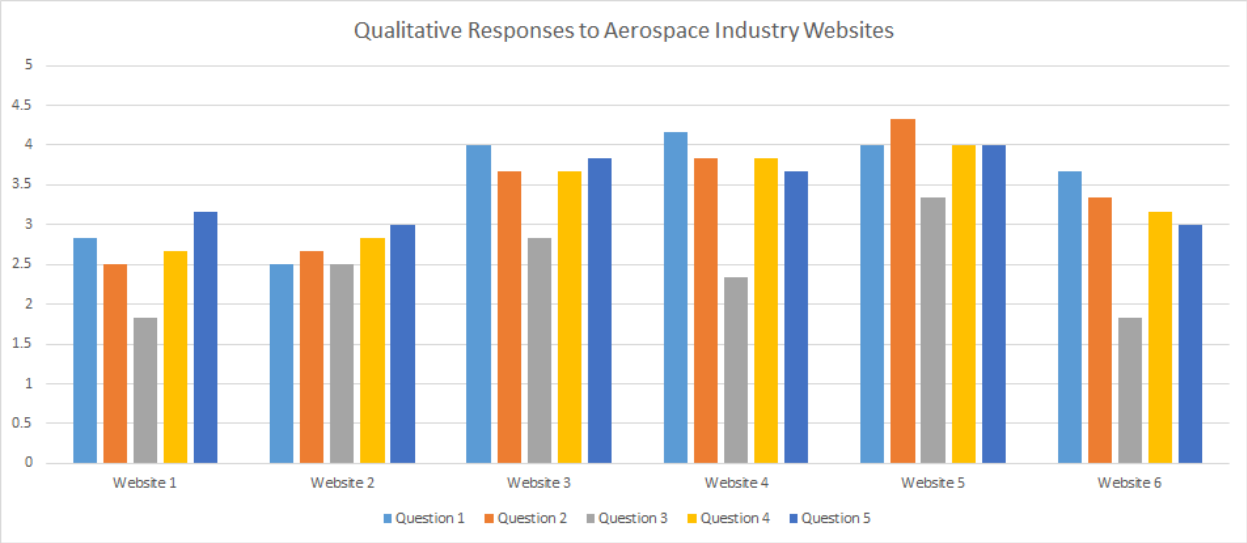

FIGURE 29: QUALITATIVE RESPONSES TO AEROSPACE INDUSTRY WEBSITES

In Figure 29, the subjective scores gathered from each volunteer on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

As seen in Figure 29, website 1, trajectory.grc.nasa.gov, had neutral to slightly below neutral scores across the board. This indicated that though the testers did not find the website easy to navigate or to find information on, they generally did not feel negatively towards those aspects of the website either. The testers did feel negatively towards the visual design, tying this website with website 6 for the most negative average answer for that question.

For website 2, rtaps.grc.nasa.gov, the average responses of testers were all between neutral and disagreement. Though this meant that though testers did not have particularly strong reactions to the website, the overall feeling was still negative. This is not surprising, as the relatively large amount of time spent on Task 3 on average would reasonably cause some frustration for users.

For website 3, dst.jpl.nasa.gov, testers responded positively on all accounts except visual design. This positivity was not particularly strong, but it does indicate that they found the site easier to navigate than the previous two. This is likely tied to Task 4 and Task 5's solutions being easier to navigate to through the website's clearly labeled navigation menus. The more negative average score for visual design indicates that though it did not stand in the way of navigating to answers, it was still somewhat disliked.

For website 4, insidedlab.jpl.nasa.gov, testers similarly responded positively on all aspects except visual design, which received an even more negative response on average. It is not surprising that it was highly received as Task 6 was very straight forward with an easily recognizable route to the answer, and additionally focused on information that was unlikely to be hosted elsewhere as Dspace is a tool created by JPL itself.

For website 5, jsc-aircraft-ops.jsc.nasa.gov, testers responded positively, with almost every question getting a response indicating agreement on average. The only exception remained visual design, and in this case it still received an above neutral response. This indicated that testers felt very comfortable navigating the site, which is not surprising as the page containing the information they needed was clearly accessible from the front page.

For website 6, turbmodels.larc.nasa.gov, testers responded with neutral scores with the exception of the visual design rating. This neutrality was likely due to the information that the testers had to find on the website about the 40% Challenge being seemingly mostly unrelated to the topic of the website and the data stored on it. This meant testers did not have to actively engage with most of the website when scrolling to find the page relating to the 40% Challenge, and so likely did not form strong opinions on its layout. This site was tied for the lowest visual design score, and had several large unexplained lists and charts on the page. As no context was given for these elements, the testers who did not actually have the full background information that a member of the aerospace industry would know could not actually determine if the lists or charts were actually well designed, and so likely thought negatively of them due to their confusion instead.

There were three sites - dst.jpl.nasa.gov, insidedlab.jpl.nasa.gov, and turbmodels.larc.nasa.gov - that were determined to decently serve their target audience. There was one site - turbmodels.larc.nasa.gov - that was determined to effectively serve its target audience mediocre in serving its target audience. Finally, there were also two sites - trajectory.grc.nasa.gov and rtaps.grc.nasa.gov - that were determined to not effectively serve their target audience.

With our quantitative and qualitative data on our testers' performances analyzed, we can examine how these pieces of data interact with each other and reveal the usability of the six NASA websites tested by the Aerospace Industry UX test.

The short test times, low page visits, high success rates, and acceptable qualitative scores of websites 3, 4, and 6 show that testers had a decent experience during their visit to these websites. Based on these results, we can infer these websites reasonably serve the Aerospace Industry. The visual design rating does indicate that users desire the site to be more visually appealing, which could push the experience towards being more enjoyable.

The short test times, low page visits, high success rates, and good qualitative scores of website 5 shows that testers had a good experience during their visit to this website. Based on these results, we can infer that website 5 effectively serves the Aerospace Industry. This could still be enhanced by making the site more visually appealing, but the testers clearly did not have issues with using the site despite that deficiency.

The long test times, high page visits, and below neutral qualitative scores of websites 1 and 2 show that testers had a neutral experience or worse during their visit to these websites. Based on these results, we can infer that these websites do not serve the Aerospace Industry well. Similarly to the other sites, they could stand to improve their visual appeal specifically, but they also would have to improve their navigation.

NASA Employee - NASA Nate

We conducted 5 UX tests for the NASA Employee persona with 5 volunteers, but could only record results for 4 UX tests. For each UX test, the volunteers were required to visit four different websites to perform two different tasks, resulting in eight total tasks for the entire UX test. Tasks in the NASA Employee UX test had users search for the location of information on various topics relating to NASA programs and benefits (Appendix D). From the responses to these 8 tasks, we gathered the average completion time, number of page visits, and success rates for each task in the test. We also recorded the averages of the answers to the five qualitative questions for each website.

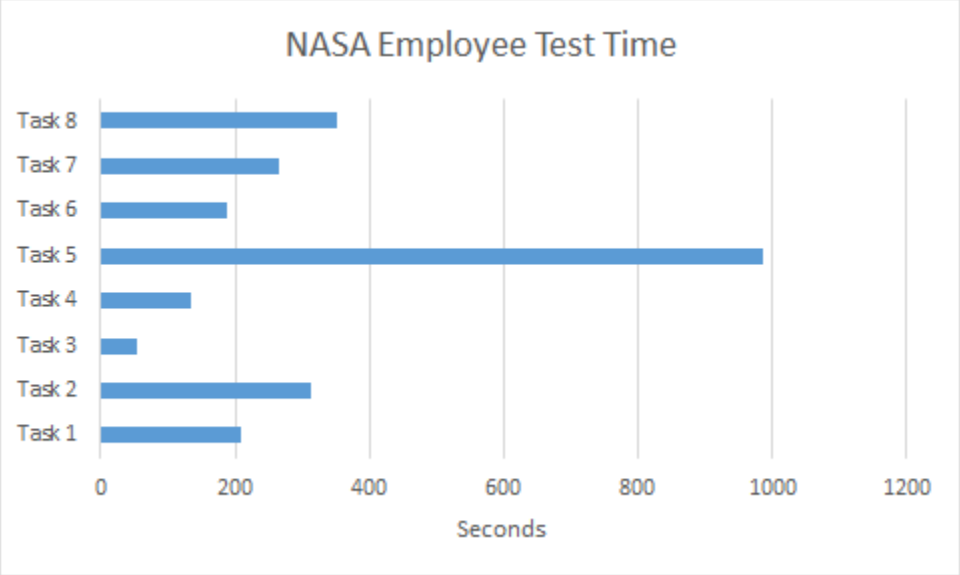

FIGURE 30: TEST TIME PER TASK OF NASA EMPLOYEE UX TEST

Figure 30 shows the average time to complete each task in the NASA Employee UX test. From the graph, we see that the time required by testers to give an answer for a task varied

