FUTURE PASSENGER

Mobile, Public, and Locative Media
A Study of Mixed Reality Narrative, Interface, and Content to
Engage Train Passengers

By

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Future Passenger

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Abstract

Google Maps and other living maps (e.g. *CartoDB*, *Mapbox*, and *Open Street Map*) provide an underlying platform for ever more creative, networked, and performative mobile experiences (Dalton, 2015). Furthermore, immersive technologies like augmented reality (AR) provide a spatial paradigm to further connect us to our immediate surroundings. Combining these locative and spatial technologies offers new ways to engage with public spaces (Liao & Humphreys, 2015).

This practice-based PhD research aims to use a mobile AR project, *Fantasia Express*, funded by the *UK Ministry of Transport*, to investigate a new concept that I call hybrid public space, one that is defined by an interdependent locative digital layer linked to a physical twin. In doing so, I want to create new knowledge that has value to both the creative industries and academics looking to understand the convergence of immersive technology with location and publicness.

As a theoretical framework, this thesis considers the insights into the social impact of AR and other technologies, such as their potential to enhance our experience of public space and each other to create a 'community of strangers' (De Waal, 2013). My methodological approach encompasses several elements, such as an extensive literature review, developing complex software prototypes, and testing these prototypes with train passengers travelling on the *East Coast Mainline*.

My findings summarise a new approach and design process to develop interfaces for immersive locative projects, new technical approaches to integrating immersive technologies within the existing information technology found on board UK trains, and new production approaches to speed up the iteration of complex software prototypes.

Keywords: Hybrid public space, hybrid space, digital public space, augmented reality, virtual reality, real-world metaverse, living maps, data narratives, soft data, amplified presence, passenger, trains

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Dedicated to Phillip Wood and Si Spencer, two Giants whose shoulders I stood on to write this thesis.

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Chapter 1
INTRODUCTION

Imagine taking a trip on the classic *Orient Express*,[1] one of the world's most evocative railway journeys. And then imagine reading a book about the *Orient Express* on that same journey. Does reading the text in this scenario lead to an increased resonance with both the story and the experience of the train journey?

This scenario lies at the heart of my creative interest and research. How can introducing an external and related element to one's present circumstance help to amplify our experience of and connection to place at that moment? In this thesis, however, my research focuses on more than just the cognitive reading of a book but on adding a digital, contextual layer to an otherwise ordinary train journey.

Why is my PhD thesis called *Future Passenger?* I would argue that we are at a tipping point and about to enter an age where augmented reality (AR) and personal location-based services will completely change our travel experience. One of the frontiers of this change will be when we are *waiting*. Travelling by train is often an experience of waiting for our destination. For example, waiting time may be 'interstitial time par excellence in contemporary Western societies' (Gasparini, 1995, p. 29). Travel is one of the most common interstitial times, as it is one of the few occasions where we are free to engage with new experiences as our context with location changes around us.

> I like trains. I like their rhythm, and I like the freedom of being suspended between two places, all anxieties of purpose taken care of: for this moment I know where I am going (Mead & Matthews, 2017, p. 129).

Anna Funder takes a positive view of this in-between time, and her description above resonates with my research intent to find ways to enhance the passenger experience.

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[1] More good information about this iconic train and journey can be found on popular sites online. Please see, for instance, this article describing the Orient Express https://www.smithsonianmag.com/history/true-history-of-the-orient-express-149702768/.

1.1. Context

Before I expand on my research, I want to set out some brief context. My professional history is split between working for many years as a designer in the creative industries for a large digital media agency and running an art practice where I create public technology-driven installations. This gave me a good grounding for some of my PhD's practical aspects and helped me understand and place the commercial and industry value and potential impact of the new knowledge I was generating.

1.2. Background

As a practice-based PhD, most of my research involved prototyping and covered eighteen months from January 2018 to May 2019. I was fortunate to win a grant of £350,000 from the *UK Ministry of Transport* to explore my ideas of engaging passengers on inter-city trains with location-based augmented reality experiences. The funding was awarded as an open call for people to propose new ideas for the rail sector. It was under the theme of *First of a Kind,* with the winners having twelve to eighteen months to deliver and test a prototype with the public on a live rail service.[2] I detail the implications of this grant later in the chapter when I discuss my research aims.

Project

The creative inspiration behind my grant proposal and research aims was the *Bewegtes Land (Land in Motion) Project* (2017).[3] This was an art event whereby four hundred residents volunteered to act out whimsical theatrical vignettes in the landscape. It occurred along a nineteen-mile stretch of rail track in Germany's Saale Valley**.** These short performances included everything from running bushes to a shark emerging from a lake and startling people in a canoe. Each vignette would be triggered by a passing train and was designed to entertain passengers looking out of the train windows.

I felt this theatrical site-specific performance could be reimagined using digital and immersive technologies. To make the experience scalable and flexible, no need for four hundred human

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[2] For more information of the grant and funding body, please follow the link. Available online: https://railtalent.org/blog/tomorrows-trains-today-funding-announced/.

[3] Please see this informative link to an article describing the aforementioned *Bewegtes Land Project.* Available online: https://www.theatreartlife.com/artistic/bewegtes-land-an-art-project-for-train-passengers/.

volunteers or to be restricted to a small section of the German track. It was also an opportunity to connect people contextually to the passing landscape. I liked the imaginative and quirky approach of the *Bewegtes Land Project,* which was also a good strategy to appeal to a diverse audience and generate interest.

Knowledge Gap

My research investigates turning the public space of a train carriage into an immersive experience, which engages and connects passengers to their locations and each other in new ways. The fact that rail industry specialists funded this idea as a first-of-a-kind indicates that my research is exploring new territory. But understanding how much new knowledge this particular scenario represented and, importantly, the value required further investigation.

This thesis argues that a train carriage represents a public space. And I am introducing augmented reality, locative and contextual experience into a train carriage. If you take these core elements of public space, locative media, and augmented reality, individually, they all have large bodies of scholarly research behind them. I asked myself to what extent my combining these elements represented new knowledge greater than the sum of its parts. I also wanted to understand to what extent the knowledge I was generating could not be found by simply reading the existing literature on each constituent part.

A large body of academic work exists describing physical and digital public spaces (See Chapter *2*). However, more needs to be researched about when the digital and physical share the same space and context. Recontextualising these individual disciplines in light of their spatial convergence is a recent approach. Immersive hybrid space is most popularly represented by *Niantic,* the developer of *Pokémon Go* (the fastest mobile game to reach $1 billion in revenue and 650 million downloads). *Niantic* frames its public use of augmented reality as a fundamental pillar of the *Metaverse* or, more specifically, what it calls the *Real World Metaverse* (Niantic 2022). My research sits firmly within this field. When I started my PhD, *Metaverse* was an obscure reference in the novel '*Snow Crash*' (Stephenson, 1993). However, it is now one of the most discussed technology terms and what many consider the evolution of the internet or what is also being called Web 3.0.

> [...] in our vision of the Web 3.0, we foresee a scenario where such ubiquitous technologies will create a convergence of real and virtual environments, where the user will seamlessly interact with humans and machines either through

virtual means or in the real world (Silva, Mahfujur Rahman, & El Saddik, 2008, p. 5).

This augmenting of physical space with a digital layer is a central strand of the *Metaverse* (Huansheng, Hang, & Lin, 2021, p. 17). My research into hybrid public space adds a contextual element that creates a narrative or thematic connection between the augmentation and the physical location. I believe this will be an essential part of hybrid space. In this sense, my research provides much-needed insights into these broader phenomena.

As my PhD progressed, I noticed that many of the technologies behind my research (such as 5G networks, smartphones, machine learning and computer vision) are being pursued and championed by the likes of *Apple*, *Facebook,* and *Google,* amongst others. Moreover, the fact that I have identified a knowledge gap in this area, I would argue indicates that my research has value.

1.3.   Aims and Objectives

The research grant and my thesis aims are closely intertwined, yet they also differ in specific ways. My grant aim, supported by a small team, was to test different types of location-based immersive content within and outside a fast-moving train carriage. My grant objectives were exploring the practical, creative, user and production challenges such a technical problem would present through creating prototypes. The grant's aims and objectives were rooted in the technical challenge of presenting immersive content to passengers on a live train. My scholarly research aims, and objectives were about researching the creative application of location based immersive experiences to engage train passengers and their potential impact.

Key objectives

- To develop an overall narrative that was flexible enough to support a series of different experiments. The resulting *Fantasia Express* prototype was a two to four-hour multi-location-based experience designed for train passengers' mobile devices. That punctuated their journey with short immersive and other locative media experiences related to local myths and legends.

- Research and design new interfaces suitable for passengers' mobile devices that supported various locative and immersive media types.

- To explore the technical, production and deployment impact of integrating immersive technology within and outside a train carriage.

- To explore the potential technical and sociological impact of locative and immersive media within the public space of a train carriage. Reimagining the connection between our mobile devices, ourselves, and public space.

- To publicly test the technical prototypes on the London to Edinburgh mainline service for two weeks in March 2019 (Fig 1).

Fig 1: *Fantasia Express* public test, March 2019: Graphic by author.

1.4. Research Questions (RQ)

A train carriage offers a peculiar set of circumstances to engage passengers and connect them to their locations and other passengers. We rarely find ourselves close to strangers for such an extended period. It is also rare to sit at a table while the world moves swiftly past through the panoramic gaze of a window. These circumstances acted as the framework for my research questions. My grant-funded project refined this framework into three distinct areas: *narrative*, *interface,* and *content*.

1. **XR (Mixed Reality) Question:** What creative opportunities and technical challenges arise when aiming to present a mixed reality experience in the spatial and geographic context of a train carriage? I am referring here to, for instance, placing augmented reality artefacts on the train window, within the panoramic landscape, within the carriage or on the table.

2. **Interface Question:** What interfaces can engage train passengers with innovative mobile locative media content? And what potential new interfaces are needed to deliver this content successfully? For example, how can dynamic data, networked GPS and living maps support this content?

3. **Narrative Question**: What potential new narratives can engage train passengers with locative experiences? How can a locative narrative experience provide a beginning, a middle and an end to a long intercity journey? Furthermore, how can this be formulated so that the experience would make sense regardless of the direction of travel or intermediatory stops where a passenger embarks or alights?

These three research domains were, in practical terms, interrelated. By splitting these up into distinctive parts and questions, I was able to investigate these through a combination of testing and evaluating practical prototypes and scholarly research. The chapter structure I developed for this thesis corresponds with the research questions mentioned above. Chapters 3, 4 and 5 relate directly to these questions.

1.5. Methodology

As a practice-based PhD, my methodology encompassed traditional scholarly methods alongside a practical design-led approach to developing complex software prototypes. I shall address my scholarly methodology first before detailing my design by practice. I then reflect on what I learned from building a thesis around complex software prototypes developed to run on a scheduled mainline train service.

Scholarly Research Methods

Literature Review and Critical Precedents:

After identifying the key themes behind my research questions (locative media, digital narratives, immersive technology, interface design and the experience of travelling by intercity

train), I undertook a literature review. I looked for references and quotes related to these key themes. This gave me an initial taxonomy of keywords and sub-themes, which I further refined in response to my prototyping and critical reflection. This led to a more focused literary enquiry and the formulation of many original ideas representing my key findings and new knowledge. Because my research involved looking at the latest developments in immersive technology, I included many creative projects and artefacts as part of this review to support my scholarly methodology, to place the *Fantasia Express* amongst similar works and, critically, to find gaps in knowledge.

Interviews of Passengers/ User Testing:

I designed two formal and ethically reviewed user testing methods combining surveys and personal interviews. The first was an initial in-person survey of train passengers to understand their thoughts on my research and to support the discovery phase of my design process. The second was during the final public live testing on the London to Edinburgh service. This was to gauge my prototypes' impact and engagement and gain qualitative opinions from my target audience.

Practice-Based Methods

User-centred Design Method (Creative, Technical & Implementation)

There are two common scenarios and methodological approaches in the creative industries to address the practical challenges I faced with the *Fantasia Express*. The user-centred design approach follows a formal academic design process (using one of many similar systems such as *Ideo* or *Stanford* methods). This is a method used to prototype, test, and validate innovative ideas. The second common scenario is the production process applied to building these prototypes. The production process is designed to deliver industry standards, minimise risk, keep to timescales, and ensure a rigorous, stable, and quality delivery.

From research and innovation (creating new knowledge) perspective, I was keen to pursue a user-centred design process. From the standpoint of creating complex technical prototypes suitable for passengers travelling on a busy scheduled train, on the other hand, I wanted the reliability and quality of a production process. Since I needed the best of both approaches for my project, I had to devise a new methodology for the *Fantasia Express* that allowed for agile iteration and robust, technically complex prototypes.

Gathering and Organising a Team of Experts,

Securing funding to develop the *Fantasia Express* allowed me to bring in experts, create complex software, and push the scope of my technical and creative research.

I had to find a way to assemble a team with the authority, budget, and skills to make and act rapidly on decisions and insights. The most critical factor in achieving this was having what would traditionally be the client as a core part of the creative production team. This allowed me, something unusual in similar commercial projects, to have both the responsibility of a traditional supplier with the authority of the client. This meant I could make bold and quick changes based on a meaningful understanding of all aspects of the prototype development.

To do this, I placed myself with a technical architect at the centre of the project, creating a core team with oversight and authority on all the work streams. When necessary, I could quickly bring in experts if I felt that an area needed more attention. The core team was complemented by two specialist agencies that could be tasked with some of the heavy content production. This allowed for iterative and informal testing of simple prototypes to prove ideas that could be pushed to the agencies, who would undertake more of a production process to create the final complex public prototypes.

Having the client integrated into the team also resulted in a more collaborative dynamic instead of adopting a typical client/supplier relationship. This worked because I had core technical and creative generalists steering the project who, although not proficient in all aspects of the work, understood the principles enough to make informed decisions.

Informal Testing

I employed an informal user testing process to help with the development process and refine the interface design. This involved testing regularly with a random selection of people. Krug strongly advocates that simple regular testing of a small test group will identify all of the main usability issues (Krug, 2000).

AR Programming (Tech Innovation; Understanding Limitations)

The first strategic technical decision was to make the core technology system architecture standalone and independent. My prototypes had to work on what I would call the hostile environment of a live scheduled train service on a predetermined two-week period. Although

my prototypes were designed to integrate with the train's onboard systems, I made a standalone system that provided all the essential core services. Not having to depend on a third party for the success of the project removed a critical risk; it also meant that I could iterate very quickly in the development stages and not rely on the third party to push updates to the onboard systems.

The second addressed a challenge to creating immersive augmented reality mobile applications. Using augmented reality on mobile devices (when I undertook my research) necessitated the development of a native mobile application. The issue with mobile applications is that any minor modifications require a full recompile, republishing, and updating on the device.. My method to address this challenge was to uncouple the immersive content (that had to be a native app) from everything else. This meant that the prototype consisted of two elements the native app that contained the rich media assets and AR functionality and a web-based interface that included the core interface, interactive and locative elements. Updating the immersive element could take a day, whereas updating the web-based content could take minutes.

Reflection

Two aspects of this project had the most impact on my methods. Firstly, the *Fantasia Express* would be publicly tested on a busy, scheduled inter-city train service. And secondly, being awarded funding meant I had the budget to create, organise and structure a team.

Many of these challenges are detailed in Chapter 3, And most involve technical or bureaucratic difficulties or, in some instances, a combination of both. Notably, many of these challenges were not simply a result of a practice-based approach but the additional complexities of creating prototypes designed to run and be tested on scheduled mainline train services.

One example was when I had to change my plans to use passengers' mobile devices for location and data. I instead looked at integrating them into the trains onboard IT hardware. I collaborated with *Icomera* (the company responsible for this hardware) for several months and fully understood how we could use their onboard systems. Their technology supported everything I needed, but their internal processes and bureaucracy introduced a time and resource bottleneck. It became clear that this approach would add significant risk and dependency to the project, and I eventually decided on an alternative and independent method. *Icomera* needs to prioritise the safety and reliability of its onboard systems. They have multiple stages of safety and testing processes that make deploying new software long and complex. Decoupling my project from its dependency on *Icomera* allowed me to test and update in minutes instead of days.

Another example, the task of speaking to a train passenger, highlights the extent that project management and organisational skills became key to successfully running the *Fantasia Express*. This seemingly straightforward task required organising an ethical review and liaising with multiple departments within *LNER*. I had to get approval from the marketing department (that was my primary contact). They would then get approval from the operations side to issue passes. Then I had to organise a time when a representative from the train company was available to accompany me and inform the onboard staff.

Overcoming the methodological restrictions and challenges of testing prototypes on passengers (both technical and interpersonal) surprisingly created more insights and research outcomes than the results of the final public testing.

1.6.   Thesis Structure

This introduction chapter introduces the scope, overall themes, methodology and research area. I then place this into context with similar projects and literary references in Chapter 2. Answering my research questions is covered in Chapters 3,4, and 5 and constitutes the main body and the bulk of this thesis. In the last part, Chapters 6 and 7, I look at the final execution and public test of the *Fantasia Express* on a scheduled passenger service from London to Edinburgh before concluding the thesis by reflecting on my findings and the impact of my research.

Introduction: Setting the Scene

The introduction: follows a standard PhD thesis format: establishing the context, background, and influences of my research topic. Then identifying where there is a gap in knowledge and the importance and impact of my research area. This leads to my specific research questions, aims and objectives and methods.

Main Body: Investigation of RQs: Scholarly Research and Prototyping

Chapter 3 details the practical and operational challenges of introducing immersive technology onto a fast-moving train carriage. It sets out the technical system architecture and conceptual approach I developed for the *Fantasia Express*.

This leads to Chapters 4 and 5, forming the thesis's most substantial part. Here I go into detail to answer my core research questions around what creative interface and narrative opportunities are there to engage train passengers with locative and immersive content. Each chapter follows

a similar structure, starting by defining the topic within the context of my research. Once this is established, I then expand on the relevant subthemes I detailed in my literature review. I then go into the methodology, approach and thinking behind how this applied to my practical prototyping with the *Fantasia Express* before ending each chapter with some reflection.

Chapter 4 explores what mobile and locative interfaces are suitable for presenting immersive and locative content to passengers. It then details the design and production processes I used to create the interfaces for the *Fantasia Express*.

Chapter 5 looks at technology-led *narrative* approaches suitable for a passenger experience, traditional, data-led, and location based. l then detail the creative story world behind the *Fantasia Express* and how this complemented the narrative anatomy of a train journey. Furthermore, I explore the development of a high-level story world that is flexible enough to support a wide collection of location-specific micro-narratives. Last but not least, I will discuss the creative story development behind the *Fantasia Express.*

Conclusion: User Research, Findings and Reflection

The last two chapters focus on my user research approach and the public testing of the *Fantasia Express*. I analyse the results of this research and reflect on the importance and potential impact of my technical prototyping and scholarly analysis of my PhD studies.

