Dynamometer Dash

Table of Contents

Report

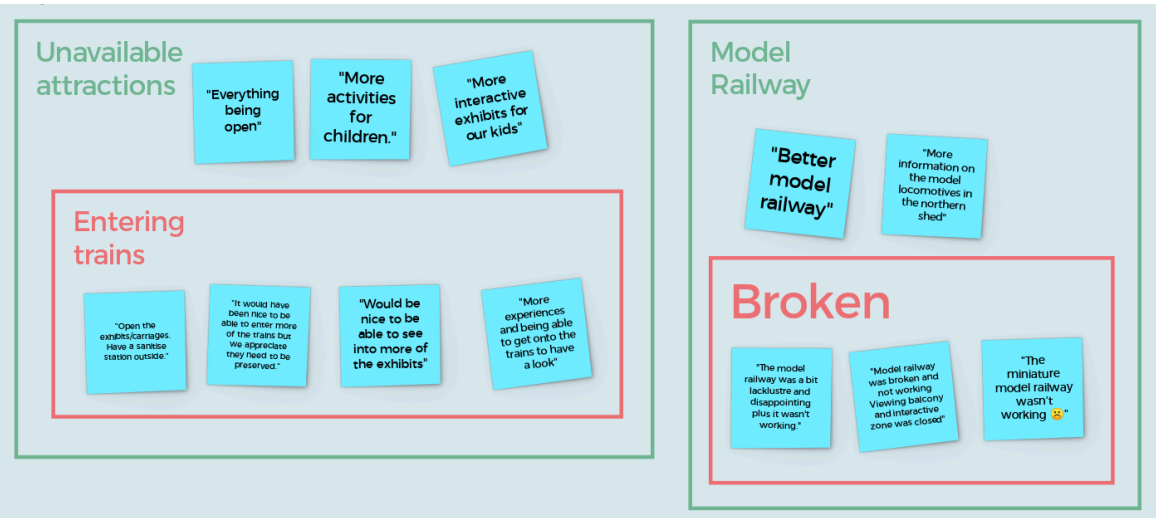
Appendices

Overview

Dynamometer Dash is a VR train experience developed for the National Rail Museum (NRM). The user sits inside a model Dynamometer Car and monitors its speed in a recreation of Mallard's record-breaking 1938 run. The project aims to give users a sense of speed, build interest in the Dynamometer Car and Mallard, and show train interiors to museum visitors, especially those who cannot get up the staircase to see inside the trains. Accessibility is key for this project, so no controllers are required to play; the experience is also fully operable from a keyboard and mouse to allow NRM staff to control it. The project takes inspiration from VR model trains in *Rolling Line* and piloting vehicles in *No Man's Sky*'s VR mode.

Design Approach

I collected data from the assessment brief, advice from the NRM team, the NRM's *Flying Scotsman VR Experience*, and independent desk research. Roughly 70% of visitors who reviewed the museum classify as non-enthusiasts (*National Rail Museum*, 2022). This was vital data for developing my primary persona (Appendix C). As I did not conduct user research myself, I relied heavily on visitor reviews and picked data representative of the largest categories of complaints.



The majority of visitor-suggested improvements fell into three relevant categories. Common visitor complaints related to closed-off trains, the broken model railway, and a lack of activities for children. I disregarded data related to the museum's food pricing and COVID restrictions as these areas are out of my control. However, I did keep mentions of sanitisation in mind as many visitors (including children) could use the prototype back-to-back. Categorising visitor suggestions simplified my affinity map and facilitated persona creation (Appendices B, C, D).

By the time I had finished persona creation, I had identified clear problem areas and created a list of functional and non-functional requirements (Appendix E). Each requirement was primarily valued by the number of visitor comments on the subject and the amount the subject was stressed by the assessment brief and NRM team.

Functional Requirements (FRs)

1. Users feel like they are inside the Dynamometer Car
2. Accessible for and inclusive of seated users and users not using their hands
3. Experience is brief, ideally less than a few minutes long
4. VR experience