between each task. The largest difference is noticeable for task 5, but there is no solid average with which we can compare this outlier. Instead, if we compare task completion times by website we can recognize closer times. The time difference between tasks for website 1 was only 30 seconds, for website 2 it was 80 seconds, for website 3 it was 800 seconds, and for website 4 it was 90 seconds. The resulting task times for websites 1, 2, and 4 are comparatively reasonable between tasks, but the difference for website 3 is extreme. The shortest completion time for Task 5 was 540 seconds which is still a long amount of time to complete a task that requires only 4 page visits to find the answer. Clearly there was an issue with testers finding information on website 3, ammos.jpl.nasa.gov. The average time for completing other tasks on websites 1 and 4 were also high compared to other UX tests with average times of 250 seconds and 300 seconds respectively. Such high task completion times could be a result of a website with navigation systems that change between webpages or poor layouts for displaying large amounts of information on each webpage.

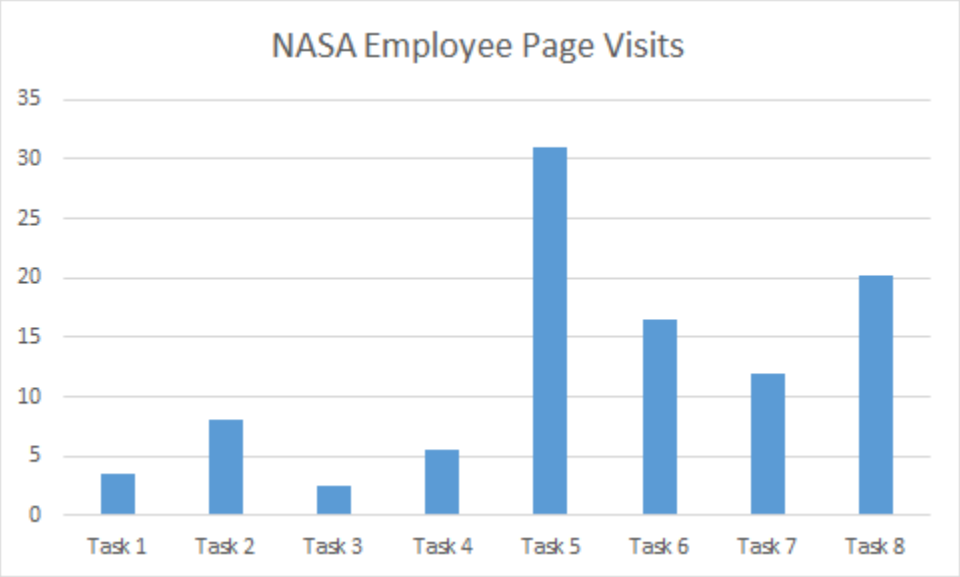

FIGURE 31: PAGE VISITS PER TASK OF NASA EMPLOYEE UX TEST

Figure 31 shows the average number of page visits taken by testers for each task. From the graph, we see a drastic difference in the number of pages that testers visited while trying to complete tasks between websites 1 and 2 and websites 3 and 4. For websites 1 and 2, testers found an answer for their task in less than twice the number of pages for the most efficient path to the task's answer. For new users, completing a task in this amount of page visits is reasonable and shows good website architecture and navigation. For websites 2 and 3, testers had to visit more than 5 times as many webpages as the most efficient path to find an answer for their tasks. In the case of Task 5, testers visited on average 31 webpages to find an answer for the task when the most efficient path was only 4 page visits. When users have to scour an

entire website to find the information they need there is an obvious issue with the categorization of sections on the website and how they are portrayed in the website's navigation menus and links.

Looking more in depth at tasks 5 - 8, answers for these questions were at times on multiple webpages or found in sections with titles found on multiple navigation menus. The answer to Task 5 was found on fvncep.gsfc.nasa.gov by clicking on Mesoscale Atmospheric Processes on the top menu bar, then science on the left menu bar, and finally Aerosols and Clouds in a sub-menu that branches out of the left menu bar. This navigation system is unintuitive compared to other website's navigation systems because of the changing menus across different pages and the hidden elements within them.

The answer to Task 6 required a publication title that could be found not in the publications section of the website, but in the calendar section. The publications section doesn't organize publications by date, but the calendar organizes all publications and events by date. This system is unclear for users who have little knowledge of the website and requires extensive searching for small amounts of information.

The answer to Task 7 can be found on oce.jpl.nasa.gov which has more than three webpages defining the command structure of the Office of the Chief Engineer in completely different ways. No two organizational charts on this website state that the same person has the same job. Testers also had to visit multiple biography webpages to find the phone-numbers of the officials they were tasked with finding once they had located the correct organizational structure list.

The answer to Task 8 required testers to find a document outlining a specifically serialized preferred practice. The problem testers had with this task was the link to the document was in a submenu section called *NASA's Preferred Practices* that could only be found by visiting the menu section *Links*. The testers had to visit each section of the website before they were able to find this sub-section.

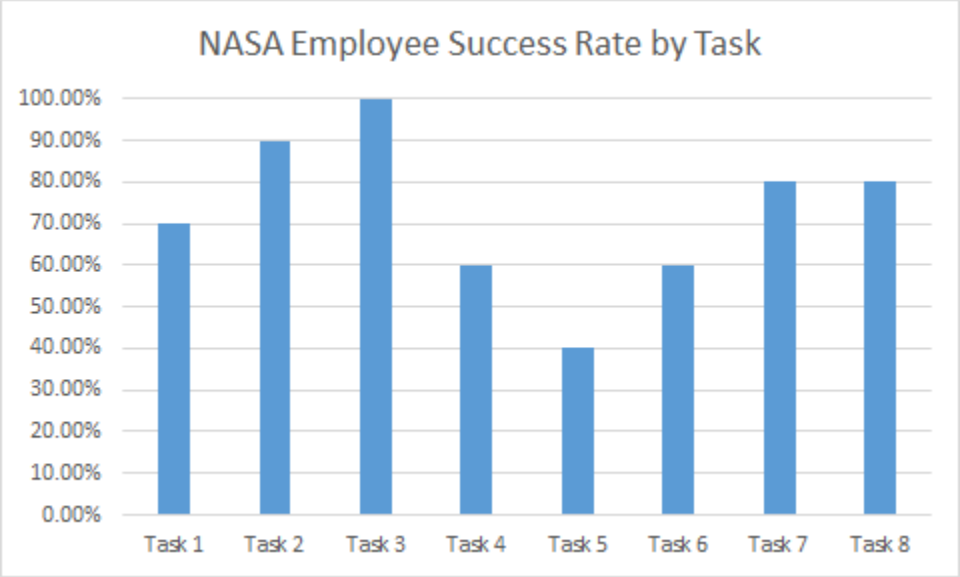

FIGURE 32: SUCCESS RATE PER TASK OF NASA EMPLOYEE UX TEST

Figure 32 shows the average success rate of each task, which was calculated by comparing the answers given by the testers to the correct answers determined when the UX tests were designed. The most apparent conclusion that can be drawn from this graph is that the testers for the NASA Employee UX test had a difficult time finding information they required from websites meant to serve NASA employees as their target audience. The only task that testers could consistently answer correctly was Task 3 for website 2, code250.gsfc.nasa.gov. Testers also maintained an 80% success rate or higher for Task 2 on website 1 and Tasks 7 and 8 for website 4. There was an issue with testers answering incorrectly half the time for tasks on website 3. This shows that website 3 either had misinformation displayed on its webpages or that testers could not find the information they needed and moved on to other tasks.