In Chapter 6, I focus on the project's final execution and a subsequent public test of the *Fantasia Express* on a scheduled passenger service from London to Edinburgh. Here, I shall consider the challenges of deploying and testing a public prototype on a busy train. In doing so, I will explain the logic behind my user research and discuss the results from my observations, surveys, and interviews from both a passenger and a train operating company perspective.

In the final chapter, entitled *Conclusion, Findings, Public Impact and Reflection,* I consider the impact of my work and discuss my findings and final thoughts on both the practical and theoretical research. I reflect on what this might mean for the future of hybrid public space in a passenger context and for future passengers and what I want to take from this process.

Chapter 2
LITERATURE REVIEW

This literature review is split into two parts: one focusing on artistic practices and artefacts relating to my work and the second on the more traditional theoretical, academic, and literary references of my key themes. As my practice-based PhD is centred around a large body of practical developmental research, it was important to include a review of similar practical projects and the current technical landscape within my research area.

2.1.   Artistic Practices and Artefacts

My research prototypes combine mobile-based locative media and immersive technology. This section presents an overview of practical examples and what they represent in my research (Fig 2).

Fig 2 Reference of related projects: Graphic by author.

The advent of GPS-enabled phones has given rise to what is referred to as locative media, particularly the notion of media that blurs the boundaries between the physical and virtual worlds. This media uses geo-tagging to augment people's experiences of real locations with additional contexts (Bilandzic & Foth, 2012, p. 66). Ben Russel anticipated the rise and impact of locative media in his influential book *The Headmap Manifesto* (Russell, 1999). In it, he lists a sequence of text fragments that imagine media that shifts from placelessness to situatedness (Foth, 2011, p. 11). This is media that can no longer be accessed anytime and anywhere but only through location or situation:

> Location-aware, networked mobile devices make possible invisible notes attached to spaces, places, people and things. the headmap manifesto articulates the social implications of location-aware devices (Russell, 1999, p. 3).

My research is situated broadly within this area of creative locative media. I have been looking for projects addressing locative media in imaginative, participatory, and insightful ways. For instance, projects like *Hello Lamp Post* (2013), a Bristol-based *Playable Cities* award recipient, encouraged the public to exchange messages with street furniture using *QR* codes, *SMS,* or *Facebook Messenger*.[4] People could enter a conversation with the street furniture and find out more about the area. Or *Yellow Arrow* (2004-2006), an art project that encouraged the public to place yellow arrows onto the urban landscape along with a message that could be accessed via the web.[5] The project initially launched in Manhattan's Lower East Side; however, by the time the project finished in 2006, 7535 *Yellow Arrow* stickers had been placed in 467 cities and 35 countries. Both *Hello Lamp Post* and *Yellow Arrow* imbue the ordinary and everyday with a personality. *Hello Lamp Post* takes the approach that the object is the protagonist engaging the public into dialogue using storytelling to inform them of historical and interesting information about an area. With *Yellow Arrow,* the agency and the storytelling originate from the public, who leave their marks on the city to express their emotional connection and memories of place. I would argue that the novelty and surprise of seeing something we take for granted being repurposed help amplify the experience. Also, by associating the media to a specific location, we are giving a digital artefact the qualities of a physical one. This elevates it from an infinitely reproducible digital file to an individual commodity. The most insightful elements of locative media for my research are the serendipity, the unusual context, and the rarity of only accessing the content in a specific circumstance.

My project's next main area of research was augmented (AR) and, to a lesser degree, virtual reality (VR). Although they form part of a similar paradigm, it is important to understand the difference. A VR environment is one where the participant is immersed in a synthetic world that may or may not mimic the properties or obey the physical laws of the real world. AR, on the other hand, places artificial elements within the context of the real world. These synthetic elements are not limited to the visual spectrum but could include sound, smell, and touch. Milgram suggests it is convenient to consider VR and AR as lying at opposite ends of a continuum (Milgram, Takemura, Utsumi, & Kishino, 1995, p. 3) (Fig 3).

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[4] For further about *Hello Lam Post* information please see project website. Available from: https://www.hellolamppost.co.uk. Learn more about the *Playable Cities* initiative, please see: https://www.playablecity.com/

[5] For more detailed information on *Yellow Arrow* in the public domain, please see: *Wikipedia* https://en.wikipedia.org/wiki/Yellow_Arrow
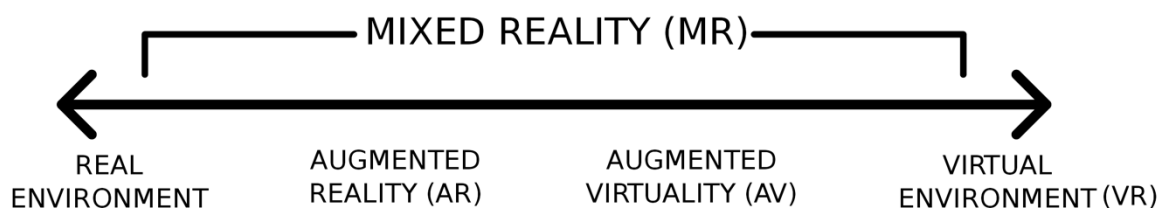
Fig 3 Milgram's Reality-Virtuality Continuum: Graphic by Giovanni Vincenti

My research concerns the application of VR and AR experienced through a user's mobile device. A classic example of a mobile AR experience is the influential and commercially successful *Pokémon Go* (2016). This combined locative media with augmented reality and was a game that brought AR into the public consciousness. It is the project that people mention most when I discuss my studies. Although an excellent example of locative media and AR, it lacks one crucial element to my research. It is what I argue is the difference between the common understanding of hybrid space and the new term I am proposing hybrid public space. *Pokémon Go* is a location-based augmented reality game, but the location is arbitrary; there is no direct context with the user's location. Zammit and Kenna highlight this disconnection and lack of context between reality and the augmentation in the following:

> We can let people hunt for Pokémon anywhere, including, for example, in a religious building or a cemetery, but do we really want to, and why? What does it mean for that place, for how and why it was designed, and for its character, cultural and practical functioning, and its raison d'etre (Zammit & Kenna, 2017)?

The above quotation raises the point that the location is merely a prop for the game. *Pokémon Go* is an example of a locative digital layer that, although location based, has a narrative independent of its location. My research focuses on hybrid public spaces using AR, where the narrative of the digital layer and physical location are interdependent. The virtual and real must share context beyond simply happening in the same location.

Finally, my research is centred on the passenger experience, an area that has yet to undergo much scholarly research. I found one interesting study that looked at the potential of VR as inflight entertainment, which recommended three challenges that VR applications need to consider within the context of air travel:

> The survey gave us three design directions for an in-flight entertainment application; to reduce the movement required to interact in VR, to provide users in VR peripheral awareness of their physical environment, and to enable interruption

without requiring any physical contact (Williamson, Mcgill, & Outram, 2019, p. 11).

All three of these design directions address the specific scenario of a cramped aircraft. It is unwise to have people flailing their arms around whilst wearing a VR headset near other passengers. Also, the ability of flight crew to interact with people without the need to touch them is essential to the safe operations of a passenger aircraft. I am interested in their discussion of allowing people to have some peripheral vision of the real world whilst wearing a headset. One of the major strengths of a VR headset experience is placing the user in a fully immersive environment, and including the real world, even if only peripherally, compromises this.

One of the assumptions I made about using headsets on a passenger train, (similar to Williamson et al research), is that people would find it socially unacceptable to wear a headset in public. Wearing a headset cocoons you from your visual and audio surroundings, making you vulnerable to other people. However, my survey conducted directly with train passengers found this was not a problem. This finding was important as I had not intended to include a VR experience in my prototyping, and as a result of this survey, I changed my mind. The resulting VR prototype turned out to be one of the most popular in the final live public testing.

Although I could not find many practical examples and even fewer scholarly articles on passenger experiences, most examples I have presented so far have been designed for pedestrians. I did discover some notable vehicle-based projects. One example is Volkswagen's *Snelweg Sprookes* (2019), a collection of audio stories for car passengers triggered by objects along routes such as bridges, windmills, trees, and petrol stations.[6] *Holoride* (2019) is another interesting approach to an immersive passenger experience.[7] It is aimed at backseat passengers and uses a virtual reality headset connected to the vehicle's telemetry. This feeds into the VR gameplay so that the physical and gravitational forces of the vehicle accelerating, braking, cornering etc., are transferred into the VR game in real-time. Their tagline is 'turning vehicles into moving theme parks', which resonates with my intention with the *Fantasia Express* to imbue a narrative entertainment experience into a typical train journey.

Not all mobile, locative experiences are, of course, digital. One of the simplest analogue travel games is *I Spy,* first mentioned by Rosamond Lehmann in her post-war stories called *The Gipsy's*

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[6] To see an industry article about the *Volkswagen* project, please visit https://www.thedrum.com/creative-works/project/achtung-volkswagen-snelweg-sprookjes-road-tales.

[7] To visit the website of *Holoride* please use this link https://www.holoride.com/en.

Baby (1946). This classic travel game amused generations of travellers, including my siblings and me, as a child on long car journeys.[8] It is a simple game whereby people take turns to say, 'I spy with my little eye, something beginning with...' They then tell the first letter of something they can see through the car window, and the other players take turns guessing what it is. This simple analogue game achieves many of the experiential objectives I wanted to accomplish with the *Fantasia Express.* It connects people to the passing landscape through a shared experience and is engaging and enjoyable.

So far, all the examples I have described take elements of locative, immersive, contextual and passenger experiences. However, I found only two other projects that combined all of them. *Sea to Sea* (2019) was a research project by the *IOU* theatre company based in Halifax, Yorkshire.[9] They developed a mobile app for a train journey from Scarborough to Blackpool. At every station, the passenger hears (and arguably imagines) a new passenger-come-storyteller board the train and sit opposite them. In the time it takes to reach the next station, the storyteller describes their thoughts triggered by the view they share from the moving carriage window. It is an audio-only experience, and I serendipitously discovered it when one of the producers contacted me after hearing about the *Fantasia Express.* Although audio only, the basic premise, objective, and creative treatment share much with my research.

The second notable project was Eurostar's *Odyssey* (2017), a 360-film experience presented to passengers travelling under the English Channel. This experience seemingly transformed the train's roof into a glass ceiling to reveal an imaginative underwater scene. Passengers were given a simple cardboard device to place their mobile phones in to create a virtual reality headset. I did have some conversations with *Eurostar* about this project, but I felt it took a very different approach than mine. *Odyssey* addressed a specific scenario designed around an approximately twenty-minute section when the train is underground. It is a re-imagined underwater animated film with no connection to the English Channel. In contrast, I created a VR film for *Fantasia Express,* which combined a 360 film from the driver's cab with an alien train driver (Fig 46). Combining real footage of the journey with a computer-generated alien produced an immersive experience that was much more of a simulation of the actual route and, therefore, closer to my own research aims.

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[8] For more detailed information on the *I Spy* game please see this *Wikipedia* article https://en.wikipedia.org/wiki/I_spy#History.

[9] *IOU Theatres* page describing *Sea to Sea* https://ioutheatre.org/process/research-development-item-2/.

2.2.   Scholarly Literature Review of Key Themes

My research questions are about narratively engaging train passengers with locative, contextual and immersive media. This section takes these high-level research topics and explores them through a literary enquiry of several key sub-themes that emerged from my research activities. I return to them in more detail in context with my practice in the *Interface* and *Narrative* chapters.

Firstly, public space (physical, digital and hybrid) is reviewed and compared to ideas of place and publicness they share with a train carriage. Secondly, I look at amplified/digital presence as the impact and result of augmenting place. Thirdly I briefly discuss living maps/living data as the technological underpinnings of the creative locative experiences I explore. Finally, I turn to *The Railway Journey (Schivelbusch, 1986),* in which I compare my thoughts on the potential of hybrid public space with the way he describes the transition from horse and carriage to steam train impacted society and our connection to nature.

Public Space (Hybrid, Digital, Physical)

My research relates to passengers on a train carriage operated by a private company. It includes discussions of digital platforms such as *Google Maps* and social media companies that are also privately owned. This makes it essential for me to note the concept of publicness. Publicness accepts that public and private spaces are not a simple binary. My use of the word *public* in this thesis relates to the types of activity that occur and by whom rather than simply whether the space is public or privately owned. The original concept of *publicness* (Bozeman & Bretschneider, 1994) is defined by comparing a core model based on ownership and a dimensional model based on political authority. My research further explains the concept of publicness in how it reflects and is accessible to the *general public* (in either a digital or physical sphere).

As my research is explicitly aimed at train passengers and concerned with connecting them to their locations, I also need to reference ideas of place. Edward Relph describes a phenomenological approach to the study of place in his classic book (*Place and Placelessness (Relph, 1976).* His central thesis is that place is not simply defined by a geographic location but by how it is experienced and its social impact. I am applying these ideas of publicness and placelessness to a hybrid (physical and digital) public context. Zammit is one of the academics whose thoughts on hybrid space closely match this research area.

> Should we therefore augment not just spaces, but our questions about 'place', and design thinking too? In those questions, and an increased awareness and mastering of a series of extended principles for understanding how hybrid space works, lies the quantum leap

between just designing self-contained interactions, which at best are 'located' somewhere, and effectively shaping augmented place, making a significant difference for our cities *(Zammit & Kenna, 2017, p. 16)*

My thesis seeks to answer some of the questions in the above quote. And I argue that hybrid space is insufficient to describe the meaningful augmentation of place Zammit & Kenna describe. Hybrid space in this context needs further clarification into what I have termed hybrid public space. This is necessary to remove confusion with other interpretations of hybrid space that are simply about the layering or convergence of digital and physical without the context of place or publicness. For example, and particularly relevant to my research, commuting is a common situation where people cohabit in physical and digital spaces. The quote below by Michael Bull highlights how this scenario often plays out.

The use of iPods demonstrates a clear auditory re-conceptualisation of the spaces of habitation embodied in users' strategies of placing themselves 'elsewhere' in urban environments. Users tend to negate public spaces through their prioritisation of their own technologically mediated private realm (Bull, 2005, p. 354)

The notion of hybrid space I explore actively seeks to counter this digital bubble. One that is not simply a layering of two realms onto one another but a reimagining of how digital and physical are designed and co-exist. As a starting point for understanding this interdependency, I first looked at some of the qualities of traditional public spaces that help create community and connection to place.

Physical public spaces are designed and have evolved with the notion of diversity, inclusivity, and serendipity. In Rotterdam after the 1940s, authorities were concerned that post-war reconstruction resulted in a brick desert, leading to social isolation and alienation. In response, Lotte Stam-Beese, an architect who interestingly described herself as an interface designer (De Waal, 2013), was tasked with addressing this in a new suburb called Pendrecht. Data fascinated her, and she grouped citizens into five life stages (single people, the elderly and small to large families). They then built and distributed houses of the size and quantity to match these statistics to ensure each district fairly represented the general population.

More recently, Rotterdam again provides an excellent example of the choreography of public space to support various types of formal and informal community behaviours. In 1990 landscape architect Adriaan Geuze won a competition to redesign a public square (Schouwburgplein) in the theatre district.

The way the square was fitted out and the mood it could create were flexible: the hydraulic cranes could be placed in different positions; the fountains, intended to encourage children to play, would spout with a force that depended on the weather; and the material itself would be affected by the passing of time. Events would leave their traces in the metal floor, and in a lecture Geuze also expressed his hope that the wooden floors would invite visitors to carve in their declarations of love (De Waal, 2013, p. 127).

Fig 4 Schouwburgplein: Credit Rook & Nagelkerke.

This framing of physical space as a catalyst for public behaviour and interaction is partly by design, as shown in the last two examples from Rotterdam, but also it is very much caused by accident and serendipity. A combination of these influences creates a parochial atmosphere of connectedness among strangers. This more organic process is perfectly described by Jane Jacobs, for whom the street is famously the most direct expression of shared public space:

The trust of a city street is formed over time from many, many little public sidewalk contacts. It grows out of people stopping by at the bar for a beer, getting advice from the grocer and giving advice to the newsstand man… The absence of this trust is a disaster to a city street. Its cultivation cannot be institutionalized (J. Jacobs, 2016, p. 66).

Jacobs is talking about the organic growth of a community born out of serendipity, routine, and familiarity of interaction across all members of society. In this regard, the street is not so anomalous to a train carriage. They share proximity, unfamiliar faces, routines, rituals, and an unwritten code of behaviours.

The concept and history of digital public space (DPS) followed a very different trajectory. The first documented use of digital public space was by Tony Ageh of the *BBC* in the early 2000s (Keller & Tarkowski, 2021).

> The Digital Public Space (the DPS) originally began life as a way of thinking about how the BBC archive could be available and accessible to all. This was swiftly followed by the realisation that surrounding the BBC content was a huge seam of additional data and a new context for digitally mediated cultural experiences (Brody, 2013).

The public space Brody describes in the above quote is similar to a public library. Jacobs & Cooper, in their 2018 book *Living in Digital Worlds: Designing the Digital Public Space* describe DPS as a hybrid space.

> [...] we are already living in a hybrid space that has digital information woven through it, and that it is a 'space' with more than the three usual spatial dimensions. The digital public space gives us a term which can be used to describe this new realm (N. Jacobs & Cooper, 2018, p. 12)

Both Brody and Jacobs describe a space made up of public information and archive rather than a space where people experience the more human concepts of place and publicness I described earlier. A digital public space more analogous to those concepts is social media.

> As people engage in and reshape social media, they construct new types of publicness that echo but redefine publicness as it was known in unmediated and broadcast contexts.(Baym & Boyd, 2012, p. 320)

This brings me to an important aspect of DPS. One that is out of my thesis's scope but needs some reflection and background. How governments and private companies track and exploit our online behaviours, data and psychology. Shoshana Zuboff defines this as *surveillance capitalism (Zuboff, 2019).* She explores how companies like *Google* and *Facebook* unilaterally claim our online experience as free raw material for translation into behavioural data. She likens this approach to mining the raw materials that fuelled the industrial revolution.

> Industrial capitalism transformed nature's raw materials into commodities, and surveillance capitalism lays its claims to the stuff of human nature for a new commodity invention. Now it is human nature that is scraped, torn, and taken for another century's market project. (Zuboff, 2019, p. 94)

Interestingly, I also make a comparison with this period. Schivelbusch describes how the industrial revolution disconnected us from nature through the building of railways (Schivelbusch, 1986). My throughline in this thesis is how mobility and the blurring of digital and physical space have the potential to reconnect us to nature and our physical surroundings.

DPS is also a commonly shared space. Physical public spaces are shared because we can all access them simultaneously. Social media extends the concept of shared space as it is also fundamentally a space where people share *things,* expressing themselves (comments, images, and videos). In social media, not only do people share these, but a recognised problem is the prevalence of bots and fake identities that spread fake news and influence others to share it (Balestrucci & Nicola, 2020; Liu, 2019).