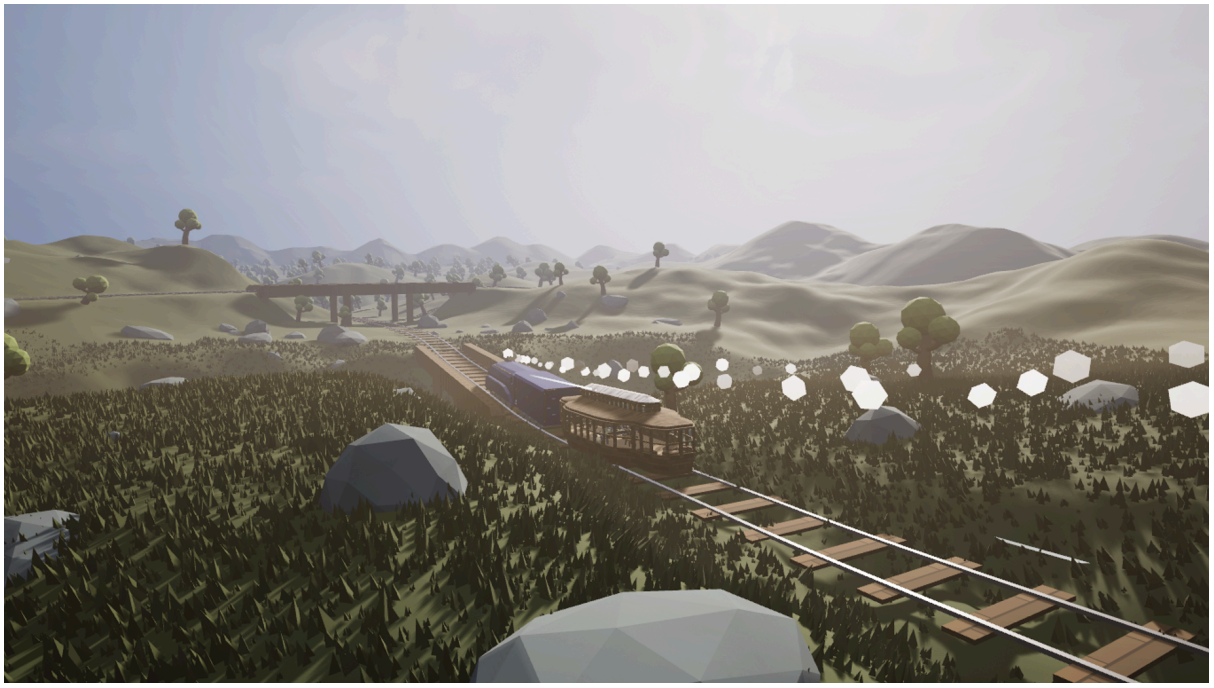
Non-Functional Requirements (NFRs)

1. Users feel fast
2. Nausea-prone users are comfortable
3. Experience is themed like a model train set
4. Non-enthusiasts and children are engaged and gain a new appreciation for the Dynamometer Car and/or trains in general
5. Equipment is easy to clean between uses
6. The train's speed is displayed accurately on Dynamometer equipment
7. The experience is low-budget and easy to implement

Requirements are referred to by category and number (e.g. NFR1 refers to "Users feel fast").

While some requirements draw directly from clear visitor feedback (NFR3), others address concerns from the NRM team (FR3) and make users feel like they are actually inside the Dynamometer (FR1, NFR6). Some NFRs build on FRs. For example, I consider NFR2 to be an accessibility issue. NFR1, NFR4, and NFR6 extend from developing the Dynamometer Car for FR1.

Design Statement



I chose to use the Dynamometer Car, and Mallard by extent, to help NRM visitors experience the speed and excitement the Dynamometer's operator felt during Mallard's record-breaking 1938 run. In the brief's own words, "the biggest problem faced by the National Railway Museum is how you present railways, a technology all about movement and travel in a museum where things are by necessity static" (Samaddar, 2023). The Dynamometer Car's purpose is to measure speed, arguably making it suffer the most from being static. A virtual recreation of its 1938 run with Mallard is perfect for letting visitors experience a historical moment while also giving them a first-person look around the car's interior.

Using VR for this prototype (FR4, NFR5, NFR7) will make users feel like they are inside the Dynamometer (FR1) while giving children and non-enthusiasts an entertaining, novel experience (NFR4). At up to 126 miles per hour, *Dynamometer Dash* is a quick and easy visitor experience (FR3, NFR1). Historically accurate speed and miles per hour readings offer a more informative, realistic element to train enthusiasts (NFR6). The toy-like model train theme helps alleviate NRM visitors' issues with the museum's model train by allowing them to shrink to a miniature scale and ride a model train (NFR3). Limited mobility users who cannot climb the staircase to the car's window and visitors who want a closer look at its interior can now enter it in VR from a seated or standing position (FR2). By featuring Mallard alongside the Dynamometer Car, the experience parallels the real-world trains beside each other in the museum. Users get a first-person look into the trains' history; they can learn more by reading the descriptions displayed next to the real-world trains.