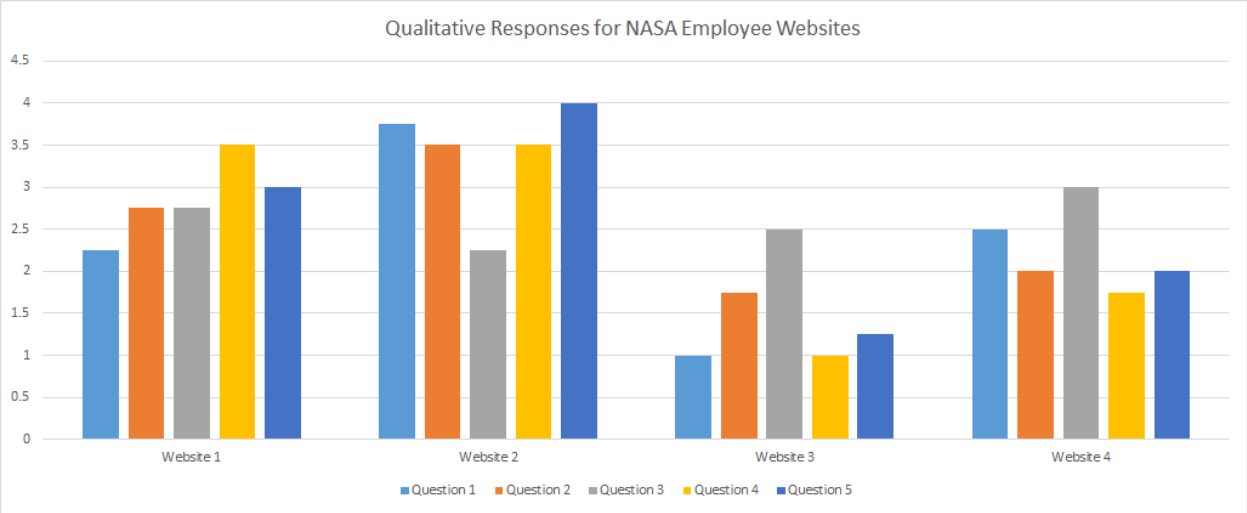

FIGURE 33: QUALITATIVE RESPONSES ON NASA EMPLOYEE WEBSITES

In Figure 33, the subjective scores gathered from each volunteer on each website are displayed side-by-side. The goal of these questions was to develop a subjective understanding of the design of each website with quantifiable results from which we could draw conclusions. Included in Table 4 are the full questions shown in this figure.

As seen in Figure 33, testers responded with an average answer of neutral with a skew towards disagree for qualitative questions about their opinions of website 1, ammos.jpl.nasa.gov. The testers disagreed when asked if they thought they could clearly find information and they slightly agreed when asked if they would use the website again. These results show that testers had a less than average experience with the website.

For website 2, code250.gsfc.nasa.gov, testers responded on average with neutral but skewed towards agree for qualitative questions. They agreed that they would recommend the website to a colleague, but disagreed when asked if they enjoyed the visual design of the website. The other questions they felt slightly positive about. Overall, the testers had a slightly positive experience with website 2 showing that they were served, but they had few lasting impressions.

For website 3, fvncep.gsfc.nasa.gov, testers responded negatively to questions about their opinion of the websites they tested by giving on a mixture of strongly disagree and disagree answers. They felt neutral about the visual design of the website and only slightly disagreed when asked if they could easily navigate the website. However, they had a strongly negative experience with finding information on the website and responded that they would not use the website in the future.

For website 4, oce.jpl.nasa.gov, testers responded negatively to questions about their opinion of the websites they tested by giving an average answer of disagree for qualitative questions. They felt neutral about the visual design of the website, but felt negatively to every other qualitative aspect of the website. This could be due to the duplicated information, uncompleted webpages, and hidden submenus within the main side menu.

With our quantitative and qualitative data on our testers' performances analyzed, we can analyze how these pieces of data interact with each other and reveal the total usability of the four NASA websites tested by the NASA Employee UX test. The overall poor test scores and qualitative answers for the websites on this test show that our testers had a poor user experience with websites in our sample of NASA websites intended to serve NASA employees. The only website to receive relatively decent results was website 2 which only had average results with qualitative answers skewed slightly positive. From the tests we performed on these websites, we found that these websites do not effectively serve NASA Employees.

Known Sources of Error

Sample Size

Due to the time frame of this project and the restrictions on who we could test, we were limited in how many UX tests we could conduct. Only five tests could be conducted per persona, with some personas having cases where a test's data could not be used as well, which resulted in the volatile values in the graphs of certain tasks. As a result of this small sample size, averages of certain data points can be affected drastically by outliers in the data. In order to combat this in future UX tests, a larger sample size can be used to lessen the impact an outlier has on the average of a certain data point.

Internet Connection

The UX tests were administered to other IQP teams in the hotel all teams were staying at, which did make testing more convenient than it would have been otherwise. However, the Internet connection supplied by the hotel was generally slow, and this affected the time of completion for many volunteers. In certain tests, the Internet would disconnect and would have to be reconnected to during the test, which could lead to higher completion times if the administrator did not carefully note this when determining task times. In the worst case, volunteer D1's General Public test, the disconnection prevented their answers from being submitted and included in our observations. The answers were later reconstructed manually from the video, but it was too late to account for them in the analysis. In order to combat this in future UX tests, the use of a faster and more reliable Internet connection is heavily advised.

Video Corruption

Every UX test conducted was recorded with either ActivePresenter or QuickTime Player depending on the administrator. Unfortunately, several of the ActivePresenter videos became

corrupted. This meant that the task times and number of page visits for volunteer A4's Researcher test and B2's NASA Employee and Aerospace Industry test could not be gathered. In order to combat this in future tests, all screen capturing should be performed by a single reliable piece of software that the administrators are experienced with using.

Human Error

With any experiment involving a person, either as the participant or administrator, human error must also be considered and minimized to ensure an effective experiment. A major point of human error in the UX tests was the design and execution of our team's UX questions. For example, task one of the Researcher persona was not considered in these results, due to a change in the website between design and execution of the tests, which resulted in longer completion times than expected due to the most efficient path changing. There were also cases where URL provided for a question was broken and had to be adjusted manually by the administrator so that the tester could start the task. Furthermore, we had not agreed upon strategies for dealing with these and other situations where users experienced unintended difficulty in completing their tasks, meaning that different administrators may have differed in how they approached the same problems. Finally, when collecting all the task times and page visits as well as grading solutions, administrators handled their own tests in order to reasonably split the work amongst ourselves in the time we had. This potentially resulted in slightly inaccurate measurements or inconsistencies in grading, as we did not have the time to thoroughly review each other's data for every test. In order to combat this in future tests, efforts to ensure a site remains static between design and execution is key, as is developing specific strategies for responding to testers' questions and making sure that administration remains consistent and includes a thorough review of the overall data.

Chapter 5: Discussion

Website Survey

With the completion of our team's website survey, our team collected information on approximately four percent of sites in NASA's webspace, including primary and secondary audiences, update frequency, and whether there were any quantitative or qualitative metrics being used on the website to help improve the design and navigability. As a result of this survey, our team found that only 22% of sites in the NASA domain use the NASA-run account of Google Analytics. This number severely impacts the representation of the overall webspace with the data that can be collected from Google Analytics, as there could be sites with plenty of traffic that is not recorded by the software. There is also a federal mandate that NASA websites connect into the NASA-run Google Analytics account which raises alarms when less than a quarter of the NASA's websites have followed this order.

While selecting websites to survey, our team also found plenty of websites no longer receiving maintenance. As many as 21% of URLs registered to NASA - which we can assume extrapolates to 650 of the 3092 total site list - are websites that are no longer active and receive no web traffic. These websites are important to note, as there is no need to maintain the URLs in the future if there is no intention of bringing the websites back online.

Persona Development

After determining the most common target audiences that NASA sites try to serve, our team developed personas to represent each of these target audiences. By developing our own personas of each target audience, our team was able to perform user experience tests using internal test subjects that would assume the role of a persona. In this project, our UX test subjects were the other IQP teams in Washington DC. For each test, a volunteer was randomly assigned a persona, and given tasks to complete, which provided a wide variety of results. The use of personas allowed our team to reach target audiences we could otherwise not be able to, whether due to ethical or legality reasons, to find what kinds of sites effectively serve their target audience, and which sites do not.

User Experience Testing

Through analysis of the results we acquired from user experience testing, we determined which of the tested websites were serving their reported target audience effectively. Our conclusions on the effectiveness of each tested website are shown in Table 5. These came to these conclusions by analyzing the connections between a website's tester performance and qualitative scoring.