All three definitions of DPS I have described so far (Brody, Jacobs & Zuboff) have evolved without any imperative to mirror physical public space. Its interpretation has taken on a separate, purely digital focus. There is a democratic dimension to making it as accessible as possible, legislating open standards and having some ethical considerations (Menezes & Smaniotto Costa, 2017). Still, the drivers behind the currently dominant interpretations of digital public spaces are very different from the legal and civic considerations that have developed over hundreds of years around the design of our physical public spaces. Private companies such as *Meta* (formerly *Facebook*) are well-known for how their users congregate into polarised tribes (Del Vicario et al., 2016). Unlike physical public spaces designed for social cohesion and diversity, social media has evolved as a homogenous, exclusive, and predictable space.

This discussion leads to the central hypothesis of my thesis regarding augmenting place. My argument is that we need a new term for hybrid space. One that more precisely defines this interweaving and convergence of the digital and physical when applied to the contexts of *Jacobs*, *Stamm-Beese* and *Zammit & Kenna*. A better term would be *hybrid public space,* as this is not just about converging the digital and physical but also about the context of this convergence, namely when the material and digital converge and have a thematic link to a physical public space.

Amplified/Digital Presence

In the last section, I described digital public space or hybrid space as the convergence of digital and physical and hybrid public space when this convergence shares the same context and publicness. Amplified presence is a term I am using to describe the result and impact of this space. It relates to being in the moment whilst experiencing a digital augmentation contextually associated with its physical surroundings. Jason Farman discusses reading about something on his mobile

device related to his location and noticing how it transformed his experience of the content compared to when he read it at home (Farman, 2020, p. 45). He expands on this idea and thinks of the phenomenon as embodiment, how our digital experiences extend our perception of self and proprioception.

> We are often more embodied in a virtual space (such as the space on the other side of the phone connection) than in material space (Farman, 2020, p. 23).

Farman is saying that when we inhabit a virtual space, we are more present in that space than in the real world. My argument follows his idea and asks what if the virtual space happens in and also relates to our current location. What happens when we are digitally and physically embodied in the same space? This is the scenario that I am calling *hybrid public space.* And I describe the experience of this space as *amplified* or *digital presence* (here used as two interchangeable terms).

The most obvious reference to this phenomenon is hyperreality*,* a phrase coined in the early 1980s by French social theorist Jean Baudrillard (Baudrillard, 1994). Keichi Matsuda's influential concept film *Hyperreality* (2016) explicitly connects this concept to locative media, augmented reality and hybrid public space. It presents a provocative and kaleidoscopic vision of a dystopian future, where physical and virtual realities have merged, and the city is saturated in media. There is a glitch at one point, and one can see a comparison of the world with and without digital overlays. What is striking is how digital content almost obliterates the real world. This is not a convergence or merging of worlds but rather a hostile takeover.

Another more subtle research pointing to an amplified reality is (Falk, Redström, & Björk, 1999). They explain the difference between augmented reality and amplified reality by comparing someone changing the colour of their walls, either wearing glasses (augmented reality) or painting the walls (amplified presence). I reference this because continuing their scenario gives some insight into how I am articulating my ideas around amplified presence. What if wearing glasses, I see a long-since-covered pencil mark on the wall my mother drew to show how tall I was as an 8-year-old? I would argue that this would engender an enhanced emotional response.

Research suggests that sharing an experience is a way of amplifying it (Boothby, Clark, & Bargh, 2014). This can be related to my interpretation in the way that an additional contextual element, in this case, another person experiencing the same context, amplifies the experience (or, interestingly, can make a bad experience worse). There are many ways to enhance our direct experience of space with technology.

> Virtual reality, augmented reality, tangible interfaces and ambient displays all propose means for adding new channels of digital information to the real world (Cai & Abascal, 2006, p. 130).

In this thesis, I am combining the mobility of a mobile phone with the personal mobility of being a train passenger as a catalyst to increase our feelings of physical connection to our immediate physical and personal surroundings. This is what I mean by digital or amplified presence.

Maps/Living Maps/Operational Archives

As we have seen from the above literature review, hybrid public space could be seen as mixing digital and physical space whilst sharing the same physical context. Digital/amplified presence, on the other hand, is our direct experience of this inter-relationship. One of the biggest enablers of this convergence is the recent technological development of maps and their reimagining as living maps. The most obvious example of a living map is *Google Maps*, with its real-time updates and personalisation.

> Google Maps exemplifies what I mean by an operational archive. Unlike a traditional archive, the operational archive is constantly under development even as it is being used. Wolfgang Ernst characterises this threshold in terms of a shift 'from archival space to archival time', from the archive as 'vault' to 'permanent data transfer' (McQuire, 2016, p. 84).

McQuire describes *Google Maps* as a living map or, in his terms, an operational archive. I draw comparisons with the concept of living data. Living maps are locative strands of living data. They both describe a transition from data residing in closed databases. Living maps and living data both share the shift from an archive to permanent data transfer or from centralised paper maps to personalised real-time digital connected maps.

Google Maps was launched in 2005, but the earliest surviving physical map is a mammoth tusk carving from 25,000BC (Wolodtschenko & Former, 2007). [10] In the 27,000 years that humans have been using maps, it is only during the last seventeen years that new technologies have enabled maps and mapping to become so dynamic and interactive. So much of how we experience the world is enabled through the locative technology infrastructure of mobile devices. The fact that we can simultaneously locate and be located has transformed our dating, travel, eating, social media,

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[10]See link to the Wikipedia article on the history of *Google Maps* https://en.wikipedia.org/wiki/Google_Maps.

deliveries, and property purchases. There is little doubt that some form of living maps will become a fundamental part of future locative passenger experiences, and this is an area I explore in detail in my narrative chapter.
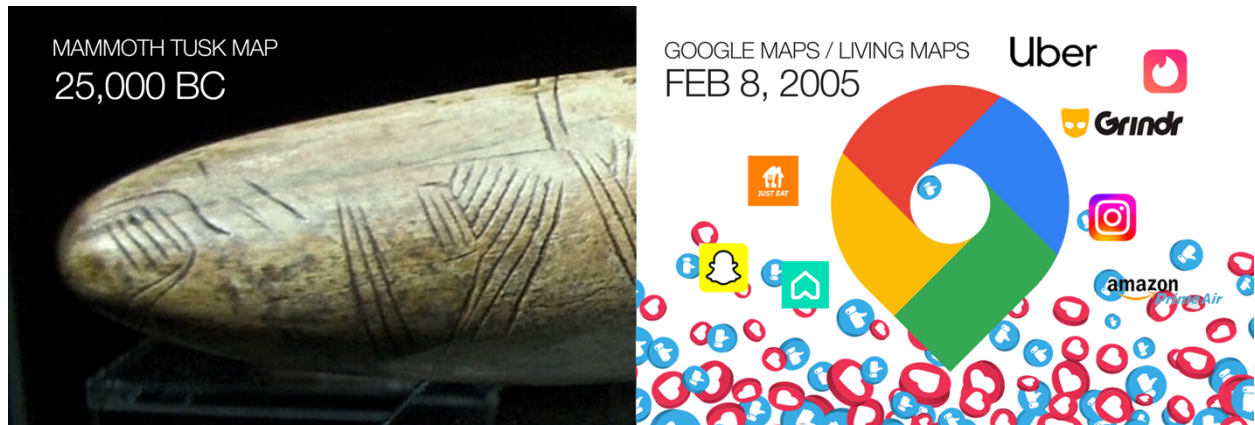
Fig 5 Early maps v Living maps: Graphic by author.

The Railway Journey: Industrialization and Perception of Time and Space by Wolfgang Schivelbusch

Finally, I want to turn to the future and one of the most influential books that helped shape my ideas and thoughts on the importance of my chosen area of research. Schivelbusch's *The Railway Journey* (1986) influenced my critical thinking about human connection and experience of the environment. Reading this book helped me formulate one of my central hypotheses: hybrid public space will be seen as socially significant as the move from stagecoaches to steam trains.

The Industrial Revolution was a period in the 18th to 19th centuries during which rural communities in Europe and America became industrial and urban. Schivelbusch's seminal text discusses the development of the railroad during this period to understand and illustrate its impact on individuals and public life more generally.

For Schivelbusch, the critical modern infrastructures such as the railway track, railway station and railway carriage all reflect the transition of human experience from a direct connection with nature to the new industrialised and mechanical world. It represents a cultural turning point from an old to a new technological epoch. As Alan Trachtenberg describes in the foreword, it '…suggests we look for evidence of culture at those minute points of contact between new things and old habits'(Trachtenberg & Schivelbusch, 2014). Schivelbusch's text seemed particularly relevant today since the current digital revolution will seemingly allow us to reconnect to our physical surroundings in revolutionary ways.

Schivelbusch talks, for instance, about the visceral and intimate connection passengers had with location and geography when travelling by horse and carriage. Every undulation, every smell, every small village, the sound of the horse's breath, and the moving carriage was experienced directly and intimately. The introduction of the steam locomotive isolated passengers entirely from this experience. Trains bypassed small towns and villages, and the railway tracks flattened the terrain. This made the journey by train so smooth that passengers could read books for the first time. *W.H. Smith*, for instance, opened the first book concession at Euston station in 1848. The popularity of reading on trains further extended the isolation from the outside to fellow passengers. A habit that can now be seen in the almost universal use of mobile phones to pass the time on train journeys.

ANALOGUE	INDUSTRIAL	DIGITAL	MIXED
Present	Disconnected	Remote	Amplified presence
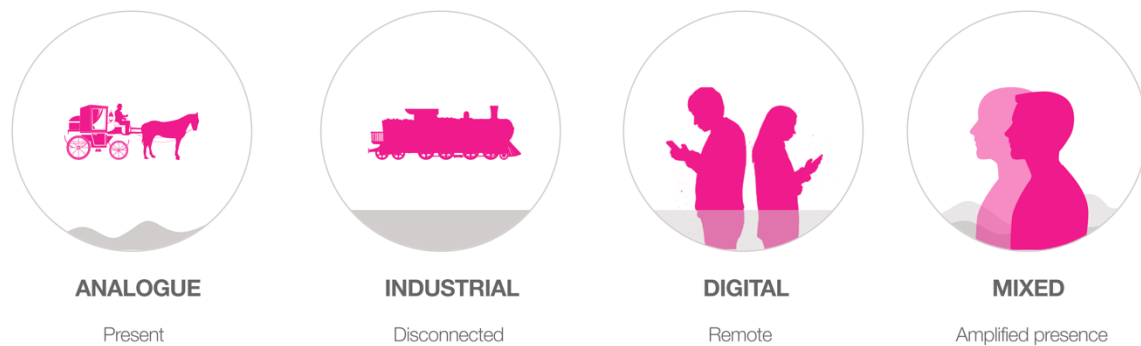
Fig 6 Illustration of stages of human experience: Graphic by author.

What struck me from my literature review is how Schivelbusch's descriptions of the transition from horse to train echo and provide a narrative arc to the other key themes I discuss in this literature review. Similar to how moving from digital to hybrid represents another revolution of how we experience public space and place (in this context, being represented by the train carriage). The stagecoach was an analogue experience (passengers were intimately present with their surroundings) that was revolutionised by the steam train into a mechanically disconnected experience. With the digital revolution, this experience has remained disconnected and characterised by how mobile phones now disconnect us from our location and cocoon us (Farman, 2020, p. 4) in remote digital layers of web and social media.

Contrary to this, however, my research aims to highlight the potential of these devices to reconnect us to our locations and fellow passengers using locative and augmented reality experiences. To make our mobile devices amplify our feelings of presence and togetherness by being a catalyst to experience our surroundings directly in new ways. To use a technological revolution to reconnect us to the landscape one hundred and eighty years after the industrial revolution disconnected us from it (Fig 6).

Chapter 3
XR INTEGRATION OF A TRAIN CARRIAGE

Out of all the chapters in this thesis, this is probably the one that will age the most. It details many technical and operational challenges to answer my research questions in a specialised area (XR) amid a period of significant investment and rapid development. This means that many of the technical difficulties I had to overcome will have been addressed as part of the natural evolution of the sector. For instance, I spent a long time attempting to minimise the barrier presented to a user of having to download an app to their phone. The solution I came up with was to have a light HTML element that could be immediately experienced, which then led to an app download (this meant that I could at least offer an introduction and a limited experience before asking the user to install a native application on their device). Two years after I finished my project, the entire experience could be delivered through a web browser, and there would be no need for any app download.

The niche I worked in, a fast-moving train carriage, is still an edge case for the XR industry. Many of the issues I document are unique to rail, and my research offers valuable insight. I also address conceptual and technical challenges that apply regardless of technology maturity.

It might be safe to assume that the technical challenges to creating a mobile phone based XR experience for train passengers would primarily concern the device itself; this was one of the mitigating factors I included in my successful grant application for the *Fantasia Express.* For example, the bureaucracy and process to get approval for any structural changes to a train carriage could easily have taken the time I had scheduled for my entire project.

My assumption that simply creating a mobile phone application and then giving it to passengers would be all that was necessary was misplaced. There are many technical and logistical dependences to developing a locative mobile experience around a train journey external to the mobile phone. Many required an understanding of the railway infrastructure, physical train carriages and the passing landscape.

The notable challenges I detail in this chapter are:

- Lack of GPS coverage on parts of the route.

- Lack of internet and user concerns about data consumption.

- Understanding the position of the user in relation to the carriage.

- Understanding the gaze of the mobile device on a moving platform (a fast-moving train carriage).

- Understanding the landscape (landmarks and topography).

- Identifying the specific train that the mobile experience will take place on.

- Taking advantage of the existing onboard information technology.

Although I will address these issues individually, I will also take time to detail how they form part of a system architecture that supports XR on trains. This system architecture sets the scene for the rest of the thesis. It details the work on creating the technical framework and platform that allowed me to create prototypes to test my hypothesis and answer my research questions. This system architecture conceptually represents what in the creative industries would be considered the *backend*. This means the layer of fundamental technical building blocks that work behind the scenes to support user *interaction* and *experience*. The *interaction*, represented in this thesis by Chapter 4 (*Interface*), consists of the structure and presentation of what a user will see and interact with (commonly referred to as the *front end)*. The *experience* relates to the content that populates the *front end* and is represented by Chapter 5 (*Narrative)*.

These three chapters (*XR Integration*, *Interface,* and *Narrative)* represent the complete production lifecycle of any mobile software product or service (The *back end, front end,* and *content)*. The research behind the building blocks that made up the back end of the *Fantasia Express* forms a significant part of this chapter. The rest of the chapter takes a more high-level view of a train carriage as a platform for immersive technology. This includes highlighting the historical significance of the train as entertainment, simulation and spectacle. Finally, I will consider what types of AR content might be suitable for the context of a train carriage and the creative opportunities to engage passengers.

3.1.   Technical Challenges of XR for Train Passengers

One idiosyncrasy of this chapter is that I could only have undertaken practical research with the technical platform I describe here. Yet only some of this section directly answers my research questions. Having said this, it was the foundation that allowed me to create the prototypes and answer the research questions I detail in the other chapters. I estimate that 50% of my grant budget was allocated to this area. A compelling reason for including some technical detail in this thesis is that so much innovation and new knowledge were created. Anybody in the future looking to create an immersive experience for train passengers may find that some of the technical challenges in this chapter resonate with their project and could be of potential value.

New Approach to AR for Moving Vehicles

To place augmented objects in real space, one needs an understanding of the space and the direction of gaze of the device displaying the augmented content. In my context, these devices would be a passenger's smartphone or tablet. The conventional approach would use spatial localisation and mapping (SLAM) employing the device's gyroscope and camera to help describe its location. This assumes that the real world is stationary, and the smartphone is moving.

A fast-moving train carriage creates movement in the real world that confuses this standard model. For example, an augmented object will appear to slide when the train takes a corner. This meant that I could not rely on an out-of-the-box AR framework (typically, AR apps will be developed using either *Apple ARkit* or *Android ARcore*). Instead, I had to come up with a new approach, and I decided to collaborate with *Corporation Pop,* a specialist AR company, to solve this issue.

The challenge that I defined was twofold and can be described in the following:

- Create an augmented reality experience inside a moving train carriage;

- Create an augmented reality experience outside a moving train to be viewed from inside the carriage.

I asked *Corporation Pop* to think about a different solution for each task. The SLAM system we had in mind had to work differently for AR inside the carriage than outside and took inspiration from the *Mars Exploration Rovers* and aerospace technology.

Inside the carriage, we used visual odometry, whereby the device's camera feed is analysed frame-by-frame, identifying specific feature points and then working backwards to understand where things are compared to where they were and how they move.
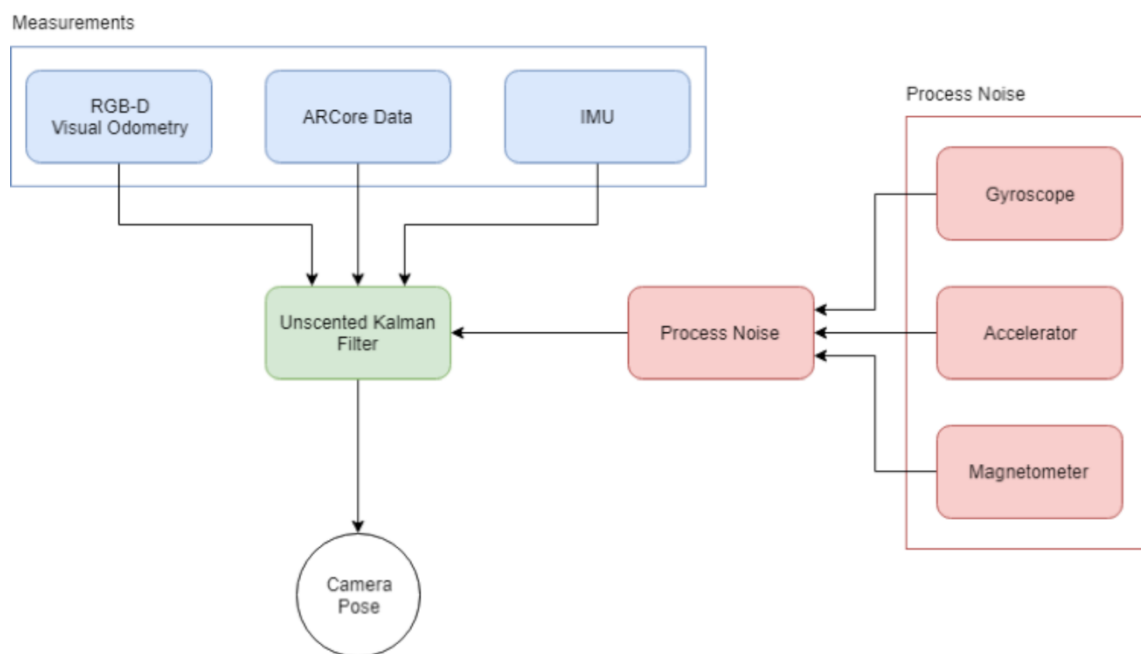
Fig 7. My approach to AR on moving vehicles to counteract slide of digital objects: Graphic by author.