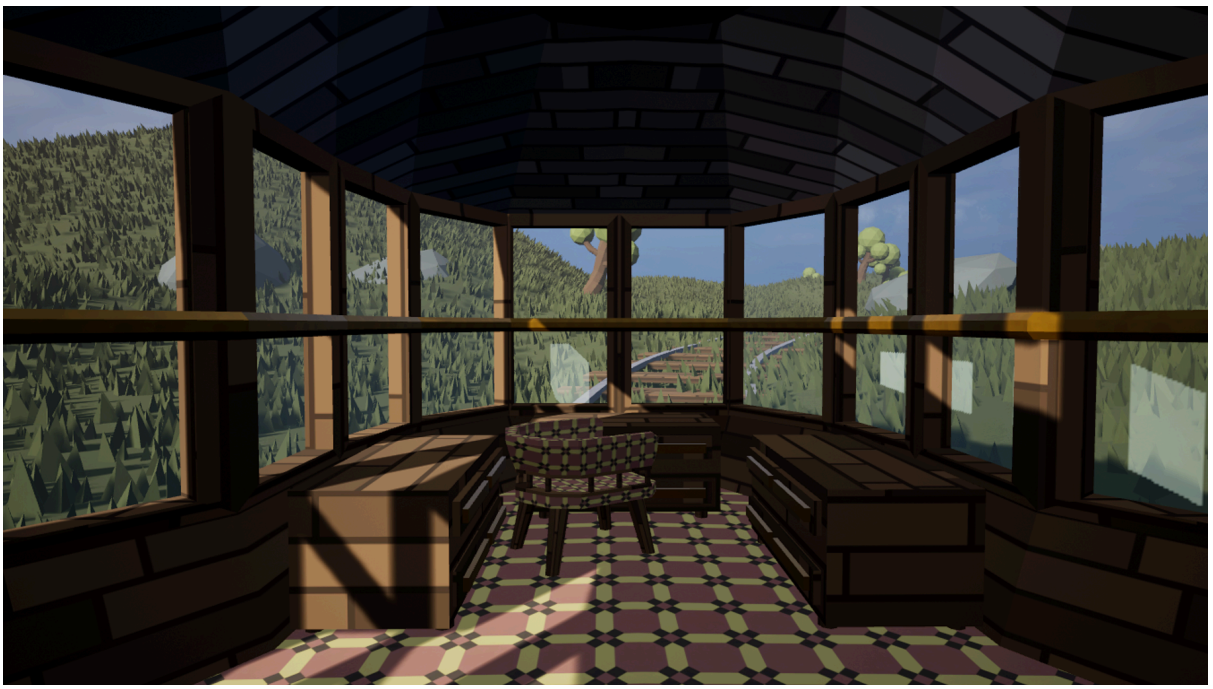
Design Context

Four VR experiences primarily influenced this project: *Derail Valley*, *Rolling Line*, the NRM's *Flying Scotsman VR Experience*, and *No Man's Sky*'s VR mode.

Derail Valley, a highly technical VR train game, includes many of the manual aspects of running a train that I initially wanted to implement. However, I realised that more interactive elements would reduce accessibility for users without controllers (FR2) and encourage visitors to spend longer playing, increasing queue times (FR3). I came to recognise the features of *Derail Valley* as prime examples of what would not work for a short, simple museum experience. In the Dynamometer Car, the equivalent technical elements would be various dials and graphs for statistics such as drawbar horsepower and coal consumption. While these would appeal to rail enthusiasts, they would draw attention from the world speeding past outside the car (NFR1). As rail enthusiasts are a smaller NRM demographic than non-enthusiasts and children, I prioritised engagement over education by dropping these features (NFR4).