TABLE 5: RESULTS ON THE EFFECTIVENESS OF TESTED WEBSITES

Persona	Website	Effectiveness
General Public	science.larc.nasa.gov	Ineffective
	www.giss.nasa.gov	Inconclusive
	eclipse.gsfc.nasa.gov	Effective
	saturn.jpl.nasa.gov	Effective
K-12 Student	cosmictimes.gsfc.nasa.gov	Inconclusive
	globalastro.gsfc.nasa.gov	Inconclusive
	mwmw.gsfc.nasa.gov	Ineffective
	spaceplace.nasa.gov	Effective
K-12 Teacher	mars.nasa.gov/	Ineffective
	olarsystem.nasa.gov/	Ineffective
	jwst.nasa.gov/	Effective
	spaceplace.nasa.gov/	Effective
Researcher	earthdata.nasa.gov/	Inconclusive
	nasirf.wff.nasa.gov/	Effective
	www-mipl.jpl.nasa.gov/mipex.html	Effective
	atrain.gsfc.nasa.gov	Effective
Aerospace Industry	trajectory.grc.nasa.gov/	Ineffective
	rtaps.grc.nasa.gov/	Ineffective
	dst.jpl.nasa.gov/	Acceptable
	insidedlab.jpl.nasa.gov/	Acceptable
	jsc-aircraft-ops.jsc.nasa.gov/	Effective
	turbmodels.larc.nasa.gov/	Acceptable
NASA Employee	ammos.jpl.nasa.gov/	Ineffective
	code250.gsfc.nasa.gov	Effective
	fvncep.gsfc.nasa.gov/	Ineffective
	oce.jpl.nasa.gov	Ineffective

The results from the UX testing we completed this project can be used in future improvements of websites and when deciding which NASA websites should stay active within NASA's webspace. With this data in hand, future NASA web developers can use this information to better target a specific audience ensuring the information reaches the right people. We also recognize that web developers and administrators at NASA wish to improve NASA's webspace by removing inactive and ineffectual websites. We intend for the data and methods gathered from this project to help them in their decisions for NASA's future webspace.

While our UX tests produced plenty of data from our testing sample of NASA websites, in order to perform a more in depth data analysis on the entirety of NASA's webspace, further testing is required. In most cases, our UX testing data comes from a sample size of five users, which can severely alter results due to outlier data. With more testing, outlier data points have less of an impact on the overall data trends, which allow for more accurate predictions. Each website in NASA's webspace would also need individual testing to determine its effectiveness in serving its target audience.

Recommendations

This project provides valuable information on persona-based UX testing and how NASA could UX testing when designing future websites, as well as providing a stepping stone for further work and analysis to be done. This project analyzes the survey data of just over 4% of the total websites in the NASA domain, which leaves 96% of the webspace not surveyed. Expanding on the survey to include more sites would ensure that more of NASA's webspace is represented, increasing the ability to draw meaningful conclusions from the data.

To further improve the ability to track websites throughout the NASA webspace, a database of all NASA websites could be created to hold information from each website. This database could include results from Google Analytics, the employee surveys, and information displayed on the website itself. By tracking this information, NASA web developers can determine if a website about a certain topic has already been created, allowing them to prevent duplication of already available information and multiple URLs being used for the same topic when the work could be consolidated on a single website.

At the time of our survey, only a fifth of the websites in our sample covering 5% of NASA webspace used the government-wide Google Analytics account on their websites. However, even with less than a quarter of the websites in NASA's webspace being tracked, the data being pulled in by Google Analytics can be used to analyze data points such as a website's user demographics and the most popular way users find a site.

With our sample showing that 21% of the websites were broken links, determining which URLs are actually broken websites could be a good initial approach. One way to do this

would be to have someone check each individual website URL and ensure that each site functions properly, marking down any site that no longer exists or redirects to another URL. However, a far more efficient way of completing this task would be to program a web crawler to go to each URL on the list provided by the Federal CIO and automatically determine if the site's status. With this information, steps can be taken to either update the broken sites or remove them from the NASA webspace.

Reflections

A major growing point for our team was our conflicting personalities. Because of our differing backgrounds and mentalities, we all approached almost every problem that we ran into in different ways. This created a lot of conflict that, while stressful in the short term, ultimately pushed our project towards being successful. We forced each other to look at our project in ways that we'd never thought of before, allowing us to thoroughly review everything we did. While it was nowhere near painless, it definitely benefitted the end results.

Our conflicting personalities also caused a lot of arguing. As we knew that our personalities were going to continue clashing, we tried to constructively figure out better ways to have these discussion. We eventually realized that there was not a simple answer, and we would need to compromise on many things in order to move forward and be productive.

Another big takeaway from this project is that nothing goes to plan. We came into this project with one seemingly clear idea of how the project would go, and at every step we ended up reevaluating and changing the remainder of our project. For example, Google Analytics was initially going to be a major part of our project. However, after exploring the tools within Google Analytics, we were unable to complete our plans in the way that we intended, and ended up focusing much more on user experience testing instead of navigation trends in Google Analytics.

Even with these experiences, overall our team had a rewarding time working at NASA Headquarters. Over the course of our project, our team has been to two NASA centers, met two astronauts, and been able to deliver a project with a visible impact on the future of NASA's web architecture. Our team is confident that we have left a positive impact on NASA's webspace.

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Appendix B: Materials

Persona Development Criteria

1. **Personal**
    a. What is the name of your person?
    b. What is the age of your person?
    c. What is the gender of your person?
    d. What is the highest level of education this person has received?
2. **Professional**
    a. How much work experience does your person have?
    b. What is your person's professional background?
    c. Why will they come to the site? (User needs, interests, and goals)
    d. Where (or from whom) else is this person getting information about your issue or similar programs or services?
    e. When and where will users access the site? (User environment and context)
3. **Technical**
    a. What technological devices does your person use on a regular basis?
    b. What software and/or applications does your person use on a regular basis?
    c. Through what technological device does your user primarily access the web for information?
    d. How much time does your person spend browsing the web every day?
4. **User Motivation**
    a. What is your person motivated by?
    b. What are they looking for?
    c. What is your person looking to do?
    d. What are his/her needs?

Data Sheet Categories

- Basic Site Info
    - Site URL
    - Notes
- Info from GA navigation summary
    - Initial perceived main goal of users
    - Common path
- Google Analytics
    - Page views
    - New sessions
    - Last page visited

    - Average duration
    - Age range
    - Sex
    - New vs returning user
- Gather from Website
    - Manager
    - Center
    - Organization
    - Contact (NASA Official)
    - NASA Official Email
    - Public Domain (Y/N)
    - Last Updated
- From Contact
    - Target Audience
    - Frequency of Update
    - What contract supports your site?
    - Qualitative metrics used
    - What is your plan for including insights from metrics into improving your site?

Appendix C: Persona Biographies

General Public

34: General Public (Genin, 2009)

Name: General George

Age: 27

Gender: Male

About:

George is a 27 year-old retail salesman in Topeka, Kansas. He is a single male living in a studio apartment in the city. He enjoys a life of working by day in retail and working on his hobbies and doing activities with friends at night. While exploring social media one night, he read an article about NASA's recent satellite flyby of Pluto. He had never put too much thought into NASA and was immediately interested in finding out more about the organization.

Goals:

George doesn't know much about NASA and wants to learn more about their programs, missions, and services. During some free time after dinner and before going to sleep on a workday he wants to visit some NASA websites for the general public. He hopes that exploring some of these sites will give him a bit more of an understanding of NASA's activities. There was a small list of terms that he found in the article on NASA that he read, and wants to find some definitions and meanings behind them.

Challenges:

George is only visiting NASA sites because an outside source piqued his interest, so he is not fully committed to staying on these websites and finding answers to his questions. His dedication and attention span for these tasks is minimal compared to the other personas. He is the type of user that skims past large amounts of text and focuses on images and pages designed to grab attention. He is also inexperienced with navigating NASA websites.

K-12 Student

35: K-12 Student (AdinaVoicu, 2015)

Name: Student Sam

Age: 10

Gender: Female

About:

Sam is currently a 5th grader. Several days of the week she has a science class, where her teacher assigns homework that requires her to look up information online. She is not very interested in the topic but enjoys having a reason to use her family's computer. She also discovered some of the games on NASA's websites, and began her journey into the world of procrastination.