For AR outside the carriage, the device's gyroscope was employed differently to make assumptions about the train's movement. Sensors then brought data together to estimate the device's motion and angle, using a fusion technique similar to that used in an aeroplane's inertial navigation system. Finally, *Kalman Filters* (Fahmedha, Prakash, Pooja, & Rachana, 2015, p. 84) were applied to cancel data drift and noise and ensure steady, accurate AR images (Fig 7).

This new approach worked for us in a test environment, but unfortunately, we encountered it proved unreliable in the live setting. Therefore, I decided to only use it for one of the micro-narratives to display ravens flying alongside the train outside the windows close to London.[11] I wanted to prove the technical approach without adversely risking the other AR experiences. For the rest of the micro-narratives, I decided to work with our proposed solution developed for the experience from inside the train. In technical terms, this meant we used a combination of visual odometry alongside an image target. This improved reliability and mitigated the train movement. We placed a flat sticker on the table as an image marker to help anchor the augmented reality. This combined approach allowed some movement, so the phone camera did not constantly need to have the image marker in view. For example, an element might originate from the marker and then move upwards, prompting the user to move their phone to follow this object. The phone would then use its IMU

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[11] The AR vignettes I developed that punctuated the journey (*Chapter 5 – Narrative/micro-narratives*).

and gyroscope to track the virtual object (using inertial navigation) until it could lock back onto the marker.

Unfortunately, the technical approach for presenting content outside the window affected some of my creative ideas and approaches during the initial design and concept phase. However, I found a creative way to compensate for this technical issue, which I detail in Chapter 5.

Issues of Location Tracking on Trains

The *Fantasia Express* required two levels of location accuracy. Some content was about the myths and legends of a town or county; as this content was not associated with a specific visible landmark, it could be triggered across a wide area. Other content related to a visual landmark or a landscape suitable for placing augmented reality objects required almost pinpoint accuracy.

The two critical factors to accurately locate a passenger on a moving train are the accuracy of the GPS module and the frequency that the GPS module reports its location. On a fast-moving train, it is important to regularly update the system with the train's location, as every second, the train could travel twenty to thirty metres.

To place AR objects into the landscape, I had worked out that I needed a couple of seconds to recognise the location and then another ten to fifteen seconds to present the content. I subsequently identified locations on the route that would give me ten to twenty seconds of unobstructed views suitable for placing AR objects within the landscape (Fig 8). This required our technology to consistently provide an accurate GPS location at intervals no greater than one second apart. I had hoped to use the passenger's mobile device for this task but found that their GPS performance on trains was not good enough. I suspected that the poor coverage was a combination of factors. In normal circumstances, mobile phones take advantage of Wi-Fi networks and cellular towers to increase the accuracy of the GPS in what is called A-GPS or advanced GPS (Diggelen, 2009). This data infrastructure is much less prevalent around railway tracks than it is on roads. Railways also follow quite a distinct topology compared to the road network, and I suspect this also contributed to the poor performance.

Fortunately, a modern train does have location-tracking infrastructure, including an onboard GPS module. When investigating this further, I found that this data can be accessed through an existing API (Application Programming Interface), a software intermediary that allows two applications to talk to each other. This approach opens up various onboard systems to external and independent companies; for example, *Trainline,* one of the UK's most popular train ticketing apps, use the onboard GPS API to show the live progress of all trains on the network. This system reports the

trains' location approximately every thirty seconds; this is useful to establish a train's rough location and progress but is not frequent enough to provide enough accuracy for my purpose.
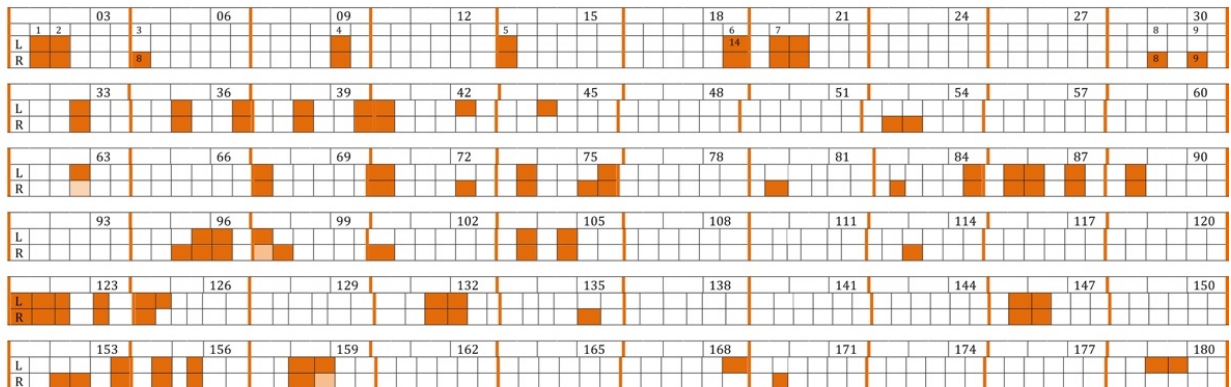
Fig 8 Diagram showing locations on each side of the train between London and Edinburgh with uninterrupted views to the distance suitable for displaying AR content within the landscape: Graphic by author.

To increase this frequency, I had to liaise with the company that owns this onboard hardware to access the GPS module directly (not through the API) using a more proprietary internal networking approach. Accessing the GPS module using this method meant I could have much more control over the data than using the API. I then encountered a second major technical problem: the location is provided from a specific point (GPS module) on a train that can be anywhere between 100 and 200m long. This meant that a passenger could be located approximately 100-200 metres away from the location I was receiving from the train. Fortunately, I was already intending to use the onboard Wi-Fi network to deliver the experience to passengers and, whilst exploring this, discovered that each carriage uses a router that supplies wireless internet to passengers in that carriage. This meant I could identify which passengers were using which routers and then offset the carriage's location with the GPS module's location (Fig 9). The approximate length of a carriage is 26m, which gave me the necessary accuracy.
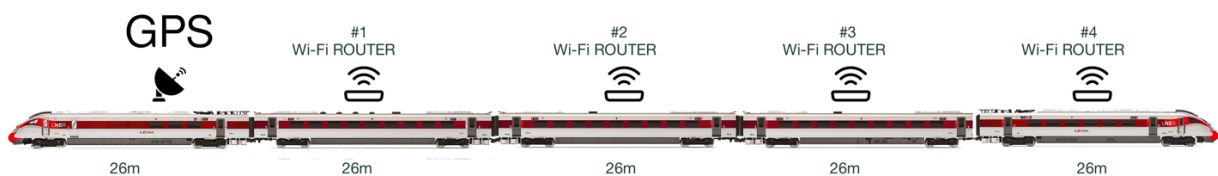
Fig 9: Identifying passenger location via onboard Wi-Fi: Graphic by author.

During testing, another issue became apparent. GPS dropouts occurred in several locations along the route, especially near London. These dropouts are generally consistent, so I could mitigate this by simply not placing locative content in these areas. I also explored another technical solution to

this problem: I developed an innovative technique that compares the train's real-time physical forces (using an accelerometer and gyroscope) with previously captured data from the same route. I learnt that the train effectively creates a physical trace based on the curves of the tracks, allowing me to estimate the train's location without using GPS. This discovery could also be applied to tunnels and other natural features that interfered with satellite signals. My final approach was to use GPS when available and then degrade to this *physical tracing* approach when necessary. I found that GPS data provided a fix of approximately 5-10 metres compared to 50m when using the physical tracing technique.

This technical approach exemplified the innovative sawdust that undertaking practice-based research can create. From conversations with rail experts, my team and I developed (more or less by accident) a completely new technique which can find application in the unique circumstances of rail travel (Fig 12).

Fig 10: Track audit showing the view from both windows, GPS (via *Google Earth)* and elevation: Graphic by author
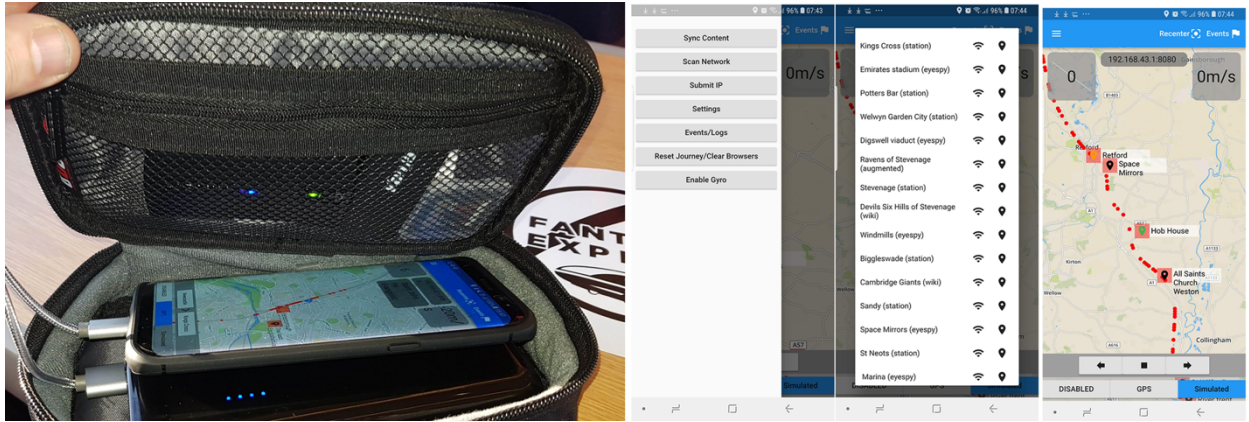
Fig 11 Image showing the hardware and software set-up that formed the backend for the Fantasia Express: Graphic by author.

Fig 12 Gyroscope and accelerometer mapping to infer location without GPS: Graphic by author.

3.2. System Architecture for XR on Trains

All intercity trains on the UK network have existing IT hardware onboard. This provides internet and entertainment media for passengers, similar to aeroplane in-flight entertainment systems. For the train company, it provides GPS data, carriage identification, seat reservations and various network functions between the train and the train operating company. I gained a thorough insight into these systems through *Icomera*, the company responsible for the hardware on the trains I was testing. Services like the *Virgin* Trains 'Beam' entertainment system and many onboard internet services provided by Train Operating Companies (TOCs) are based on this infrastructure. Similar systems are also used extensively on *Greyhound* buses in the USA.

Icomera sent me a testbed they use to develop and test content for their onboard hardware. This was a standalone version of the system integrated into the train, built to work in a test laboratory. This allowed our tech team (Bailey) to develop a way to access the services I needed (GPS, datalink, media server) to create an architecture suitable for XR and specifically to run the *Fantasia Express*. I could theoretically host the XR assets onboard and distribute them to passengers using the train's onboard Wi-Fi network. I could also identify the passenger's location on the train and get an accurate GPS location. This made it easier and faster for passengers to access the large, rich media AR assets of the *Fantasia Express*. This also lessened some technical dependencies on a user's device, making the experience more consistent and reliable across various devices.

I had worked closely with *Icomera* for several months, after which I had a plan of action that would have enabled me to host the *Fantasia Express* on the train and a solid plan to host it across *LNER*'s entire East Coast network. However, to use this approach for the prototype, I would need to make software and configuration adjustments to the specific hardware on the train that I wanted to use for the testing. As trains are sometimes only allocated to their routes on the morning of the services, this introduced a critical risk and dependency to the project. Relying on a third party to push updates also introduced a bottleneck to the project development.

To address these issues, I developed a version of their system using the functionality that we intended to use. This mimicked how I would have taken advantage of the *Icomera* onboard hardware. I used a smartphone running custom software with a Bluetooth GPS module and a Wi-Fi extender. This could then be configured as a server and a Wi-Fi hotspot providing data and GPS for up to ten mobile phones in a train carriage. It accurately reproduced the elements we had developed to integrate with *Icomera* (Fig 11).

This had the operational benefit of making the project independent of the train and the train company. With this portable setup, I could test the software and make content changes or get updates in almost real-time, liaising directly with the tech team (Bailey). With *Icomera*, I would have had to follow their standard publishing protocol; this would have involved scheduling each update in advance and then testing the update on several test environments before seeing it finally pushed to the live environment.
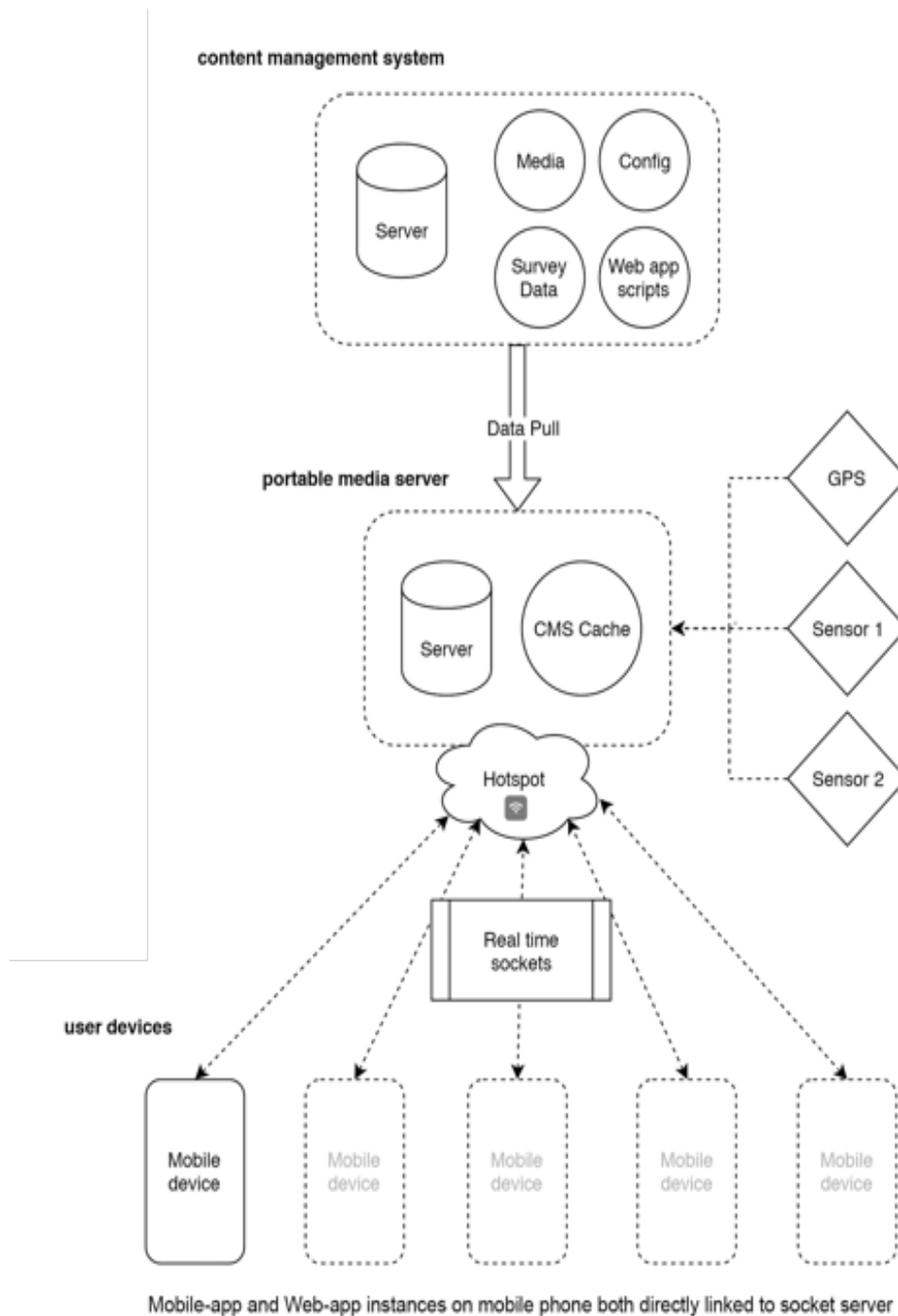
Fig 13 Image showing the XR system architecture for trains developed for Fantasia Express: Graphic by author.

3.3.   The Train Carriage and Entertainment

> The optical experience of the train carriage window long prefigured the cinema, providing passengers with a cinematic experience sixty years before the emergence of cinema itself (Christie, 1995, p. 17).

The canvas for my immersive research is a train carriage. I am exploring opportunities to use emerging technological advances to engage and entertain train passengers. Ian Christie's quote above highlights that the railways, the emerging technological advancement of their day, also provided a glimpse into the future of entertainment. He is comparing the cinematic experience presented by the view through a train window into the passing scenery with the cinema screen. This relationship between spectacle, trains and technology reached its peak in a short period in the late 19th Century. A period that starts with one of the first moving pictures to reach European audiences, the 1896 Lumiere brothers' *The Arrival of a Train*. A film that Susan Sontag described in a *New York Times* article as the beginning of cinema.

> Everything in cinema begins with that moment, 100 years ago, when the train pulled into the station. People took movies into themselves, just as the public cried out with excitement, actually ducked, as the train seemed to move toward them (Sontag, 1996).

The groundwork for this birth of cinema and the late Victorian love affair with the convergence of trains and the cinematic spectacle was set fifty years earlier. Three significant events represent the social and cultural backdrop of this relationship between trains and the mass cinematic experience. The most obvious event was the world's first inter-city railway between Manchester and Liverpool in 1830.[12] In my literature review of *The Railway Journey (Schivelbusch, 1986),* in Chapter 2*,* I discuss the cultural shift this represented. This was the *golden age* of rail, and within twenty years, Great Britain had acquired the arteries of its current railway system, with almost 7000 miles of track built by 1850 (Crouzet, 2006, p. 284). Photography followed a similar timeline with the first photographic process developed by Daguerre in 1839, and by the 1850s, millions of *Daguerreotype* portraits and landscapes began circulating all over the world (Hirsch, 2000, p. 27). The railways brought people from the countryside into the cities as tourists or workers. Photography made images of the world accessible to everyone. The *Great Exhibition* of 1851 represents the third of

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[12] A link to the Wikipedia article on the opening of the Liverpool and Manchester railway
https://en.wikipedia.org/wiki/Opening_of_the_Liverpool_and_Manchester_Railway.

these defining moments. A mass public celebration of the industrial revolution and its global impact. Thomas Hardy describes it in his novel The *Fiddler on the Reels* in the following quote.

> 'Talking of Exhibitions, World's Fairs, and what not,' said the old gentleman, 'I would not go round the corner to see a dozen of them nowadays. The only exhibition that ever made, or ever will make, any impression upon my imagination was the first of the series, the parent of them all, and now a thing of old times—the Great Exhibition of 1851 (Hardy, 1893).