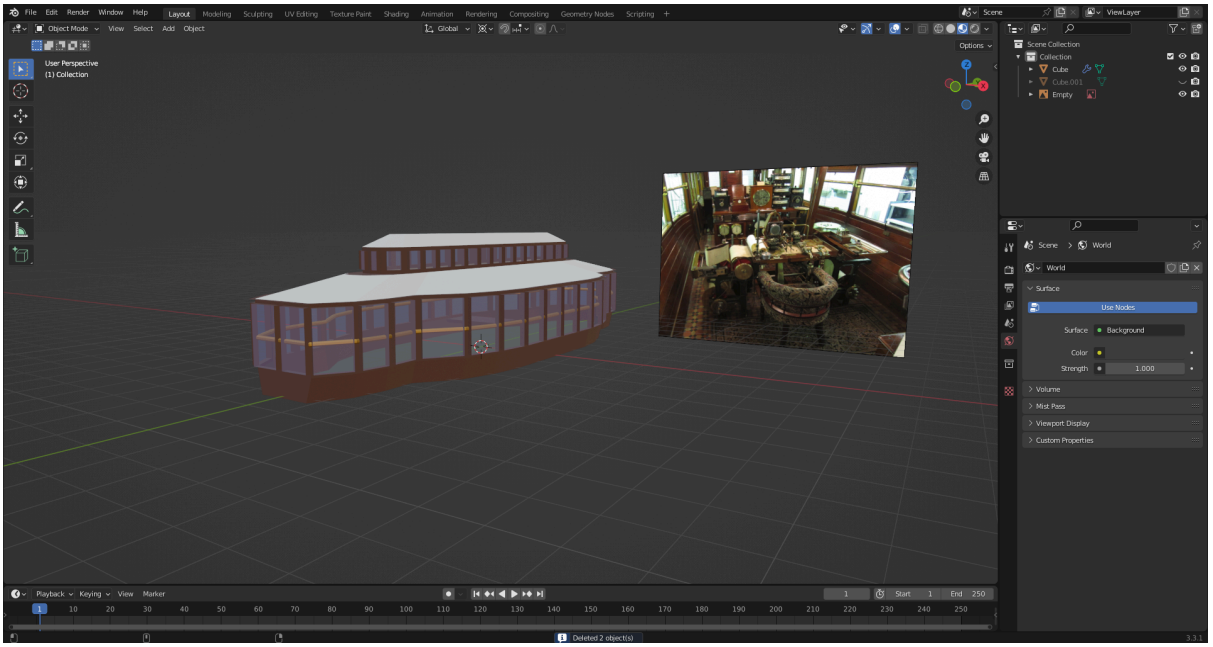
Rolling Line, another VR train game, more closely reflected my aims for this project. Players can manipulate a model train sandbox as they see fit and shrink to the scale of the model trains to ride inside them. I initially intended to include the user scaling mechanic to emphasise the model train aspect of the game but decided against it to keep playtime (and queues) short (FR3, NFR3).

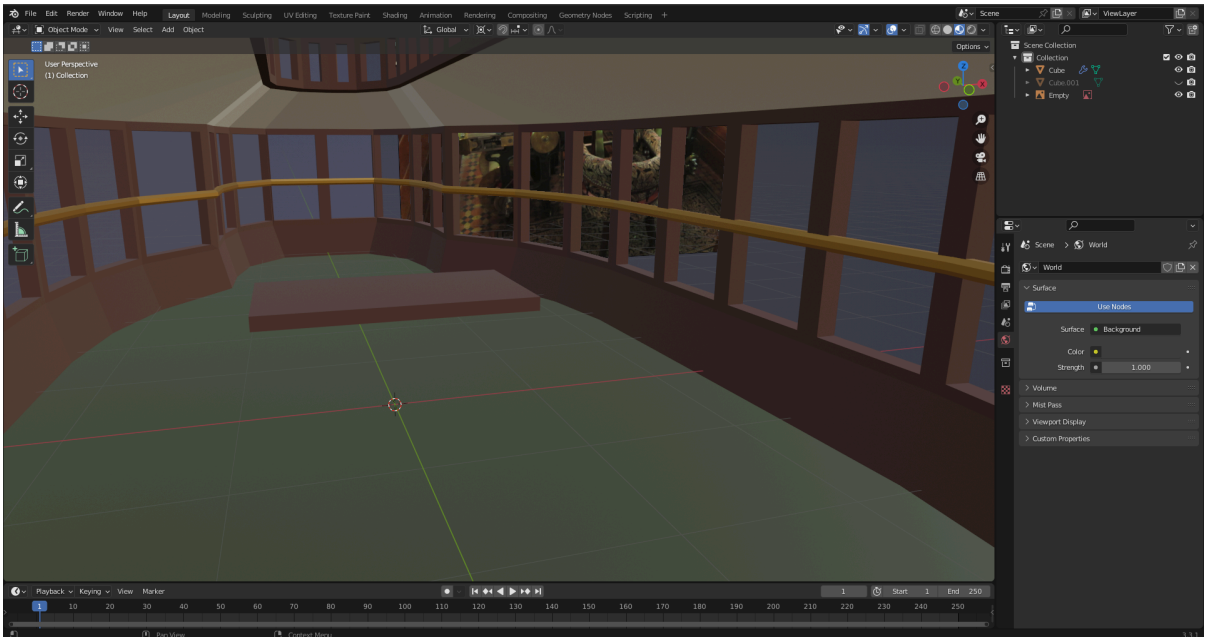
The NRM's recent *Flying Scotsman VR Experience* is very educational, taking users through the history and anatomy of the Flying Scotsman. The experience succeeds at providing information about the train while entertaining users with a multisensory trip through train stations and an engine. As the NRM now had an educational VR experience, I focused on creating a more engaging, memorable experience. The *Flying Scotsman VR Experience* is a hefty installation, operating out of a separate room with themed props and 12 VR headsets. Recognising the NRM's free entry and donation boxes around the museum, I added another requirement for a low-budget experience (NFR7). Requiring only a headset and a computer makes the project more financially feasible. The experience's shaking floor inspired me to add multisensory feedback to *Dynamometer Dash* with controller haptics, though I later reversed this decision (FR2).