Goals:

Sam was given a homework assignment by her science teacher during class today. She has to visit a few NASA websites and answer some questions about different science topics and NASA history. Sam doesn't have too much interest in space, but she wants to get a good grade on the assignment to impress her parents. If she finds online games on NASA sites, she will take a short break to play them to relax and procrastinate. Afterwards, she will want to spend time with her friends, so she'll continue the rest of the assignment.

Challenges:

Sam is visiting NASA websites looking for information for her assignment. She has only been taught about these topics on a very basic level and cannot understand any technical explanations of them. She is also much more used to navigating mobile websites, so she might take longer than usual to get used to a site's menus.

K-12 Teacher

36 K-12 Teacher (Stroble, 1974)

Name: Teacher Tom

Age: 35

Gender: Male

About:

Tom is an 8th grade teacher for a middle school in Maryland. He enjoys teaching and strives to keep his assignments both challenging and entertaining. He recently moved from New Jersey, and has to change his teaching style from 3rd graders to 8th graders. He learned about NASA's websites while trying to find resources for teaching his class.

He took a look through the course work required of the district in which he was teaching and felt that though the topics were important, they were also not very engaging. He wants to add some fresh, new material to his lesson plan, so he decided to take a look at the educational material found on NASA's websites. In previous years and at other schools, he had good experiences with the STEM program materials found of NASA sites, and hopes to find some assignments for the students he is currently teaching.

Goals:

Tom is looking for educational resources that he can use for a fun lesson for his students. He wants to find something that's not too easy to complete while still being interesting enough to hold their attention. As he majored in science, he can understand complex scientific explanations on NASA's websites and uses this to his advantage while navigating.

Challenges:

As he taught 3rd graders for most of his 12 years of teaching, he is still unsure of how difficult he should be making his assignments or what older students find interesting.

Researcher

37: Researcher (Ausmus, n.d.)

Name: Researcher Rob

Age: 39

Gender: Male

About:

Rob is a researcher at Worcester Polytechnic Institute who is studying Earth's atmosphere. Rob's research into the atmosphere is based largely off of NASA data, which is collected by orbiting satellites pointed at Earth and taking images to determine flow patterns of wind and particles through the atmosphere. With the data collected by these satellites, Rob can analyze and make conclusions about the state and future of the atmosphere.

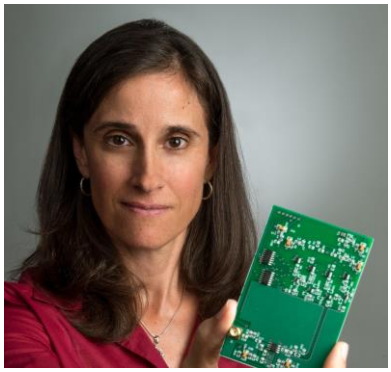
Goals:

Using data from NASA satellites, Rob hopes to make discoveries about the state of Earth's atmosphere, and hopes to publish the next great finding in atmospheric science. To find the information he needs, Rob hopes to find NASA websites that will help his studies. He knows that websites will be helpful in the future if they contain answers to some basic questions he has come up with.

Challenges:

Analysis can take a long time, which means that another researcher can make a discovery using the NASA data before Rob can take a look at a piece of data, as the NASA data is public record. Rob also prefers sites that have very specific technical information available. He doesn't care if the websites are poorly made so long as they serve his needs. When searching websites, he looks for terms matching his needs and skims through other information. He's also not fond of flashy webpages or interactive sites.

Aerospace Industry



38: AEROSPACE INDUSTRY (NASA, 2015)

Name: Aero Alexis

Age: 55

Gender: Female

About:

Alexis is a veteran in the aerospace field, and has been working in it for over 3 decades. She's worked at various aerospace companies including Lockheed Martin, Boeing, and most recently, United Launch Alliance. Alexis works with the engine and thrusters (also called the propulsion systems) of the Atlas V, which is one of the most common American rockets today.

Some things Alexis needs to know while doing her job is the standards NASA sets for launch vehicles that interact with NASA equipment. This means that she will be communicating with NASA on certain aspects of rocket design and manufacturing.

Goals:

Alexis wants to ensure that the Atlas V engines and thrusters are up to NASA specifications for rocket engines. She may have to return to NASA websites throughout development, so she wants to have a list of trustworthy sites.

Challenges:

Alexis must keep material costs down while still keeping the engines and thrusters up to NASA specifications, as she must work within a set budget.

NASA Employee

39: NASA Employee (Peterlinton, 2012)

Name: NASA Nate

Age: 53

Gender: Male

About:

Nate is a NASA Employee working out of the Langley Research center (LaRC). He has worked for NASA for 30 years and is currently working as a Project Manager. He has his PhD in Atmospheric Sciences. His current project involves research on Earth's atmosphere. The project is just starting up and he wants to search NASA's websites for tools and services available to assist his research.

Recently, he has considered changing his insurance plans, primarily life and health. In changing his plans, he knows that he'll have to check up on the benefits available to NASA Employees.

Goals:

Nate wants to make use of the many resources available to him as a NASA Employee. He has a list of websites with information on NASA provided health and medical services and wants to browse the websites for anything that will help him with his problems. He also wants to check out the Atmospheric Analysis tools hosted on some sites.

Challenges:

Nate does not have the same technical skills as newer generations. He doesn't have a problem using computers or the internet, but isn't as fast or knowledgeable as others. Instead of quickly skimming through the information on web pages, Nate reads through everything looking for something that might help him. He doesn't have the best retention for sight navigation and doesn't remember very well the paths he has taken through menus and links. He also has slower hand-eye coordination.

Appendix D: UX Test Questions

General Public

Website: http://science.larc.nasa.gov

Task 1

- Question: What was the purpose of the EV-1 TEMPO mission?
- Answer: Monitor Pollution in atmosphere
  http://science.larc.nasa.gov/research-timeline.html

Task 2

- Question: How many programs related to climate and weather are there?
- Answer: 5
  http://science.larc.nasa.gov/research-ClimateAndWeather.php

Website: http://www.giss.nasa.gov

Task 3

- Question: What was different about the snow cover in California in 2015?
- Answer: There is significantly less
  http://www.giss.nasa.gov/research/features/201511_snowpack/

Task 4

- Question: How does NASA validate the measurements of aerosols taken by satellites?
- Answer: AERONET
  http://www.giss.nasa.gov/research/features/201512_smoke/

Website: http://eclipse.gsfc.nasa.gov

Task 5

- Question: How many solar eclipse events will there be in 2016?
- Answer: 2
  http://eclipse.gsfc.nasa.gov/SKYCAL/SKYCAL.html?cal=2016#skycal
  http://eclipse.gsfc.nasa.gov/solar.html

Task 6

- Question: When is the next total eclipse visible from the US, and where is it most visible from?
- Answer: August 17th, Missouri http://eclipse.gsfc.nasa.gov/SEmono/TSE2017/TSE2017.html

Website: http://saturn.jpl.nasa.gov/

Task 7

- Question: Which of Saturn's rings is closest to the center?
- Answer: D Ring http://saturn.jpl.nasa.gov/science/index.cfm?SciencePageID=55

Task 8

- Question: When was Ijiraq discovered?
- Answer: 2000 http://saturn.jpl.nasa.gov/science/moons/ijiraq/

K-12 Student

Website: http://cosmictimes.gsfc.nasa.gov/

Task 1

- Question: What is the URL of the article describing what a new universe looks like?
- Answer: http://cosmictimes.gsfc.nasa.gov/online_edition/1993Cosmic/baby.html

Task 2

- Question: When did Albert Einstein die?
- Answer: http://cosmictimes.gsfc.nasa.gov/online_edition/1955Cosmic/death.html

Website: globalastro.gsfc.nasa.gov

Task 3

- Question: Find the image labeling the technology on the Astro-H Satellite. What is that page's URL?
- Answer: http://globalastro.gsfc.nasa.gov/?page_id=221

Task 4

- Question: What are X-Ray Calorimeters?