This history of presenting technology as a mass spectacle offers interesting insight and reference to my research, particularly how the Industrial Revolution not only created the technology behind the cinema but also (through the industrialised working-class factory workers) its audience. In her article about the *Great Exhibition*, Sylvi Johansen discusses this new audience; 'a cooperative industrial sector and a working class which could gather without incident, riot or dreaded revolution' (Johansen, 1996, p. 60).

The point I am making is that the public appetite for a cinematic experience can be traced back to the visual spectacle of a train window and the mass spectacle of world fairs like the *Great Exhibition*. And that for a brief period at the turn of the 19th Century, the train epitomised the convergence of industry, entertainment, and spectacle. For the first time, moving pictures could bring the world to the public. And what more entertaining way to represent this shrinking world than the train? These early experiences focused on a documentary approach with the evolution of phantom rides and simulations. The world's first permanent ultrarealistic cinema attraction, *Hale's Tours,* took the form of an artificial railway carriage. This included various haptic and audio elements and a large projection screen typically showing films taken from the front of trains (Fielding, 1970, p. 39) (Fig 14).

> Will you go with me to HALE'S TOURS at 165, Oxford Street, W.? We can visit the Colonies or any part of the world (without luggage!) and return within fifteen minutes. Trains leave frequently from eleven to eleven. It is not only educational but intensely interesting (Hayes, 2009, p. 191).

Cinema quickly replaced these spectacles, and this fascination with the train as a source of entertainment and technological marvel was lost. It is interesting to note that some of the most influential figures in the development of cinema came from *Hale's Tours*. For instance, Sam Warner's (cofounder of the *Warner Brothers* film empire) first job in the film business was as a projectionist for *Hale's Tours* (Fielding, 1970, p. 40).

My PhD poses the question, are we at a turning point comparable to the impact of the steam train in the way we use immersive technology to perceive public space? I found poetic serendipity, especially in light of my *Fantasia Express* project, to discover that the steam train also contributed significantly to the birth of cinema and mass public entertainment.
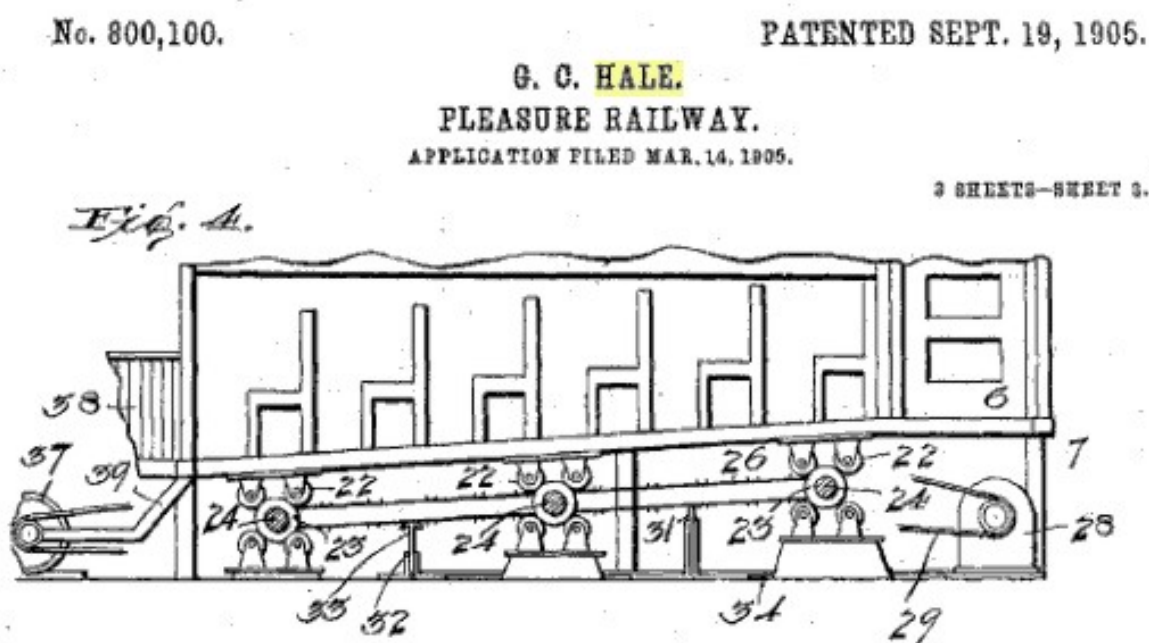
Fig 14 George Hale's 1905 design for a film show is a mocked-up railway carriage which rocked to and fro, marketed as Hale's Tours: Credit US patent office (US patent 800100)

3.4.   XR Potential of a Train Carriage

My *Fantasia Express* prototype brings the train back into the spotlight from a technical and entertainment perspective. I found an interesting comparison between historic train experiences and the immersive experiences of augmented and virtual reality,

Virtual reality shares some of the key attributes of cinema. Sitting in a dark auditorium facing a large screen that fills one's viewpoint reminds me of the immersion of a virtual reality headset. An excellent example of this approach was the *Eurostar Odyssey* (2017). Passengers travelling on the *Eurostar* were given a simple cardboard device to place their mobile phones in to create a virtual reality headset. Like a dark cinema, they were isolated from their physical surroundings and other passengers and absorbed into a virtual world.

On the other hand, early proto-cinematic simulators share many of the attributes of an augmented reality experience. Unlike the blacked-out experience inside a cinema, these popular attractions

placed the audience in an actual train carriage, where they could interact with the space and each other. This 'third element, space'(Gauthier & Barnard, 2009, p. 331), broke the sacred relationship between the audience and the screen. Erkki Huhtamo points out that in *Hale's Tours*, unlike conventional venues, the audience was not occupying a neutral space but rather a part of the show itself.

> In the motion simulator ride, the phantom vehicle is materialised. The neutral audience space is turned into a kind of set, a theatrical space, that is a material extension of the virtual space on the screen (Huhtamo, 1995, p. 171).

The approach of making the theatrical environment, the stage, integral to the performance (not just the movie screen) aligns closely with augmented reality and my interest in connecting passengers to their locations and each other.

For this reason, I began my research by focusing on opportunities to display augmented reality (AR) content within the context of a train carriage. I identified five spatial types of AR content suitable for a fast-moving train carriage. Each type represents differing technical and creative challenges and opportunities. Three content types are related to the window, and the other two are related to inside the carriage.

AR and the Train Window

Fig 15 Detail of the three AR content types for the window of a train carriage: Graphic by author.

The window is a train carriage's most evocative and cinematic focal point. Indeed, one of the most striking features of train carriages is the fact that they produce a panoramic, story-telling landscape; this landscape provides a narrative backdrop that connects a train journey with entertainment. NanaVerhoeff talks about the panoramic gaze as the peculiar circumstance of looking out of a train window. She describes the difference between the foreground being rendered almost invisible by the speed of movement whilst the distant scenery seemingly slows time by its persistence.

And, like travelling in a train, the body of the driver remains immobile, regardless of travel speed. But what she sees does, in fact, have an effect, and so it should. This makes the performance (in the theatrical sense) of the panorama also performative (in the speech-act sense) so that it becomes generative of a 'solicitation effect' in the recipient; the mobile gaze, first mobilized, is also mobilizing (Verhoeff, 2012, p. 46).

From an XR and immersive perspective, this passenger agency – the notion of a perspective of the view being both performance and performative – resonates directly with augmented reality and with my project. Unlike the cinema, where you sit watching a fixed two-dimensional screen, the panorama of a train window has a spatial quality that is sensitive to any slight movement by the passenger, making them both *mobile* and *mobilised.* Adding augmented reality artefacts within this panorama (as mentioned earlier in this chapter) became the *Holy Grail* for my project. All the eventual *micro-narratives* developed for the *Fantasia Express* included a narrative element to take advantage of the window or external landscape. Still, the technical challenge meant, apart from one, they did not make it into the final prototypes.

Aside from its role as a viewport into the passing landscape, the train window offers another potential for augmented reality. A window is a flat plane and has the physical characteristics of a digital screen, and so using augmentation to create a virtual two-dimensional screen is an obvious approach.

Fig 16 Image illustrating AR on windows: Graphic by author.

As my research is about connecting people to the passing locations, part of which included encouraging passengers to look out of the window, I was interested in the potential to partially overlay the window with information graphics or place names, effectively captioning the passing landscape.

Another approach I explored was considering treating the window as a prop for 3D content. This offers more creative and immersive potential. One of the ideas that I developed for *Fantasia Express* was for a location near Berwick on Tweed. On this part of the route, the railway track follows the coast. I had created the outline of a story involving sea monsters. At a certain story point, a giant octopus would attach to the outside of the train, meaning its tentacles would appear outside the window (Fig 16).

AR and the Train Carriage
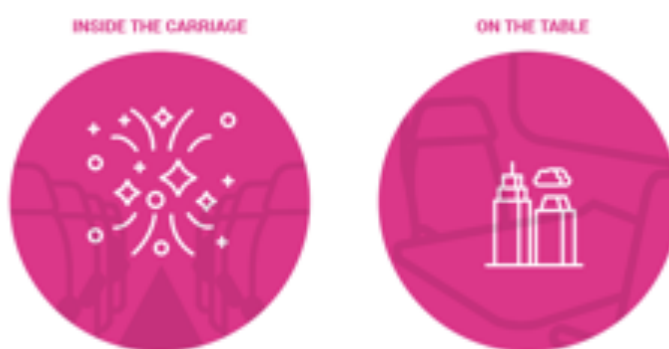
Fig 17 Image illustrating AR in a carriage: Graphic by author.

The train carriage comprised the other spatial types of AR content I explored. I considered the creative opportunities for AR experiences *inside* the carriage or *on the table*. A good example of this type of experience was *IOU* theatre's audio, immersive experience for trains *Sea to Sea* (2019), whereby a person sits next to you and tells you stories or poetry about what is visible through the windows. This was an interesting project as most people assume augmented reality is a visual medium, but audio, touch and smell can also be used to create augmented reality experiences.

I commissioned the artist Yoshinari Nishiki to develop an augmented reality concept for train carriages. His answer to my brief was an interactive experience called *Coin Clouds* (Fig 18). Acting similarly to a weather system, he envisioned that at specific locations, the train would appear to travel through the clouds of coins, which would suddenly appear in the carriage. The passengers would then attempt to collect them by moving and touching their phones. Taking this initial idea further, I come up with the idea to connect these AR coin clouds to real-time weather data. This was an interesting approach to base an intervention on a situation rather than a location.

The train table presents a unique opportunity and canvas for augmented reality. It is the perfect format to display AR content as a playing surface for shared interactive games. This became the

common platform for displaying the location-based AR micro-narratives I created for the *Fantasia Express.*

During this investigation, a second idea to display AR content emerged. A train table also presents an excellent opportunity to present an augmented reality version of a traditional board game, not least because the counters and parts are unlikely to fly off due to the train's motion. It provides a novel context for collaborative and group play, which has many recognised psychological benefits (Gobet, 2004). A compendium of games with elements that dynamically relate to the train's location would be an entertaining and innovative way for a family to travel and enjoy a shared journey together.

Fig 18 Illustration of concept designed by artist Yoshinari Nishiki for Fantasia Express: Graphic by artist.

This chapter detailed many technical and operational challenges to deploying mobile XR onto a fast-moving train carriage, many of which created new knowledge for the XR sector. Notably the techniques I developed to counter GPS dropout and the architecture I developed to integrate into the legacy onboard media infrastructure. Some aspects created operational and technical challenges that I mitigated without compromising the key research questions and concepts. For instance, creating my own version of the onboard media server to remove the risk, dependency, and development bottleneck of integrating with *Icomera's* onboard hardware.

I made creative changes to the narrative to limit the issues I had with placing augmented artefacts in the passing landscape. Most importantly, the research I conducted as part of this chapter made me realise that the convergence of physical and digital is not just about software. That there are also technical considerations of physical and digital infrastructure and environment. That hybrid space (or hybrid public space) requires a technical and conceptual understanding of the convergence of the real and virtual.

Chapter 4

INTERFACE

Fig 19 Image showing Fantasia Express interface: Graphic by author.

Having set out the creative and technical building blocks (the back end and augmented reality content types) in the last chapter, I now turn to the R&D of the interface (*the front end*) to address both how you can engage train passengers with smart mobile locative media content and what potential new interfaces are needed to successfully deliver this content.

This chapter will start with a basic definition of interfaces and a focus on public computer interfaces. I will then describe the process and development of a computer interface for train passengers following the design process, methodology, prototyping and testing of the *Fantasia Express* (Fig 19).

4.1.   What is an Interface?

The term *interface* is used in a variety of contexts, and the common interpretation that is most relevant to this chapter and my practical research is that of a computer interface. The *Fantasia Express* was a mobile locative app, and in this context, the interface relates to user experience design and human-computer interaction. Indeed, this is the main focus of this chapter. However,

as the throughline of this thesis relates to the merging and converging of digital and physical spheres, I think it is helpful to mention a couple of dictionary definitions that frame interface in terms of its wider scientific and literary origins and my thesis as a whole.

> A surface forming a common boundary of two bodies, spaces, or phases, an oil-water interface (Thefreedictionary, 2023)

This scientific definition resonates with the technical context of augmented reality, specifically, the interface as applied to the point that digital artefacts appear in the real world. It can also be applied to how the camera on a mobile device creates an interface between the eye and the natural world in a similar fashion to looking through an optical viewfinder.

> The place at which independent and often unrelated systems meet and act on or communicate with each other; (Merriam Webster, 2023)

This definition represents one of the essential findings and insights of this thesis. That explores how a mobile device can encourage publicness and feelings of place within a train carriage. When you make narrative and content displayed on the mobile device related to the physical location, it can act as a trigger and a catalyst that brings the experience of real and digital together meaningfully. In this definition, the mobile device becomes an artefact that acts as the interface. It is the point at which the mobile device connects the passenger to the carriage, the landscape and other passengers that is the meeting of unrelated systems that act on each other.

Public Computer Interface

I am focusing on a public computer interface as most computer interfaces are designed for professional applications and to do specific complex tasks. Applications like *Microsoft Office* and *Adobe Creative Suite* rely on users spending many hours learning and operating the software efficiently. I use the term *public computer interface* to describe interfaces that are designed for people to operate on their first interaction or on a casual basis. Internet browsers, the standard means of accessing the Web, are an excellent example of a public computer interface. An internet browser is pre-installed on all personal computing devices and is built on standards and principles to allow for casual use and casual users. This also makes the Web an appropriate reference point for passengers in moving vehicles.

This public computer interface is the composition, hierarchy, and visual representation of interactive tools and display areas within a browser window (menus, buttons, controls) (Hartson & Hix, 1989) It is typically a way for users to navigate and explore the content (text, image, and

video) stored within a website. It is the role of information architects and graphic designers to create a bespoke interface that represents the content and underlying taxonomy (architecture/structure) and makes them accessible to the user. This description typifies a closed system, where the interface is surfacing a database of static content held within the single repository of said website. By static content, I am referring to content that is not dynamically updated. Static content is input by a human editor and can be compared to a newspaper or magazine article.

A typical scenario for this type of interface is a user sitting at a desk operating a personal computer. Ten years ago, this was the overwhelmingly dominant way people accessed the internet. This situation, however, has drastically changed in recent years, which, in turn, has had a major impact on digital and creative development worldwide. In 2015, desktop computers accounted for roughly 70% of internet views; in 2020, this figure was less than 50% (Fig 20). The dominant way that people consume online content is now via their smartphones. Jason Farman discusses how a multi-dimensional mobile computing paradigm is replacing the one-dimensional static desktop computing experience:

> The move from personal computing to pervasive computing, a shift characterised by the move from immobility to mobility, has allowed for online space to interact with material space in unprecedented ways [...]. By having a device (we carry with us wherever we go) that is able to interface with the world in a way that transforms our everyday experience of space into an experience of multiplicity, the production of virtual space is with us on seemingly unprecedented levels (Farman, 2020, p. 39).
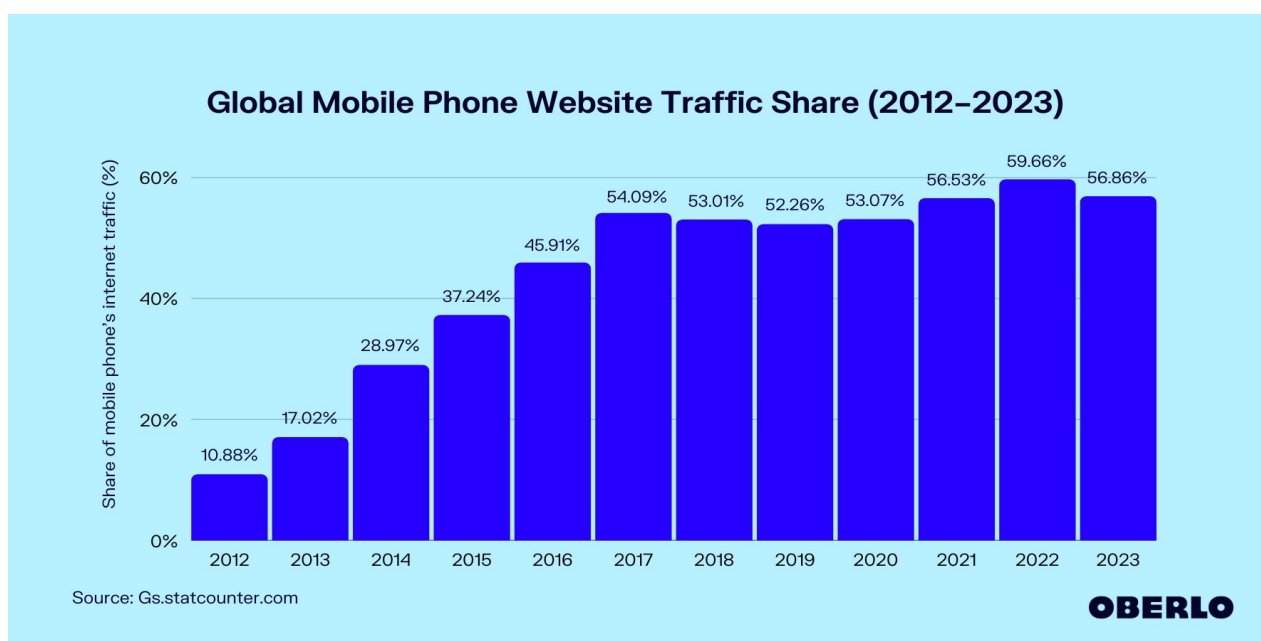
Fig 20: Statistical chart of internet usage comparing mobile to desktop over last 10 years: Source: Oberlo.

This evolution of the computer interface still draws on many modalities and aesthetics of traditional computer applications and interface design but incorporates many other influences, affordances, and actors. For example, the role of the *information architect* is now commonly replaced by a *user experience designer* and *content management systems* (traditionally used to populate websites with text and imagery) are being replaced with *experience management systems*.