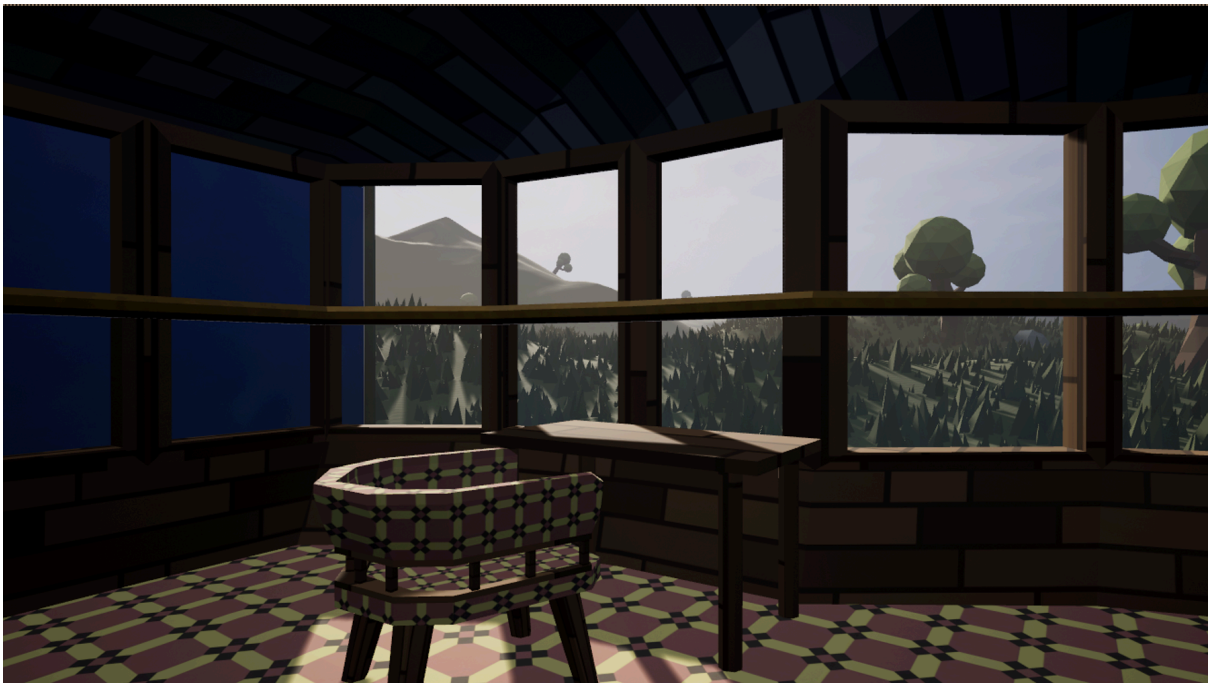
No Man's Sky, an unlikely influence for a train experience, was actually one of my biggest inspirations for the project. The visibility from inside the vehicles helps build a sense of speed in VR by allowing the player to see their surroundings. This is especially clear through the side windows in larger vehicles. *No Man's Sky*'s approach to vehicle models inspired me to model the Dynamometer Car with wide, visible windows on all sides of the car. While this required removing physical elements like walls and large equipment, the main table was unaffected. Having less equipment inside the train helps to push the player's focus toward the windows and the miles per hour display on the table (NFR1). I also removed the carriages that followed the Dynamometer Car during the Mallard's 1938 run to increase visibility from the back window. The back window was directly inspired by the circular spaceship cockpits of *No Man's Sky*; I added a chair at the window to encourage users to experience the open view it provides.