- Answer: http://globalastro.gsfc.nasa.gov/?page_id=1662

Website: mwmw.gsfc.nasa.gov

Task 5

- Question: What are gamma rays?
- Answer: http://mwmw.gsfc.nasa.gov/mmw_rainbow.html#visible
  http://mwmw.gsfc.nasa.gov/mmw_sci.html#egret

Task 6

- Question: What is an SBC Galaxy
- Answer: http://mwmw.gsfc.nasa.gov/mmw_define.html

Website: http://spaceplace.nasa.gov

Task 7

- Question: Find and play the game Helios! What is that page's URL?
- Answer: http://spaceplace.nasa.gov/helios-game/en/#

Task 8

- Question: Find the crafts page for making colorful star cookies.
- Answer: http://spaceplace.nasa.gov/star-cookies/en/

K-12 Teacher

Website: http://mars.nasa.gov/

Task 1

- Question: Find the lesson plans for teaching students about what it would be like to live on Mars.
- Answer: Located on http://mars.nasa.gov/participate/marsforeducators/soi/; found by hovering over “Participate!” in the top nav bar and clicking Mars for Educators, followed by Lesson Plans: 2012 NASA Summer of Innovation Collection.

Task 2

- Question: Find resources for using the Imagine Mars project to teach students more about Mars.

- Answer: Located on http://mars.nasa.gov/imagine/leaders/project_resources/activities.html; through the Mars for Educators page, it is found by clicking on Imagine Mars, then Project Leaders in the top nav bar, then Project Resources.

Website: http://solarsystem.nasa.gov/

Task 3

- Question: Find the full size downloadable solar system lithograph set.
- Answer: http://solarsystem.nasa.gov/educ/lithos; found through clicking the menu bar, then Education, then Print-and-Go.

Task 4

- Question: Find the event calendar for the solar system ambassadors program.
- Answer: From the Education menu, click Solar System Ambassadors, then click Event Calendar in the left navigation bar.

Website: http://jwst.nasa.gov/

Task 5

- Question: Find the lesson plan for teaching about the importance of space telescopes. What is that page's URL?
- Answer: Located at the top of http://jwst.nasa.gov/teachers_formal.html; found through clicking For Educators in the leftside navigation bar, then Formal Education.

Task 6

- Question: Find videos showing how the JWST has already been used in education. What is that page's URL?
- Answer: "JWST in Education" on http://jwst.nasa.gov/videos.html; found through Images & Videos on the left hand navigation bar, then Animations & Videos.

Website: spaceplace.nasa.gov

Task 7

- Question: Find the September-October 2014 issue of the Educator newsletter. What is that page's URL?

- Answer: Located on http://spaceplace.nasa.gov/educator-newsletter/en/; found through Parents & Educators in the top navigation bar, then clicking the Space Place Educator newsletter in the Classroom Resources section.

Task 8

- Question: Who should you e-mail if you're interested in partnering your school's astronomy club with Space Place?
- Answer: info@spaceplace.nasa.gov from http://spaceplace.nasa.gov/astronomy-clubs/en/; found through clicking Astronomy Clubs on the Parents & Educators page.

Researcher

Website: earthdata.nasa.gov

Task 1

- Question: What is the originating center of the Measurement of Air Pollution from Satellites (MAPS) satellites?
- Answer: LARC/DAAC. http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=daacs&KeywordPath=Parameters%7CATMOSPHERE%7CAIR+QUALITY%7CCARBON+MONOXIDE&OrigMetadataNode=GCMD&EntryId=MAPS_OSTA3_CO5X5_HDF&MetadataView=Full&MetadataType=0&lbnode=mdlb1

Task 2

- Question: Find the near real-time display of global satellite imagery. What is the URL for this page?
- Answer: worldview.earthdata.nasa.gov. Can be found in bottom banner of page

Website: http://nasirf.wff.nasa.gov

Task 3

- Question: Find information on the High Winds experiments performed in 2004. What is that page's URL?
- Answer: Find the High Winds Experiment 2004 page. http://nasirf.wff.nasa.gov/page/6.html

Task 4

- Question: Find the mission statement of the Wallops Field Support Office. What is that page's URL?
- Answer: http://science.wff.nasa.gov

Website: http://www-mipl.jpl.nasa.gov/mipex.html

Task 5

- Question:
- Find information on the VICAR image processing system's source code. What is that page's URL?
- Answer: http://www-mipl.jpl.nasa.gov/vicar_open.html

Task 6

- Question: Find the MIPL Infrastructure Functional Diagram. What is that page's URL?
- Answer: http://www-mipl.jpl.nasa.gov/mipl-diagram.html

Website: http://atrain.gsfc.nasa.gov

Task 7

- Question: What sensors on the A-Train are active?
- Answer: CALLOP & CPR. http://atrain.gsfc.nasa.gov/sensors_see.php

Task 8

- Question: Find the A-Train Data Depot. What is that page's URL?
- Answer: http://disc.sci.gsfc.nasa.gov/atdd

Aerospace Industry

Website: trajectory.grc.nasa.gov

Task 1

- Question: Find information on Solar Power Systems Analyses for Electric Propulsion Missions. What is that page's URL?
- Answer: PDF of Solar Power Systems Analyses for Electric Propulsion Missions. http://trajectory.grc.nasa.gov/aboutus/papers/1999-01-2449.pdf

Task 2

- Question: Find information on the Satellite Tool Kit and who to contact to receive the software. What is that page's URL?
- Answer: PoC = Leonard A. Dudzinski
  http://trajectory.grc.nasa.gov/tools/stk.shtml

Website: rtaps.grc.nasa.gov

Task 3

- Question: Find the RTAPS Federal Acquisition Regulations. What is that page's URL?
- Answer: https://rtaps.grc.nasa.gov/rtaps/procurement-references/

Website: dst.jpl.nasa.gov

Task 4

- Question: Who is the Task Manager of the Formation Control team?
- Answer: Dr. Fred Y. Hadaegh

Task 5

- Question: What is the task objective of the thrusters team?
- Answer: "Development of a Miniature Xenon Ion (MiXI) thruster development that will enable precision spacecraft positioning and formation maneuvers for formation-flying spacecraft. The current MiXI thruster prototype will provide 0.5 – 3 mN thrust at 3000 sec specific impulse and efficiencies around 50% or better. The MiXI thruster will use Xenon propellant, a noble gas, minimizing spacecraft contamination."
  http://dst.jpl.nasa.gov/thrusters/

Website: http://insidedlab.jpl.nasa.gov

Task 6

- Question: Find the information on Dspace software. What is that page's URL?
- Answer: http://insidedlab.jpl.nasa.gov/Dspace/index.php

Website: http://jsc-aircraft-ops.jsc.nasa.gov

Task 7

- Question: What is the length of the Super Guppy aircraft?
- Answer: 111' long

Website: http://turbmodels.larc.nasa.gov

Task 8

- Question: Find the information on the NASA 40% Challenge. What is that page's URL?
- Answer: http://turbmodels.larc.nasa.gov/nasa40percent.html

NASA Employee

Website: https://ammos.jpl.nasa.gov

Task 1

- Question: When is a "Call for Ideas" to improve or contribute to AMMOS sent out to NASA Employees?
- Answer: December / Biennially
  https://ammos.jpl.nasa.gov/contributing/

Task 2

- Question: What are the services provided by the Multimission Data Management Team as listed in the AMMOS Catalog?
- Answer: "DMT provides a multimission service that supports long-term data archive and associated engineering support for the mission operations environment."
- https://ammos.jpl.nasa.gov/toolsandservices/downlink/dataarchive/multimissiondatamanagementteam/

Website: code250.gsfc.nasa.gov

Task 3

- Question: At what clinic and what time can civil servants and contractor employees get free flu shots?
- Answer: Greenbelt, 10-11:45 AM, Mon-Thurs.
  http://code250.gsfc.nasa.gov/medical/medical.html#flu

Task 4

- Question: When are Zumba classes at the Goddard Space Flight Center Fitness Center?
- Answer: Wednesday 12 - 1 PM
  http://code250.gsfc.nasa.gov/medical/fitness.cfm

Website: http://fvncep.gsfc.nasa.gov/

Task 5

- Question: Find information on the precipitation and convective systems for aerosols and clouds. What is that page's URL?
- Answer: http://fvncep.gsfc.nasa.gov/meso/index.php?section=160

Task 6

- Question: Find what books/papers were published under atmospheric chemistry and dynamics on October 16th. What is that page's URL?
- Answer: http://fvncep.gsfc.nasa.gov/acd/calendar/view.php?m=10&d=16&y=2015

Website: oce.jpl.nasa.gov

Task 7

- Question: What are the name and phone number for the ETA Chief Engineer, Knowledge Management Specialist, and Executive Staff Engineer[1]?
- Answer: Bharat Chudasama ((818) 354-5338), Charles White ((818) 354-2743), and Maeve McGrath ((818) 393-8683)
  http://oce.jpl.nasa.gov/staff.html

Task 8

- Question: Find the Practice Description and Benefits for NASA Preferred Practice No. PD-AP-1317. What is that page's URL?
- Answer: http://oce.jpl.nasa.gov/practices/1317.pdf

Qualitative Questions

The following questions were repeated after the questions for each individual website:

1. I was easily able to find the information I needed:

strongly disagree disagree neutral agree strongly agree

2. Navigating through this website was clear and easy:

strongly disagree disagree neutral agree strongly agree

[1] This question, as included here, asked for the Executive Staff Engineer rather than using the proper title of Executive Staff Coordinator.