The interface in these use cases is inherently social. So instead of traditional websites with a fixed hierarchy and content map, whose content is authored (for example, the *BBC* website), they are dynamic and fluid entities designed for participation and user-generated content creation. I see them in today's context as personalised, temporal, and curated experiences that shape our views of the world.

Computer interfaces have evolved from a predominantly static context to the much more complex, spatial, and multi-dimensional experience of smartphone-based computing. They have taken advantage of the processing power, GPS, computer vision, compass, and gyroscopic sensors of mobile devices, creating what Jordan Frith describes as *hybrid spaces*.

> In these hybrid spaces, the digital influences experiences of place, but places also influence experiences of the digital. This co-construction of place and locative media is the most relevant shift from older forms of mobile media (Frith, 2018, p. 25).

Frith alludes to how geo-locative experiences create a second screen that helps contextualise both the computer interface and the real world. Hybrid spaces are still computer interfaces as the mobile phone screen is visually distinct. The user switches their view from the mobile device to the real world. Augmented reality is when the natural world and the computer interface share the same viewpoint, and this is the point we transition from the *computer interface* to the broader dictionary definition. In the *Fantasia Express,* the computer interface was the dashboard that alerted people to a waypoint and enabled them to launch an augmented reality experience.

Mobile Interface for Train Passengers

This section covers the practical and conceptual process, approach, and development of the core interface elements of the *Fantasia Express*, namely the interactive controls, menus, functionality, usability, process, and methodologies, all of which were created as part of my project. I am expanding on the computer interface definition described earlier and specifically the evolution into mobile interface design and mobility. My principal research in developing interfaces for passengers on long journeys focuses on two essential attributes. The first, on how the interface represents

location; connecting train passengers to the passing landscape lies at the heart of my research, so designing an interface that supports this is crucial. Secondly, it is important to consider the interstitial nature of a train journey. What I mean by this is that travelling is inherently an experience of being in between places. Passengers may be uncomfortable, bored, waiting for time to pass, off guard or anticipating their destination. This also makes them a captive audience and potentially receptive to new experiences.

I employed many industry-standard methods during the development of the *Fantasia Express* interfaces. While I will detail some of these general user experience and software development principles, my focus will be on those that relate directly to my particular scenario and answer my research questions.

Context to UX Design Theory vs Practice

When designing the mobile interface for *Fantasia Express*, one of the references that framed the project's development was Steve Krug's famous text *Don't make me think* (Krug, 2000). It is one of the most frequently referenced books amongst user experience and information architects. Although it is now over twenty years old, its basic principles, I would argue, are just as relevant today. Krug's central premise is that a user interface needs ruthless regard for having just enough interface elements to allow a user to complete tasks and nothing more.

For example, interfaces are often designed with the assumption that it is easy for a user to quickly look at a host of options and decide which one is appropriate for their requirements. Steve Krug argues that this creates focus and attention from the user making a negative experience '[…] It doesn't matter how many times I have to click, as long as each click is a mindless, unambiguous choice (Krug, 2000) .' Krug's approach to clean, minimal, and targeted interface design can be seen in other scholarly texts. His principles share similarities with many eminent experts and scholars (Jakob Nielsen & Budiu, 2013; Norman, 2013; Tufte, Goeler, & Benson, 1990), amongst others. They all propagate a similar approach to interface design and suggest that a reductive approach to interface design is more effective than presenting a user with many options and links.

Prologue – The Invisible Interface

A conceptual by-product of my research into interface design was a fascination with Krug and Nielsen's ideas of refinement and simplification of computer interfaces. I started to imagine how far I could push this approach of reductive interface design. It began as an academic exercise but ended in some innovative mobile interface designs in the *Fantasia Express* that I detail later in the chapter. I wanted to try and push these ideas and imagine what type of interface could

be so intuitive that it doesn't make you think. So intuitive that a user would not even notice they were using an interface. Could an interface be refined to the point that it became invisible?

To illustrate this point, I will use a couple of everyday life analogies where I believe the interface becomes invisible; they both involve cars, but each describes different approaches to making an interface invisible.

Analogy 1 – Learning to Drive

Firstly, if you cast your mind back, learning to drive a car is generally accepted as a rather painful experience. In this example, the interface is everything between us and moving the vehicle. Learning all the controls peddles, switches, and displays. We are absolutely and awkwardly aware of every bit of the interface; the only person more aware is possibly the unfortunate person watching nervously from the passenger seat.

However, after several years of driving, all these interface elements seem to have disappeared – they have become invisible. Driving has become second nature, even to the point that we sometimes arrive at a destination without realising it. This is now what I would call an invisible interface. This is all common sense, but it made me realise that when applied to UX, the big challenge is whether I could design a computer interface that is second nature from the beginning. From the moment someone is presented with it.

How does this process work at a basic level? We could certainly say that physical activity such as driving a car does employ many, if not all, of our senses. Some aspects are, for instance, haptic; others are spatial. We can say that we develop muscle memory and the ability to act without thinking, eventually arriving at a state where our body can react to our intent almost instantly. Reducing the time between intention and taking action is the key to creating an invisible interface.

Analogy 2 – Navigating a Crossroads

My second car analogy takes the example of designing a road junction, or to be more precise, creating what I called an invisible interface by removing the junction altogether. Whereas my first analogy was about simplifying the interface, this everyday life analogy is a bolder approach that means questioning the core ideas and underlying system that the user is interfacing with.

I will use the example of a crossroads with the design challenge being getting a driver from point A to point B as quickly and safely as possible (Fig 21). I am going to list four options of increasing complexity:

Fig 21 Example crossroads: Graphic by author.

1. A typical crossroads can be compared to a basic Information Architecture (IA) approach: all options are available to everyone; as a driver, I need to be alert as there are potential dangers from all directions. It requires a considerable amount of thought and attention and some delay.

2. Introducing traffic lights (the computer interface equivalent to labelling and some interactive mechanics) removes most of the thinking and risk. A driver has to adhere to a standard red, amber, and green light convention. It is safer than a crossroads but not necessarily any faster.

3. A roundabout affects the underlying system (no longer a junction). It requires attention, keeping an eye to the right as the driver enters the roundabout and is careful on exit. However, it is safer than a crossroads and faster than traffic lights.

4. An overpass changes the system's architecture to the point of invisibility for most drivers, the only compromise being to give some thought to the minority wanting to access the minor road.

This simplistic example is aimed to illustrate a point that is often neglected. The interdependence of the interface (front end) and the system behind it (the back end) makes for an intuitive user experience. Sometimes, it is worth questioning the system's underlying structure (junction) itself instead of refining and simplifying the current way of doing things. In this extreme example, we have removed the interface for most people by changing the system.

When we compare these real-world examples with a computer interface, there is one obvious challenge: the connection between the intent and the action is abstracted with the vast majority of

computer interfaces. If I wanted to turn left in a car, I would naturally turn the steering wheel to the left. There is an obvious feedback loop between the intent (turning left) and the action (turning the steering wheel left). A simple task within a computer interface, for example, if I wanted to change the colour of some text in this thesis using *Microsoft Word*, would require the following steps.

I would have to move a mouse over the text, press the left mouse button and then drag it across so it highlights blue. I then would move the mouse to a menu on the top of the interface, select the home bar, look around for an icon showing capital *A* with a coloured bar underneath it, and click a tiny arrow to reveal a dropdown box with a selection of colours and select my colour. At the final stage, I would see my text change colour. I am proficient at using *Microsoft Word*, and this task is second nature to me, but for someone new, this is a complex sequence of steps to accomplish the simplest of tasks.

In terms of my applied research findings, the invisible interface approach offers a complimentary way of thinking to Steve Krug's seminal and self-explanatory *Don't Make Me Think* book. Each of the two analogies I describe offered insights that fed directly into my research.

The first insight is to consider a design challenge from a physical interaction (intent and action) perspective. To consider any relevant real-world interactions that might help make the computer interface second nature. This is the insight that is particularly relevant to my research into spatial and AR interfaces because these are computer interfaces that naturally make use of physical and three-dimensional modalities.

The Second insight relates to more disruptively questioning the fundamentals of the brief. In the *Fantasia Express,* I used this approach to consider how to mitigate the challenges I had placing AR objects into the passing landscape. I was so focused on solving this technical challenge it was only when it was clear that I could not rely on the technical approach that I had to consider the fundamental rationale behind wanting to do this in the first place. I mainly wanted to place AR objects in the landscape to encourage passengers to look out of the window. In the end, I achieved the same result by simply alerting people to physical landmarks along the route that could be seen from the window. Something that I had been trying to achieve for weeks of technical development was solved in an hour.

One interface element of the *Fantasia Express* (which I describe in detail later in this chapter) employed a mix of both approaches to make an interface that was second nature from the beginning. It did not make people think and was the closest I came to an *invisible interface*.

4.2.   Design and Production Process
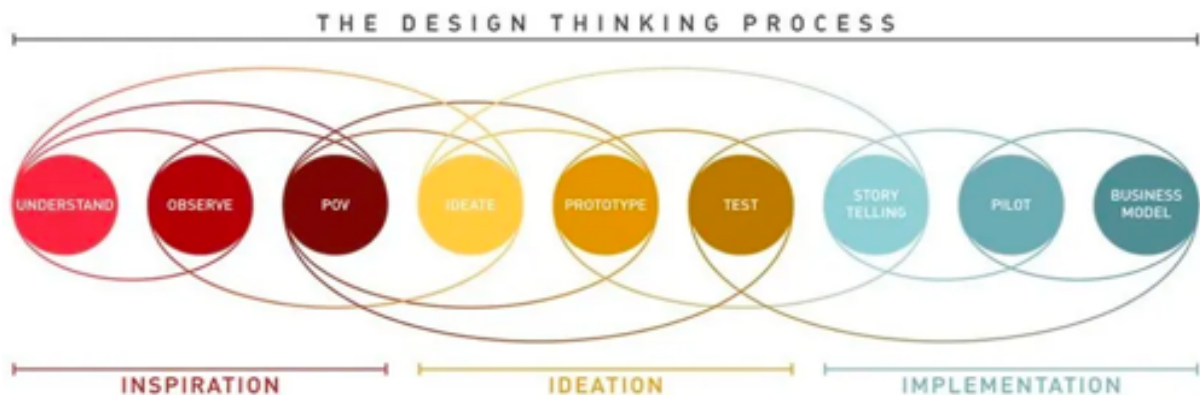
Fig 22 Design thinking process: Source TeoYu Siang.

It is common for a school math problem to be presented with the question *What is...?* and then solved by applying a predetermined formula or method. This involves two fundamental processes: the established mathematical theorem and the student's skill at applying that theorem to the specific question to come up with the answer.

I want to use this same individual analogy (and I, importantly, will return to it later) to describe two of the forces at play when answering complex research or commercial challenges with teams of people: the method and the application. In the creative industries, the method is a design process, and the application is a production process (Fig 23). The design process is commonly used to develop and test an idea, and the production process builds the concept into a product and deploys it into a live environment.

The creative industries provided the closest practical methods for my research and funded project. However, I needed elements of both a design and production process for reasons discussed later. This meant creating a new hybrid approach, and as with many aspects of my design-by-practice, this was not something I planned but a product of this research approach.

Comparing the Design Process and Production Process

A design process (Fig 22) can be seen as a methodology to answer one or a series of design and even non-design questions. Several competing approaches, such as *Harvard* and *Stanford,* originate from scholarly research and the *IDEO* process born out of industry (Kwon, Choi, & Hwang, 2021). They all follow a standard high-level human-centred design approach. They prioritise understanding the target audience throughout the process, from early exercises and

research approaches aimed at gaining empathy, during the prototyping phases that prioritise quick testing and iteration of ideas and the final implementation of a live prototype phase.

This creates a system that allows a team to consider many different ideas and refine those they see as valuable. Although the process follows a linear trajectory, it is designed to encourage a non-linearity of execution so that insight discovered at any point can be fluidly moved backwards to be further explored, tested, and refined.

> A nimble team of design thinkers will have been prototyping from day one and self-correcting along the way. As we say at IDEO, 'Fail early to succeed sooner' (Brown, 2019, p. 22).

Testing, failing, and iterating are central (along with the human-centred approach) to the innovative outcomes and the motivation behind design processes.

On the other hand, the production approach is a methodology applied to managing and developing design deliverables. This is similar in principle to a design process, they are designed to work together, and the same team of specialists have the potential to follow either approach. Still, I would describe it as product-centred, not human-centred, because a production process is designed to operate much like a production line in manufacturing. It is about building a product in a linear sequence as quickly and efficiently as possible.

Standard terms used by teams when embarking on a design process include *risk, failure, iteration, refinement, and testing.* Common words used to describe a production process include *de-risk, reduce iteration, minimal viable prototype, cost, time, re-use, and de-scope.* As you can see, the words used to describe each process are contrary. A design process prioritises creativity and innovation; the production process prioritises quality, profit, reliability, and time. The terms I needed to describe my research crossed both a production and a design process.
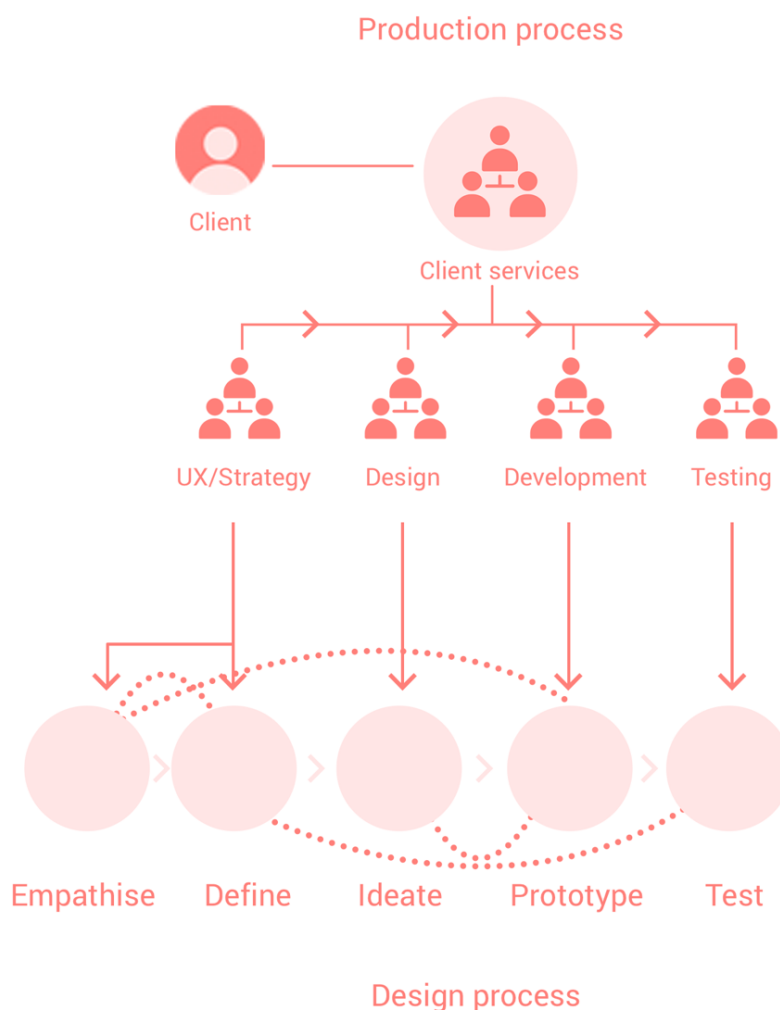
Fig 23 Comparing design process and production process: Graphic by author.

The Importance of Process for My XR Research and Prototyping

I quickly discovered that the UK train network is a highly regulated and bureaucratic system built over a hundred and eighty years. Navigating through a series of necessary permissions to pursue my intended work was slow. Furthermore, I was creating augmented reality (AR) prototypes which required complex software development that typically included a protracted compile, publish, and deploy workflow; again, this is a slow process. All these factors suited the rigour and reduced risk of a production process, but to answer my R&D questions effectively, I needed to focus on the creativity, innovation, and human-centred design approach offered by a well-executed design process.

I, therefore, realised that I needed an approach that combined the advantages of both the design and production process, one that allowed for rapid testing and iteration but was also able to address the complexity of immersive software development and be robust enough to be tested on unsuspecting passengers on scheduled high-speed train service.

After unpicking how a design and production process could be applied to my particular circumstances and working closely with the technical director (Bailey), we formulated a high-level approach; this took the form of a strategy where we identified the key overall technical requirements needed to enable agile testing and iteration of complex software in our context.

But the key to making it work goes back to my math analogy at the beginning of this section. I said that answering a math question requires a method and the skill to apply that method, but there is a third equally important factor: *Who is asking the question?*

This is typically the client with the most influence and authority in the creative industries. I discussed this with Natalie Gross, former CEO of *Amaze* (a large international digital agency) and former president of *BIMA* (British Interactive Media Association). We discussed how a client could often be a barrier to innovation. The client is outside the production team and may only interact with them periodically. Clients may have many responsibilities outside of the development of the project they have commissioned. This means they remain distant from the production and can sometimes miss important details. Or the team need to make a quick decision but does not have the same access they would have if the client were part of the team. Also, some clients do not necessarily have the skills to engage at the same level as the development team, especially a project looking to apply new approaches and ideas. Finally, clients also exist in a hierarchy and have to report to line managers; this can make them less likely to take risks or innovate.

As the person that secured the funding for the *Fantasia Express,* I was in the fortunate position of the client. I was also the person closest to the project in a position broadly equivalent to a product owner in the creative industries. Taking the client and product owner role is very unusual in the creative industries. As the client, I had the authority to make decisions, and as the product owner, I was responsible for running the project. It was this combined role that was key to being able to devise a new hybrid process, combining the best of a design and production process. It was also one the reasons that led to the success of the *Fantasia Express.*

4.3.   Creating the Fantasia Express Interfaces

In this section, I will detail the build process and interface development of the *Fantasia Express.* This fundamentally follows the three stages of a design process: inspiration, ideation, and implementation (Brown, 2019). Inspiration is about understanding the challenge and the relevant contexts and actors. Ideation is about using the inspiration from the first stage to inform and help with the creation of ideas and to do some very light prototyping and testing. The last stage is building the final project and creating a strategy to deploy it to a live environment.