Development Process





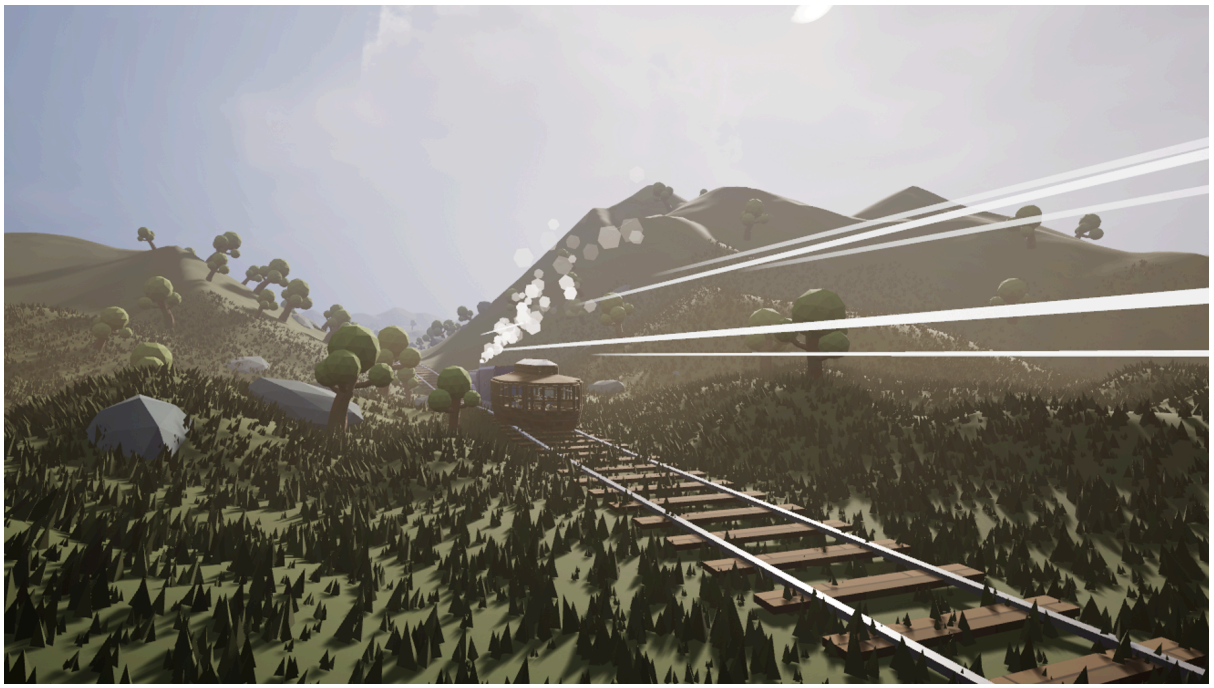
I created the wood texture, trains and environment assets in a cartoony, low-poly style to meet NFR3. The carpet texture is a recreation of the carpet inside the Dynamometer Car. The table that records the miles per hour is also a recreation of the Dynamometer's equipment for FR1; though I did not recreate all aspects of the car, I was sure to accurately represent this table as it is the centrepiece of the experience. I made the windows especially low to ensure small children could see outside (NFR4).



I designed the experience to be accessible for and inclusive of seated and hands-free users by placing the only relevant information, the miles per hour table, directly in front of the player's starting position (FR2). The user begins the experience at the chair's location, meaning seated users will not need to move to align with the in-world chair. They can also see out of the windows without moving. If a user wishes to navigate around the car but is physically unable to, an NRM staff member can move them using keyboard controls. There are two other chairs on the train to provide more locations for seated users. These chairs are angled toward different windows, allowing seated users to view the environment from multiple locations without breaking immersion.

I initially intended to include controller haptics to add a multisensory element to the project but decided against it. As haptics are known to drain controller battery quickly, I had trouble justifying them in the context of a simple, straightforward installation. Using controller haptics would also exclude users without controllers from experiencing the project in its entirety, which would fail to meet FR2. I also decided against using screen shake as many museum-goers would be new to VR and likely prone to VR-induced nausea (NFR2).

After many small changes, I successfully implemented a consistent movement speed independent of framerate or platform alongside a function to translate in-game movement to real-world miles per hour (FR6). This value only visually updates on the Dynamometer table a couple of times per second to improve readability and simplify the information given to the user. The train reaches maximum speed after 25 seconds and can complete a full circuit in under a minute so that users can quickly see all the experience offers (FR3). The train slows down in only 5 seconds to ensure the user can promptly pass the headset to the next queued visitor once finished.



To enhance the user's sense of speed, I created wind particles for a pseudo-speed-line effect (NFR1). I also added trees, rocks, and grass to the environment so users could see objects fly past the train. I created a track with tight turns and verticality to make the track more dynamic. I attempted to remedy some of the resulting nauseating effects by preventing the train from rotating up and down hills (NFR2). However, this caused more issues than it solved, so I left the rotation untouched. I was able to fix the most glaring bumps in the tracks but the issue still stands.

One final addition for NFR1 (and NFR6) was a text indication displayed when the train breaks the pre-Mallard record of 114 miles per hour.

I applied Nielsen's usability heuristics to ensure the experience would be fluid and easy to use. Rather than showing the user confusing lines drawn by pens, the miles per hour table displays an easy-to-read number. This meets Nielsen's heuristic for providing information in a way the user will be familiar with (Nielsen, 1994). The heuristic for minimalistic design came in handy when decorating the Dynamometer Car; I avoided adding extra Dynamometer equipment to keep users' focus on the miles per hour table and the environment outside (Nielsen, 1994). Following Nielsen's tenth heuristic, I provided users with help and documentation by displaying a tip near the table explaining how to start or stop the train (Nielsen, 1994). Ease of access is especially important for this project to keep queue times short.