3. I enjoyed the visual design and style of the webpages on this website:

strongly disagree disagree neutral agree strongly agree

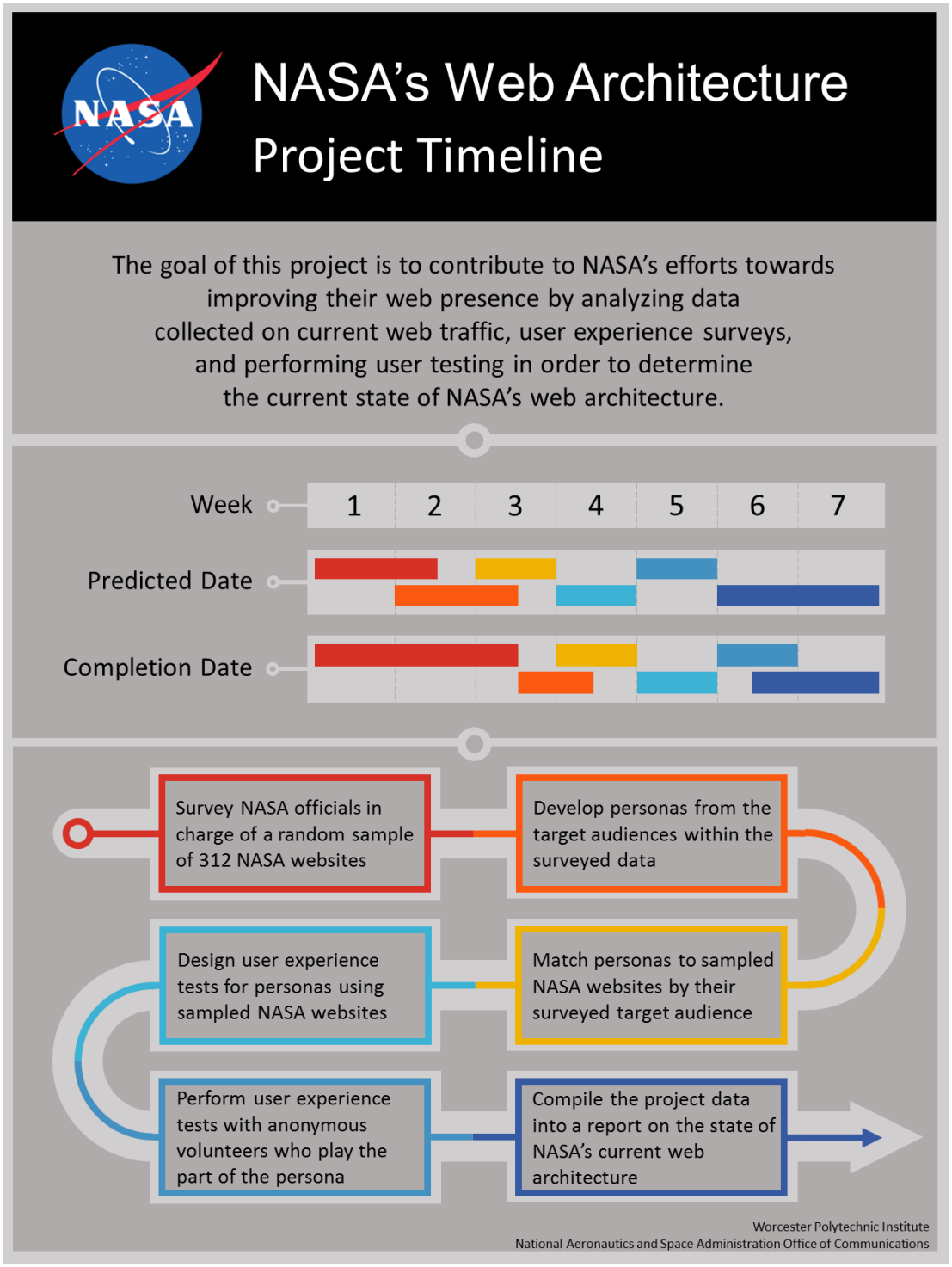
4. I would return to this website in the future to find more information:

strongly disagree disagree neutral agree strongly agree

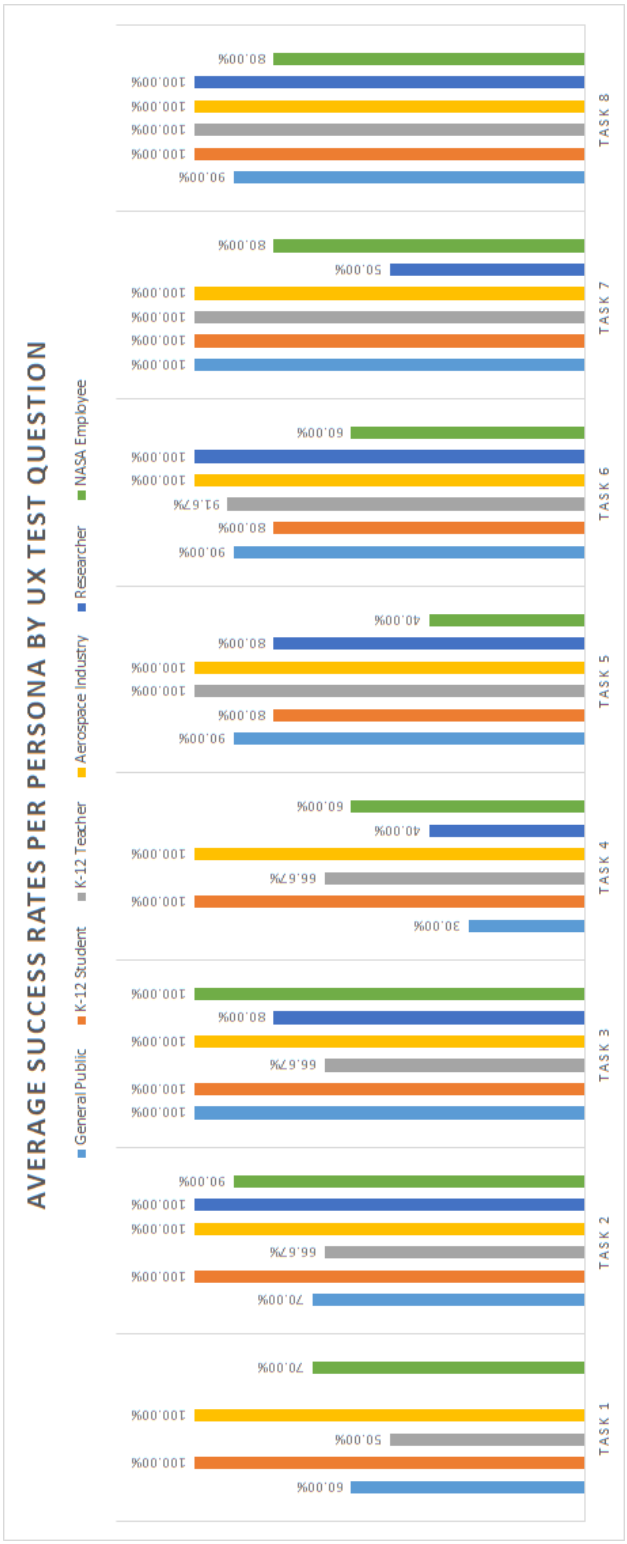
5. I would recommend this website to someone else if they are looking for the same information:

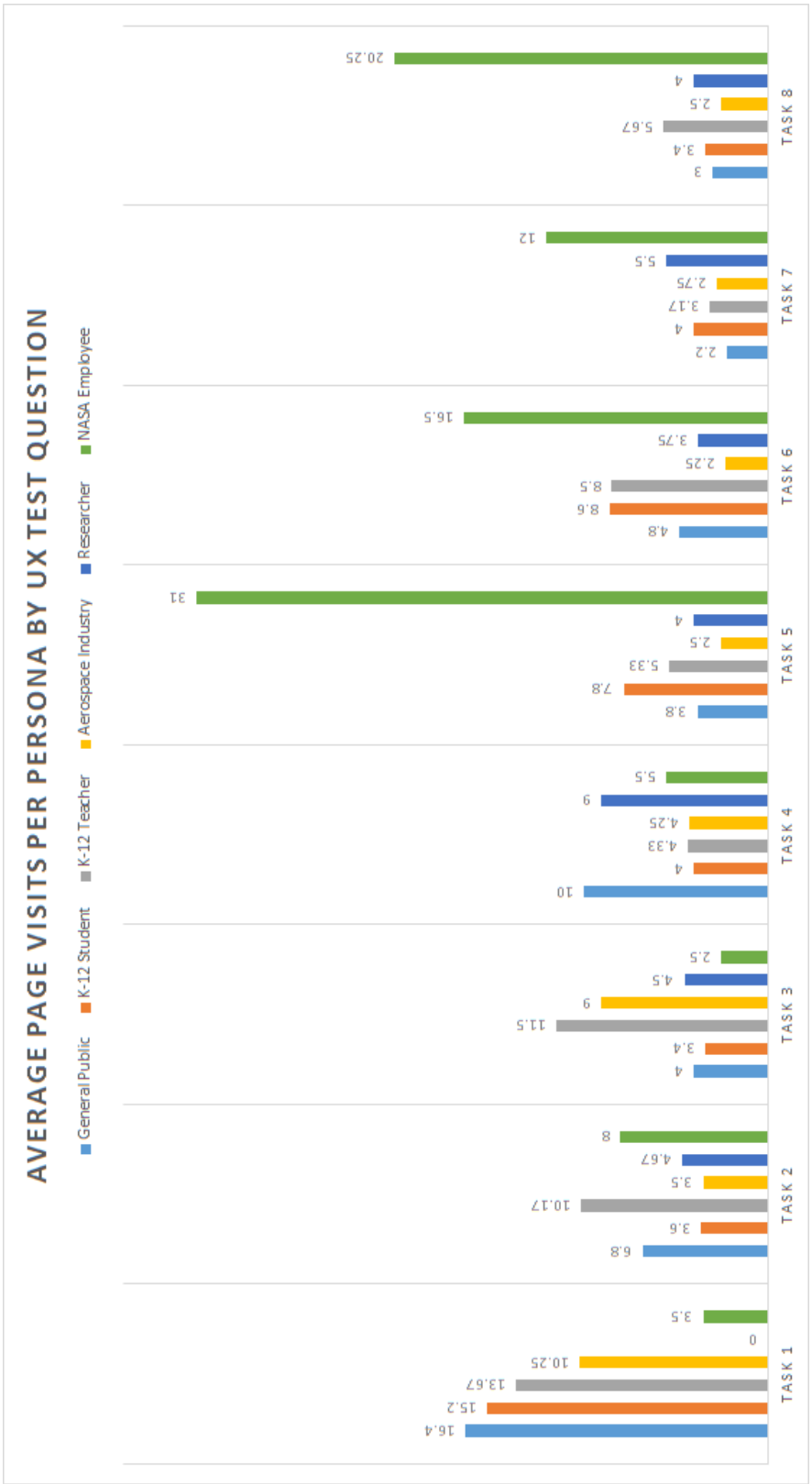
strongly disagree disagree neutral agree strongly agree

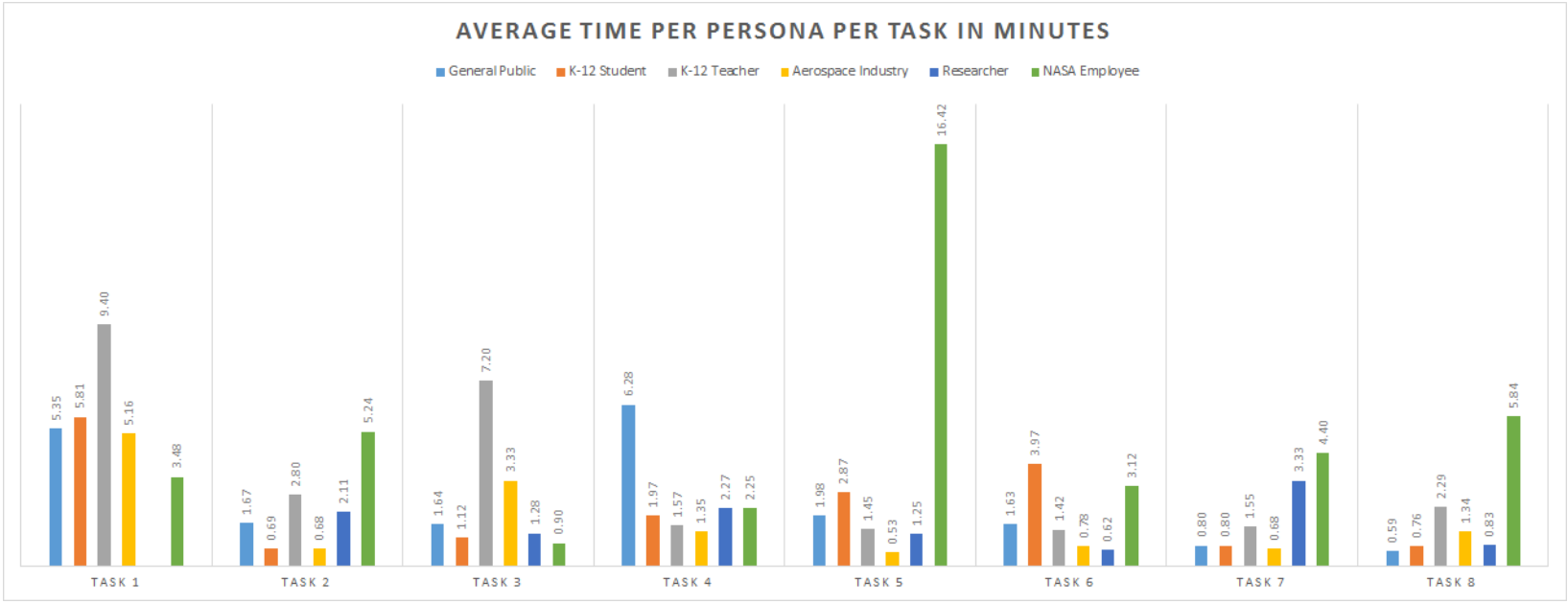
Appendix E: Project Infographic



Appendix F: Full Page UX Test Results




AVERAGE PAGE VISITS PER PERSONA BY UX TEST QUESTION
General Public
K-12 Student
K-12 Teacher
Aerospace Industry
Researcher
NASA Employee
TASK 1
16.4
15.2
13.67
10.25
0
3.5
TASK 2
6.8
3.6
10.17
3.5
4.67
8
TASK 3
4
3.4
11.5
9
4.5
2.5
TASK 4
10
4
4.33
4.25
9
5.5
TASK 5
3.8
7.8
5.33
2.5
4
31
TASK 6
4.8
8.6
8.5
2.25
3.75
16.5
TASK 7
2.2
4
3.17
2.75
5.5
12
TASK 8
3
3.4
5.67
2.5
4
20.25


AVERAGE TIME PER PERSONA PER TASK IN MINUTES
General Public
K-12 Student
K-12 Teacher
Aerospace Industry
Researcher
NASA Employee
5.35
5.81
9.40
5.16
3.48
1.67
0.69
2.80
0.68
2.11
5.24
1.64
1.12
7.20
3.33
1.28
0.90
6.28
1.97
1.57
1.35
2.27
2.25
1.98
2.87
1.45
0.53
1.25
16.42
1.63
3.97
1.42
0.78
0.62
3.12
0.80
0.80
1.55
0.68
3.33
4.40
0.59
0.76
2.29
1.34
0.83
5.84
TASK 1
TASK 2
TASK 3
TASK 4
TASK 5
TASK 6
TASK 7
TASK 8