My innovation was to combine the ideation and implementation stages into the second stage. This is where I integrated elements of a production process into the design process to combine the best of both worlds (Fig 24).
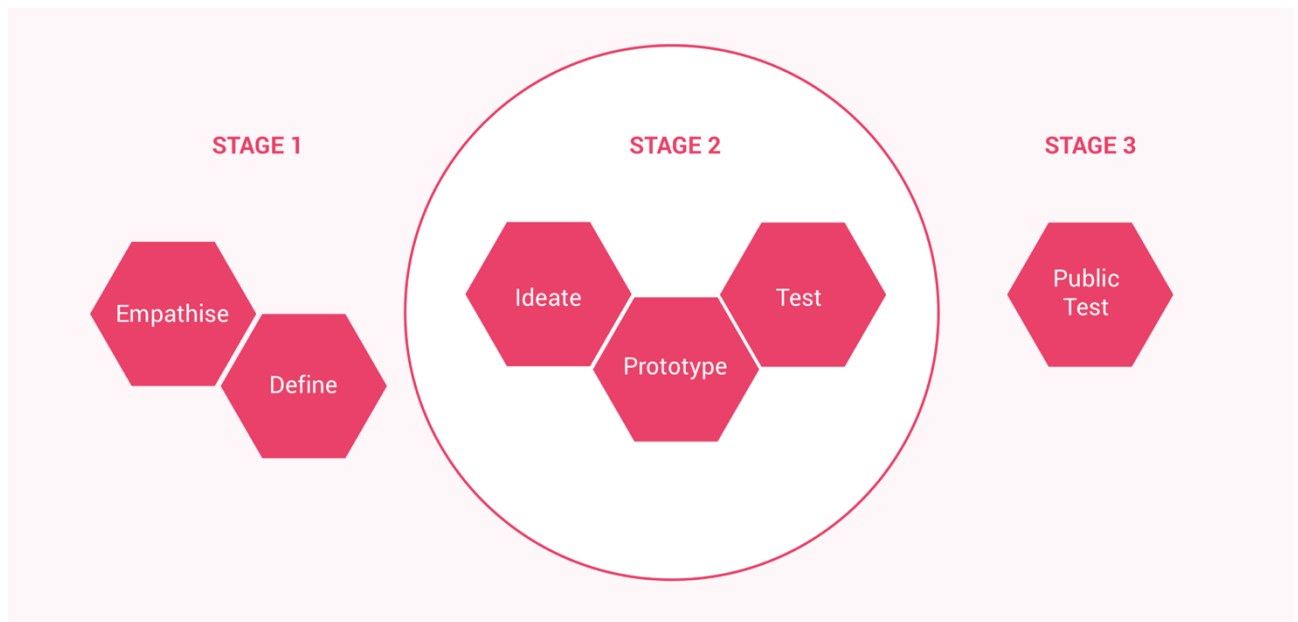
Fig 24 Methodology in practice: Graphic by author.

Stage 1: Inspiration: Empathise and Define

For this initial process, I followed a standard design process. This was about putting my mindset within the practical context of my research questions. Within the creative industries, this is about understanding the user and their needs (train passengers), the framework within which the intervention will operate (a high-speed train facilitated by the staff of a train operating company, in this case, *LNER*) and any potential impacts.

One of the techniques I used was to work out who my core end users were and then create a set of personas that would help me design and concept with empathy. This is a standard industry practice,

also mentioned in design literature. These are hypothetical archetypal users whose goals and characteristics represent a larger group of users (Faller, 2019). A strong sense of the user helped me define the user experience and interface. I initially conducted audio interviews and paper surveys of passengers travelling from London to Edinburgh to assist in the creation of the archetypes and personas.

This conceptual modelling and user research became the background to a series of workshops to create a log of user stories (See appendix 2: User Stories) that defined the functionality and elements required in stage two – my ideate and prototype phase. User stories are a technique used in agile software development that employs an informal conversational language to describe a feature or function from a user perspective.

Initial User Research

In collaboration with *Corporation Pop*, I commissioned the research and innovation team of *LNER* (London Northeast Railways) to undertake initial research. The innovation team at *LNER* are familiar with this type of research and has established ethical review and data protection policies.

This research was based on audio interviews and a paper questionnaire of train passengers travelling from London to Edinburgh over two days supported by *LNER*, who accompanied the testing team. Its objective was to gather qualitative user research by conducting semi-structured contextual interviews and observations to obtain data and observe potential users in the intended environment. It was essential to use this one-to-one approach to ensure that I was speaking to people who represented my target audience in the same context (on a train) that I planned to test on.

End Users and Personas

I used the results of the one-to-one interviews to gain insight into the type of passengers I needed to target. One characteristic of the East Coast Mainline (from London to Edinburgh) is that it is different from a typical commuter route, unlike many other mainline rail routes into London. It serves mainly leisure passengers to the North and people taking long journeys. This resulted in two categories of core users: *Day Trippers*, who take a one to two-hour trip and *Stayoverers*, who would typically travel three to four hours.

I then used this categorisation of a user type to create three archetypal users. This is a technique to help empathise and think about ideas that appeal directly to this audience. Each persona is a detailed

life story of a fictional individual, which helps to humanise people instead of just thinking of them as anonymous users (Pruitt & Grudin, 2003).

I created two passenger personas that reflected the core user categories of day tripper and Stayoverer. I also created a train staff persona to consider the operational and administration side of running the *Fantasia Express*. All three personas were created from the initial passenger surveys and in collaboration with *LNER*'s innovation team. I was fortunate that *LNER* regularly undertakes data analysis of their passengers, and this meant that the personas I created, although fictional, accurately represented real passengers.

I have included the persona for Jess, a day-tripper, below; Matt (stayoverer) and Brian (Train Manager) can be found in Appendix 1: Personas.

Core End Users

The Day Tripper

- Journeying between one to two hours to go on a leisurely adventure to a destination.

- Often in family or friend groups, interested in shared experiences.

- They are likely heading to a big urban destination, sporting event or cultural hotspot (for shopping, beach, heritage site, museum, gallery, zoo, football, and restaurants), but they are more local than the Stayoverer and likely to know the area they are travelling in better.

- They tend to get out more in the Spring/Summer months and during the school holidays.

The Stayoverer

- Travels between three to four hours to stay somewhere overnight.

- Includes families, young people, students, weekend leisure seekers, people going to/from holiday or visiting distant relatives/friends.

- Doesn't usually make a journey this long, so they seek experiences to help pass the time for themselves and their fellow passengers/children.

- Seeks out experiences to tell others about.

- Likely to be in family or friend groups, interested in shared experiences for them and their fellow passengers. Parents interested in edutainment. has serious time to kill and will use a mobile phone to reduce the monotony of the journey.

- Likely heading to a big urban destination, sporting event or cultural hotspot (city, shopping, beach, heritage site, museum, gallery, zoo, football, London).

Personas

Persona 1: *Jess (Day-tripper)*

Attributes:

Age: 37

Experience: Works in Engineering

Hobbies: Currently a working mum, she has temporarily abandoned her hobbies but will happily relax with a book or listen to the radio.

*Activities***:** Spends time with kids but tries to maintain her friend network all over the country.

*Profile***:** Jess is a working mum with two kids (6 and 8) who take up most of her life. Married to Steve, she worked in a big city corporate job. She has recently moved to the suburbs, which is a sign that her life predominantly gravitated around her children. She has settled in a place where she didn't grow up, so she regularly travels for day trips to meet old friends, take her children on cultural experiences, and visit her family.

Responsibilities: Children, a house, but wants to maintain a sense of fun in her life. She is an adventure seeker and will spend much time planning family or personal activities on most weekends.

Pain Points: She tries to manage work and life but feels guilty about it. She tries to keep her kids entertained when travelling on the train. Prefers family entertainment that also has educational value: Edutainment.

Key Drivers/Motivation: She has bought iPads, bags of travel toys and other things to help her journeys be more interesting, but really, she would love it if someone

could help her when she is making the journey on her own. She often settles with letting the kids watch downloaded content, but they constantly argue. She just wishes for the day she could spend a few moments reading a book or doing something for herself. She will seek out creative ways to save money.

Validations: Her children's happiness is a big validator for her. If they are smiling, then she can relax a bit. She doesn't really need any other external validation, not even from her closest family, but it always makes her feel better when they say something nice.

Persona 2: Matt (Stayoverer) – (See appendix 1: Personas)

Persona 3: Brian (Train Manager) (See appendix 1: Personas)

User Stories

The next step of the empathise and define stage was to use the archetypes and personas to create a log of user stories. This is a way to define and prioritise a list of tasks that form the work and scope of the prototype development in stage two. It is important to note that these user stories are not only related to end users but are also a way to log technical requirements for the production team, for example: 'as a developer, I need to be able to mask the windows so I can present immersive content on them.'

User stories have two significant advantages: Firstly, they replace the need for lengthy requirements documents that are part of the standard software development approach. Secondly, because they roughly define the feature or function in conversational language, this leaves the actual implementation up to the last possible moment and allows for a much more agile and creative approach to the eventual solution.

> Because we never had the time to write a beautiful, lengthy requirements document, we settled on a way of working in which we would talk with our users. Rather than writing things down, passing them back and forth, and negotiating while the clock ran out, we talked. We'd draw screen samples on paper; sometimes, we'd prototype, often we'd code a little and then show the intended users what we'd coded. At least once a month we'd grab a representative set of users and show them exactly what had been coded. By staying close to our users and by showing them progress in small pieces, we had found a way to be successful without the beautiful requirements documents (Cohn, 2004, p. 25).

Cohn describes here how the informal principle behind conversational user stories also generally sets the rhythm and approach for the project. His description of his project closely mirrors my experience with the *Fantasia Express*. The interesting and novel approach we took was to extend this to technical elements designed to work on a train (with the train effectively becoming another user). I would spend many hours periodically jumping on a train to test aspects of the technical build. This was only possible because we made technical decisions and created a technical framework (See Chapter 2) that could run independently of the train company and its internal systems. My user stories included both train passengers and technical elements of the development.

To create the user stories, I used an industry-standard approach following the informal conversational format below (O'Heocha & Conboy, 2010, p. 26).

As a… (input persona), *I want to…* (input functionality or feature) *so that*. (User goal)

Below is an extract from a spreadsheet that shows some of the *Fantasia Express* user stories (See appendix 2: User Stories for the complete list)

As a…	I want to...	So that...
DAYTRIPPER (JESS)	Input my destination	My experience can be tailored to my journey
DAYTRIPPER (JESS)	See experiences connected with landmarks on my journey	The experience is connected to my surroundings
DEVELOPER	Not use high poly assets	I don't have any compatibility and performance issues

Table 1: An example of three of the ninety-two user stories created.

Inspiration from Other Travel Experiences

The final phase of stage one consisted of discovery workshops and brainstorming. One of the main tasks was to look at and compare existing reference material from travel and train apps to get insight into how other people tackled similar design challenges, look for any conventions and generally get a feel as to what users might expect and what was out there (Fig 25).

Surprisingly, a use case that seemed evident and the mainstream had no direct references. I have discovered many location-based interfaces, almost all walking tours, but hardly any for moving vehicles, and none designed to enhance the passenger experience of intercity high-speed trains. My passenger surveys had identified an interest amongst passengers for custom train experiences, yet no companies were creating them.
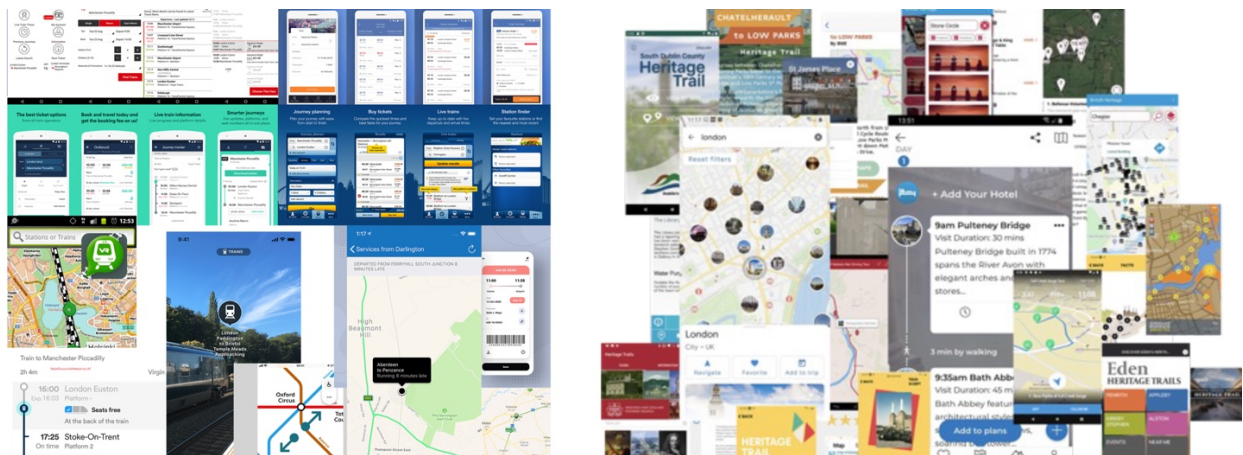
Fig 25 Examples of mobile interfaces for railway sector and location-based heritage tour app: Graphic by author.

Stage 2: Ideate, Prototype and Test

The objective of this stage was to apply my new hybrid approach. As I have alluded to, this was about more than just integrating elements of a design and production process. This also relied on the system architecture for XR on trains I developed (See Chapter 3) that allowed for rapid testing of complex, robust custom software. Informal testing was critical from a technical and interface perspective, as Steve Krug explains:

> If you want a great site, you've got to test. After you've worked on a site for even a few weeks, you can't see it freshly anymore. You know too much. The only way to find out if it really works is to test it (Krug, 2000).

Krug strongly advocates that simple regular testing of a small test group will identify all of the main usability issues. I used this type of testing throughout this stage to refine the interface designs and identify technical problems.

Most of the interface work focused on the user experience and graphical interface design. As well as Krug, I used many of the best practices and industry standards developed by the likes of Jakob Nielsen and his team (Jakob Nielsen & Budiu, 2013).

I have listed some of the leading UX design best practices I employed below.

- Create effective visual hierarchies.

- Break pages up into clearly defined areas.

- Make it obvious what's interactive.

- Eliminate distractions.

- Format content to support scanning.

I do not detail these general best practices, as I want to focus on the design considerations I developed specifically for the *Fantasia Express*. These comprised the initial *empathise* and *define* work undertaken in stage one and the subsequent iteration and testing in stage two. These were specific to creating an interface for passengers on a fast-moving train. They were a combination of human-centred design along with more practical technical challenges:

List of the Specific Interface Challenges for the *Fantasia Express*

- Work at an interstitial level – the ability to drop in and out during the journey.

- Chart progress along the journey.

- A clear indication of the next intervention/waypoint.

- Work at low bandwidth - Does not require high bandwidth internet.

- Be able to mitigate GPS dropout.

- Accessible to both adults and children with the same interface.

- Do not follow conventions of other train location apps – explore new approaches.

An interesting dynamic from my new approach of being a client product owner was that I wanted to try something different, whereas if this had been a standard creative industries project, in all likelihood, the client would like to be safe and push the direction into more of an iteration of current styles rather than a fresh look at the problem based purely on the human-centred design challenge. Comparing my final designs (Fig 30) with those I initially referenced (Fig 25) is noteworthy. There is a commonality among the reference designs. They share many design and interface cues, whereas my design looks completely different, yet passengers found it very easy to use.

The *Fantasia Express* experience was structured around a beginning, middle and end (Fig 26). This mirrored the underlying narrative (which I detail in the next chapter) and the fact that this was an

ephemeral experience that people would stumble into. Any complex software application would need some introduction and familiarisation to introduce the user, manage their expectations and get them started. While the introduction had to act as an onboarding and orienteering stage, the ending was meant to add a closing experience. Creating a story that ended dynamically based on the audience's journey was something I had yet to see before. It was accomplished by asking passengers to input their destination as part of the onboarding process. I could then use the GPS to trigger the timing of an intervention approximately ten minutes before their destination station, leaving them plenty of time to prepare to alight the train.

As the experience was designed around long journey times of one to four hours, most of the interface and user interaction would occur in the middle. This main interface was where I spent most of my resources because it offered the most transferable insights into future interfaces for passengers. Although designed for a long journey, the intention was that the experience would only be accessed periodically so the passenger would hear an audible alert when approaching a point of interest. It was designed so passengers could dip in and out of it whilst still engaged in other activities.

Onboarding/Intro

Onboarding is a standard software development approach designed to introduce new users to a particular application. It is a way to familiarise and set up user expectations about the mechanical controls of an interface and the more general features of a product, service or game (Petersen, Thomsen, Mirza-Babaei, & Drachen, 2017).

One problem with introducing a train passenger to an experience is how and when you can attract their attention. Boarding a train is a busy experience; that can take several minutes before people are settled into their seats. The starting point I chose was the *captive portal* page of the onboard media server. This web page appears when a passenger attempts to access the Wi-Fi and allows them to connect to the service by agreeing with the terms and conditions. The idea is that they would also be presented with a link that they could click to begin the experience. This allowed them to start the onboarding process before entering the experience and provided a place for contextual and promotional content. Passengers access the captive portal when they are settled and ready to engage with content, making it a suitable moment to introduce the *Fantasia Express.*
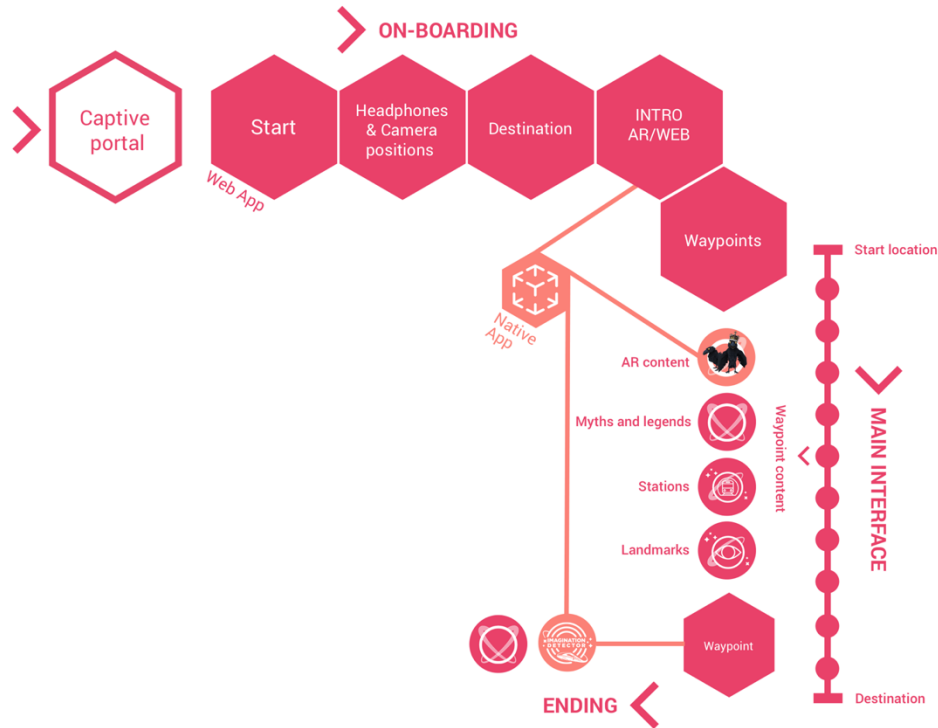
Fig 26 Overview of interface: Graphic by author.