Critical Reflection

Dynamometer Dash met its FRs and most of its NFRs. I successfully created a short VR train experience set inside the Dynamometer Car that is accessible for seated and hands-free users (FR1, FR2, FR3, FR4). The train feels fast (NFR1), supported by the display of its actual speed (NFR6), and should provide an exciting experience for non-enthusiasts and children (NFR4). Requiring just a VR headset and a computer, the experience is relatively low-budget and easy to clean between uses (NFR5, NFR7).

In its current state, the project fails to satisfy NFR3. I hoped to include a depth of field effect to make the environment feel smaller. I was unable to do this in VR due to technical limitations but would attempt to implement it in the future. I would also add an option for the user to increase their scale and view the model train and environment from above, though this could only be justified if queue times for *Dynamometer Dash* proved to be short enough (FR3). I also believe I misinterpreted the accessibility aspect of the project in some cases by limiting user actions rather than adding more options for all users. The experience would benefit from optional features like additional Dynamometer equipment for train enthusiasts or lowering the windows' blinds to reduce nausea. NRM staff could toggle these features on user request.

The project includes other issues that need resolution before a museum installation. If the player starts or stops the train before it has reached its target speed, it will jolt to its target speed immediately. This speed jump becomes apparent when the player accidentally stops the train and wants to start again or if they wish to stop moving early on. The speed and jolting of the train are nauseating. I can confidently say that I did not meet NFR2 as *Dynamometer Dash* is the first VR experience to upset my stomach. I would improve this by removing the tight turns and verticality from the track as well as limiting the train's rotation speed. I would also implement a customisable maximum speed to keep the experience from overwhelming users; this would help the project meet Nielsen's user control heuristic (Nielsen, 1994).

Overall, I am satisfied with my result. While I worry the project's failure to meet NFR2 will make users uncomfortable, I believe the experience is a solid starting point from which I could iterate and improve. With more user control features and further usability testing, *Dynamometer Dash* could become a worthy addition to the NRM.

Word Count: 2376

References

Altfuture (2019). *Derail Valley*. [Video game].

Gaugepunk (20168. *Rolling Line*. [Video game].

Hello Games (2016). *No Man's Sky*. [Video game].

National Rail Musem (2023). *Flying Scotsman VR Experience*. [Virtual reality experience].

Nielsen, J. (1994). *10 Usability Heuristics for User Interface Design* [Online]. Nielsen Norman Group. Last updated: 15 November 2020. Available at: https://www.nngroup.com/articles/ten-usability-heuristics/ [Accessed 28 March 2023].

NRM_PostVisitSurveys_January22OpenResponses (2022). [Online]. National Rail Museum. Available at: https://docs.google.com/spreadsheets/d/1vmn5m_e8ae_bHmglefmE3aYXCvZtU0o1/edit?usp=sharing&ouid=113417064039468825763&rtpof=true&sd=true [Accessed 19 March 2023].

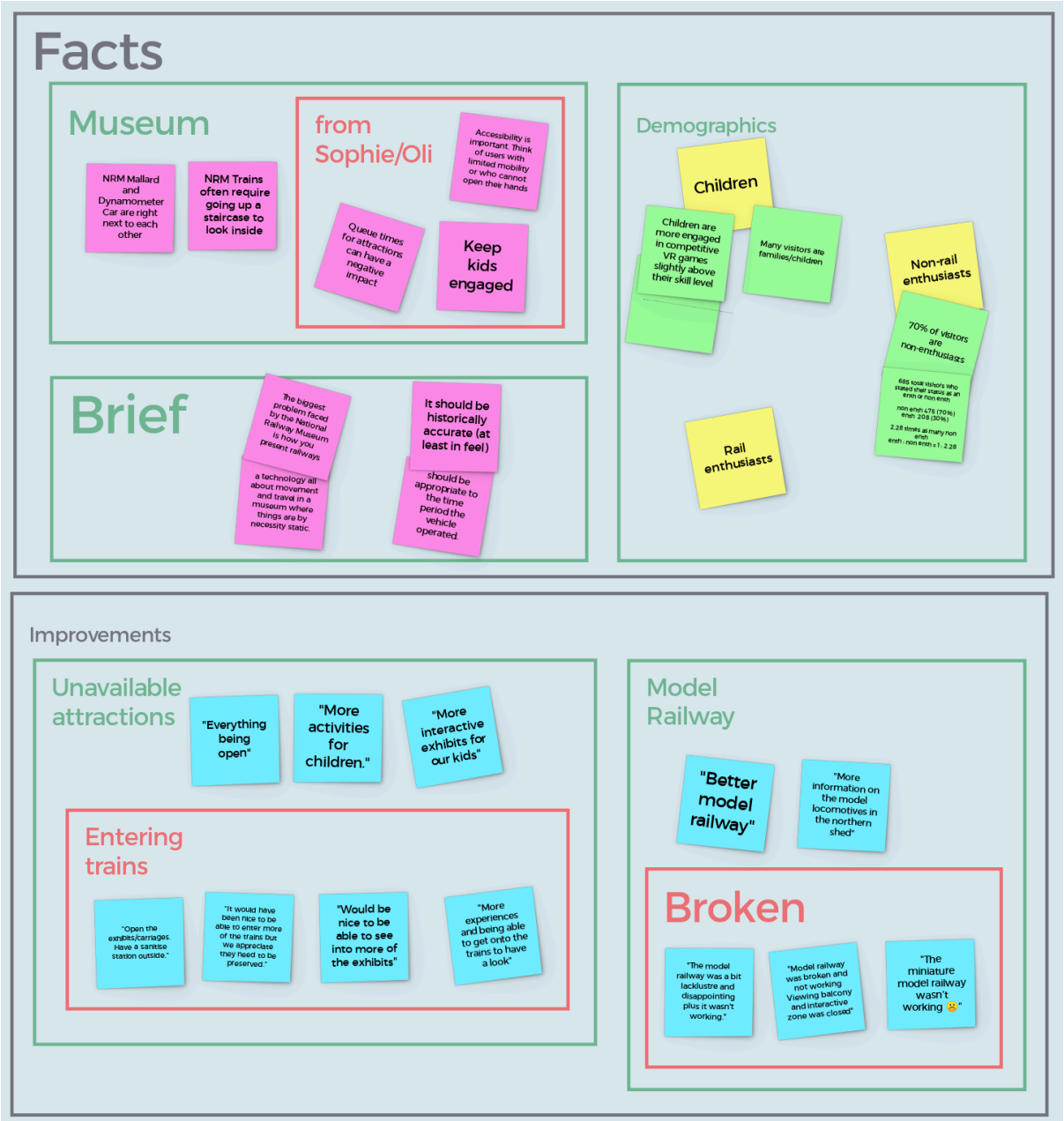
Samaddar, S. (2023). Lecture: *Assessment 2 Briefing*. York: University of York, 27 February 2023.

Appendices

Appendix A - Copyright Appendix

Description of Asset	Source	Location on prototype	License
Steam engine whistle sound	https://pixabay.com/sound-effects/emmentaler-steam-train-33423/	Played when the train starts and continues moving	Pixabay License
Train on railroad sound	https://pixabay.com/sound-effects/train-railroad-traffic-sound-8002/	Played when the train is moving	Pixabay License

Appendix B - Affinity Map



Appendix C - Primary Persona

Primary Persona

Name: Charlie Childson
Age: 8
Opinion on Trains: Doesn't care
Quote: "Old stuff is so boring!"
Bio:

Charlie spends his time at home on his iPad watching YouTube videos. He likes chicken nuggets and Sonic the Hedgehog. Charlie's parents like to take him and his sister to historical sites and museums in the North Yorkshire area, but Charlie is rarely interested. He also tends to get bored and carsick on long drives.

Wants:

- Kid-friendly way to appreciate museum visits with his family
- Exciting, fast-paced games

Dislikes:

- Motion sickness
- Lots of information about topics he isn't interested in
- Waiting his turn

Photo from https://stock.adobe.com/uk/search?k=%22bored+child%22&asset_id=10255546

Appendix D - Secondary Persona

Secondary Persona

Name: Lucy Locomotive
Age: 53
Opinion on Trains: Enthusiast
Quote: "I would love to see the interior of historical trains for myself."
Bio:

Lucy is a model train collector who collects replicas of famous trains. She lives in London but visits the NRM at least twice a year to admire the trains. Lucy uses a wheelchair and is very careful about her health; she usually avoids touching surfaces in public spaces. She is inexperienced with newer technology like VR but loves researching trains on her laptop.

Wants:

- First-hand look inside the NRM's trains
- Cleanliness

Dislikes:

- NRM's staircases to see most trains' interiors - inaccessible to her
- Model trains being broken

Photo from https://www.pinterest.com/pin/539939442807319562/

Appendix E - Functional and Non-Functional Requirements

Functional Requirements (FRs)

1. Users feel like they are inside the Dynamometer Car
2. Accessible for and inclusive of seated users and users not using their hands
3. Experience is brief, ideally less than a few minutes long
4. VR experience

Non-Functional Requirements (NFRs)

1. Users feel fast
2. Nausea-prone users are comfortable
3. Experience is themed like a model train set
4. Non-enthusiasts and children are engaged and gain a new appreciation for the Dynamometer Car and/or trains in general
5. Equipment is easy to clean between uses
6. The train's speed is displayed accurately on Dynamometer equipment
7. The experience is low-budget and easy to implement