The next challenge was guiding the user through some of the practical parts of the onboarding process (Fig 27). Arguably the most significant barrier existed because the AR functionality central to the experience required an app install. This involved the user being taken out of the experience to visit a third-party app store and potentially downloading a large file. This presented a barrier to passengers electing to experience my project, so it was important to make this process simple and accessible.

After considering various options, the technical strategy described in my methodology to decouple the AR elements from all the other interface and non-AR content elements (allowing for faster prototyping) provided an innovative solution. It meant I could present the initial stages of the experience using web technologies and delay the point at which the user needed to download the app. This allowed me to engage and inform the user about the experience while building some trust and anticipation so that they would be more inclined to go through the app install process. Another benefit to this decoupling of the AR was that it offered the potential to show a version of the experience that did not include the AR content, making it available to people without smartphones or with other accessibility issues.

Once the user had clicked the link on the captive portal, they would be presented with an initial introduction page with a *start* button, followed by an instruction to put their headphones on and

choose their destination station. They would then be directed to download the app, which would be hosted on the onboard media server, meaning that there was no need for internet connectivity and, as the file was local, the download would be much faster.
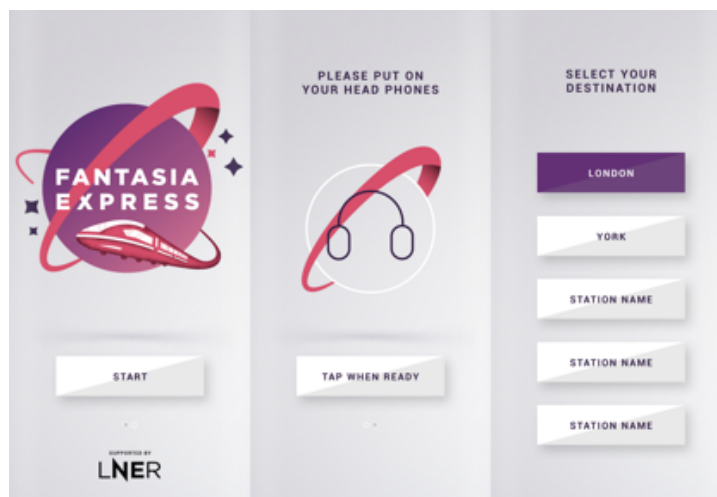
Fig 27 Interface screens for onboarding: Graphic by author.

Development of Main Interface

The purpose of the main interface was to inform people when they came close to the forty-seven points of interest distributed between London and Newcastle and provide a graphical way to interact with them. The points of interest were a mixture of different content types with varying levels of complexity. The most complex was the immersive micro-narratives, and the least were simple *I-Spy* style prompts that encouraged passengers to explore landmarks visible through the train window (See Chapter 5).

I made initial assumptions about the user experience at the start of the design process. One of them was that the user needed to be made aware of their location. My first thought was to follow a standard approach with which most users should be familiar when using common apps like *The Trainline, Google Maps* and many heritage trails. These all visualise geography or at least a list of destinations or waypoints with the user's position highlighted along the route.

My aim was then to apply both Steve Krug's *Don't make me think* (Krug, 2000) principle and Jakob Nielsen's research into selective vision (Nielsen, 2012). Nielsen explains, for instance, how users will often miss related interface elements unless placed in proximity to their eye line.

> How can people overlook something that's right there on the screen? If you've ever observed a usability study, you've probably had many occasions to ask yourself this question. Users don't look around much. They often stay highly focused on the

screen section that they're engaging with or that they assume contains the answer to their problem (Jakob Nielsen, 2012).

While applying this insight to my interface design, my next aim was to narrow down the area of the map that the user would see, reduce the number of visual elements, and make it easier for the user to focus on the waypoints. I showed the previous and next stops and the narrative waypoints in between (Fig 28). I displayed the user's position with a coloured tint, and when they were within a set distance of each point of interest, a button would appear to inform the user to access the information.
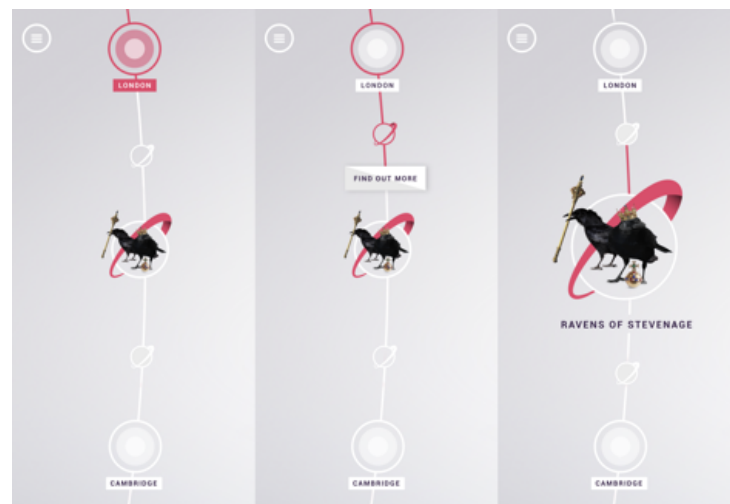
Fig 28 Iteration 2 of main interface visual design. Graphic by author.

Once I had some initial mock-ups of this design, I tested it with other team members unfamiliar with this part of the project (so they would have fresh eyes). This quick and effective approach allowed me to identify several issues. One of the problems that emerged from the feedback was that users could not tell in advance that a button would appear, so they tried to interact with waypoints that still needed to be made active. It was also a problem that I had a unique animated visual for the primary micro-narratives and more diminutive, static and less apparent visuals for the secondary, less complex content types. The AR links overshadowed the secondary types of waypoints. People were using a process of elimination to work out what they should press and when; it was not causing much of a delay, but it was obvious that the interface could be refined and simplified.

After further design thinking, research, and iteration, I realised that the location was less critical a factor than I had assumed based on my study of other location-based mobile apps. By following user-centric design methods, I realised that the most important information for the user was

understanding when the next waypoint would become available. A more straightforward way to communicate this was by using time instead of geography. Displaying a countdown to the next waypoint gave a single interface element for the user to focus on and a familiar mechanic that people would recognise from a multitude of real-world scenarios. Both these techniques followed the insights I found from my invisible interface thought process. This pivotal moment in the project was the closest I came to realise my ambition of an invisible interface (Fig 30).

Using a countdown timer to display geography was the headline finding from the main interface research. However, another contributing approach to its success was my focus on the earlier quote describing selective vision by Jakob Nielsen (2012). The conventional approach to counter this phenomenon is to place interface elements that relate to each other near each other, splitting the screen into zones of contextually related content. Krug describes a home page of a website as like a shop window. It's where you want to get across the site's core purpose and present a small selection of representative highlights. It is fixed in time, and the user browses the interface in a digital version of window shopping. I realised that I was designing a temporal interface, and instead of a shop window, my interface was more like a train window. My interface was moving whilst the user was stationary. I embraced this paradigm; instead of thinking of the interface in terms of zones, I thought about it as moments and situations. I refined the interface so the user only needed to focus on one part of the screen (not several zones). The main interface comprised two moments: the primary moment with the timer occupying 95% of the screen. The other secondary moment is accessed either by a swipe up of a thin interactive element at the bottom of the screen or by selecting an interactive waypoint when available. I focused on making the interface do one thing well and would describe this novel approach as a *tunnel vision interface.*

The invisible and tunnel vision interface approach proved to be very successful; none of our test groups, as part of the project team and during the final public trial, encountered any problems with this part of the interface.

Secondary Interface: Progressive Disclosure and Progressive Affordance

Whilst the primary user story (main interface) was to inform passengers of waypoints and alert them when they could access the various content types and micro-narratives. The interface also had to support several secondary use cases.

The most important secondary interface element was a submenu that showed a list of all the waypoints on the route. Each time a user interacted with a waypoint, it would be noted on the list and also offered passengers the opportunity to revisit some of this content. This secondary menu

could be accessed by touching an arrow at the footer of the interface, which animates up to reveal a list of all the waypoints on their journey (Fig 29). To keep the interface clean and simple, this functionality was hidden behind a small arrow at the bottom of the interface, following the principle of *progressive disclosure* (one of the primary usability approaches when designing for the reduced screen space of the mobile web and within application development). This approach is considered one of the best ways to satisfy the two opposite requirements of complex functionality with simplicity.

> Initially, show users only a few of the most important options. Offer a larger set of specialised options upon request. Disclose these secondary features only if a user asks for them, meaning that most users can proceed with their tasks without worrying about this added complexity (Volz, Higdon, & Lidwell, 2019).

Volz is describing a version of the *Pareto 80/20 Principle* (Dunford, Su, & Tamang, 2014), whereby eighty per cent of the results come from twenty per cent of the features. In this scenario, you prioritise a particular audience type or task. All the interface elements unrelated to that specific task are placed out of the way, generally behind a drop-down menu.

An additional challenge for my scenario was that the secondary content only became relevant once the user had selected their first waypoint. This meant that my secondary interface was visible but made no sense. To solve this problem, I borrowed a technique from the games industry (Salmond, 2016), whereby early levels are designed to work like tutorials to familiarise the user with the mechanics of the game, for example, by presenting a challenge that requires a specific single technique to overcome rather than make them learn everything in advance. I adopted a very simple version of this technique in the *Fantasia Express*.

The bottom bar that slides up to reveal the list of waypoints and collected stories only appears as an interface element once the user has interacted with their first waypoint (Fig 29). Not only does it appear, but it also animates up part way to reveal the underlying functionality. This animation is only triggered once.

Applying this technique to a mobile experience is unusual, and I could find no reference to it in my user experience research. It is a process that I am calling (after discussions with James Fox, Experience Director at *Kin+Carta,* a leading international UX company) *progressive affordance.* Whereas progressive disclosure is about hiding secondary interface elements, so they do not interfere with the primary tasks, progressive affordance is about surfacing these elements and

bringing them into focus for the user at the appropriate time and only on the first encounter. It is like applying an onboarding technique to an individual UX element.
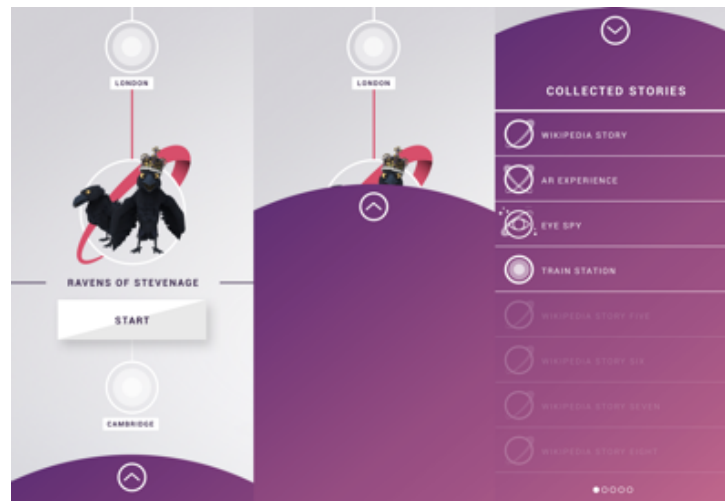
Fig 29 Showing the secondary pull up the interface: Graphic by author.

Another technique I borrowed from the games industry was incentivising the user to interact with the experience by adding a simple point system. Each time the user interacted with a waypoint, they would collect it in their list and gain points. The points would vary dependent on the type of waypoint (AR micro-narratives would accrue more points than simpler content types) (Berkovsky, Coombe, Freyne, Bhandari, & Baghaei, 2010; Xu, Weber, & Buhalis, 2013).

One of the content types, Fantasiapedia, was similar to Wikipedia, providing images and text to describe location-based myths and legends along the journey. Initially, this content obscured the main interface so a passenger could miss a waypoint. I iterated the interface to show a smaller version of the main interface below the *Fantasiapedia* content (Fig 30).

Fig 30 Iteration four of main interface visual design Graphic by author.

Multi-user Type Interface

During the persona phase, I identified Matt, a young singleton, and Jess, a single mum with children (appendix 1: Personas), representing very different target users. This raised a challenge of how the experience could appeal to adults and children. At an earlier stage of my design thinking, I considered offering a choice while onboarding a different path and subsequent interface for children or adults. I thought adults would prefer text-heavy mythological stories and children would like game-like, visual AR micro-narratives. However, simplifying the interface made it almost invisible, like a TV remote, where user behaviour is based on program choices, not selection mechanisms. This means different users can enjoy different experiences with the same interface.

Ending Interface

From an interface perspective, this was simply a way to choreograph an intervention approximately ten minutes before the passenger arrived at their destination. The objective was to support the narrative and allow people to come to the end of the experience without any anxiety about getting themselves ready to leave the train. The rationale and content of this final experience are discussed in Chapter 3, but from an interface perspective, it created a different type of waypoint. Unlike the previous geo-locative points of interest, this is an example of creating an intervention based on rules. Creating an intervention that displays media that is based on *situatedness* (Foth, 2011, p. 11).

My practical investigation and research into suitable interfaces for train passengers covered much ground. I was surprised by the amount of work that was required to create a simple interface. Most of the new knowledge that emerged from this research was produced when I pushed the high-level conceptual thinking behind an interface. My ideas behind an invisible and tunnel vision interface resulted in novel approaches I had not seen before. One of the unique ways that I achieved this was by using time to indicate location. It was ideally suited to a train journey's semi-linear and fixed route but could be applied in many other scenarios.

Progressive affordance was another approach that, although based heavily on game design practice, was novel in the granular way I applied it to a small user interface element. Having the context of a temporal interface for train passengers created a particular set of parameters and constraints that resulted in some new and fresh approaches to mobile interface design.

A clear indication that my interface work was breaking new ground was when I compared it to the locative apps and websites I reviewed in stage one of my interface development. These all used similar design cues, styles, and approaches; they felt like a family. My final designs looked very

different, yet they also tested very well with passengers. Notably, even in a discipline such as interface design (UX) that relies so heavily on convention, there is still potential to create original user interfaces that can improve a mobile user experience.

However, the most enduring reflection on my interface research relates to the wider aims of my thesis. Even though the main body of this chapter is about designing and creating computer interfaces, it is also important to consider how to *break* an interface. How to pull a passenger from gazing at their mobile screen to gazing out of the train window.

Phones often hold our attention and distract us from our surroundings. They can become the main protagonist in our passenger experience. My research has shown that making the mobile phone a supporting actor in the passenger experience is possible. To act as an ice breaker that might prompt passengers to interact with each other and the passing locations. In this context, the interface alongside the narrative has to encourage passengers to look away from their phones, and I explore the narrative opportunities of a train journey next.

Chapter 5
NARRATIVE

As this chapter is dedicated to the narrative, maybe I should begin with a spoiler alert: it does not end well. This is one of two research areas where the results fundamentally differed from what I originally intended. Much of the *Fantasia Express* was groundbreaking as research and prototyping. Still, it would require much more investment to make it into a live and commercial project. The narrative is one area that would necessitate refinement and iteration. I came tantalisingly close, and this was a very steep learning curve into an area I had no previous knowledge of. Luckily, I got to collaborate with some talented writers, which has given me the confidence to push immersive narratives in the future.

The experience of working on the *Fantasia Express* felt at times comparable to creating a film while simultaneously developing the camera used to film it. While this analogy is, of course, exaggerated, my point remains. The scope of my research meant that to test the creative use of immersive technology on train passengers; I needed to develop new technology alongside new innovative approaches to storytelling.

Finding a Narrative Structure

This chapter is entitled *Narrative,* a term commonly associated with a structured approach to storytelling. At the core of this meaning, and when applied to my practical method of engaging train passengers, this is precisely what I pursued: a narratively structured approach to changing the experience of a train journey using contextualised and locative AR technology.

I had intended to create a series of individual geo-located story experiences, which are all thematically linked up within an overarching narrative to explore new ways to take advantage of the capabilities of passengers' own mobile devices. Some of this I could do practically with prototyping; some were based on literature reviews, and some followed a design and concepting process similar to the one I discuss in the *interface* chapter. Since my background lies in creative technology and public art installation, I have long been fascinated with the potential for the public's smart devices to be used creatively within public spaces. I would argue that when you take a story out of the confines of a book or a film and place it into a public space, new dynamics and imperatives become available. These increase when the narrative relates to the same public space and is mediated through the technology of ubiquitous mobile personal devices.

Much of this chapter describes how these external layers (technology and public mobility) provide new tools and ways to think about narratives. I found so much potential for innovation, rich interaction, and participation in the various types of real-time data, network, and mapping technology available through a smartphone connected to GPS and the internet.

A combination of factors (priority, time, scope, technical constraints, and budget) meant that I could not take advantage of this potential as much as I would have liked within the *Fantasia Express*. The overarching priority of creating a single coherent story that would work within the structure of a two-to-four-hour train journey meant that I decided to let some ideas remain theoretical and untested.

For this reason, the first half of this chapter is devoted to exploring how technology can be leveraged to create innovative and unique storytelling experiences. Through a systematic approach that includes scholarly research and literature reviews, I aim to address narrative questions that I could not answer or explore through my practical project. I start by discussing the technological underpinnings and sociological considerations of narrative before narrowing these into the context of passengers and transport. Finally, I will move into the practical and theoretical thinking behind the *Fantasia Express*.

The starting point of my narrative journey starts with a simple scenario; the act of reading about a historical event at the location the event took place. By associating (or linking), a series of GPS coordinates with a story, the impact and resonance of that story are amplified. This example articulates the power of mobile devices and digital layers when acting as a force multiplier to a story. At a basic layer, a narrative or story is a piece of content comprised of an idea, thought, emotion, fiction, or non-fiction. When you add metadata that helps to amplify that piece of narrative content, I would argue that it becomes a data narrative. Like the example above, GPS is an obvious way to amplify a story by linking it to a location.

The data in a data narrative is cold and technical. However, I would argue that there is another type of data that can also be warm and emotive. Social media represents a type of data with some emotional characteristics and what I would term *soft data*. Although some social posts could be seen as traditional stories, their profusion and ephemeral nature warrant this new categorisation of soft data.

The way that this massive database of soft data is interfaced becomes a powerful narrative framework. Machine learning combined with some basic metadata provides powerful dynamic search tools. In this instance, the narrative is created by how these mini-emotional snippets are

collated, accessed, curated, and distributed. Creating ways for audiences to browse this soft data empowers them to create their own personalised soft data narratives, increasing their agency and individual authorship. It has the potential to fundamentally alter the relationship of the traditional author-audience model.

I expand on all three components: data narratives, soft data narratives and authorship. They are an important foundation on how technology enables new and original narrative approaches, and they can all be applied to my passenger context. It is this application of technology and location to the passenger experience that I turn to in subsequent sections.

I explore ideas behind living maps, performative cartography, and the sociological importance when mobility and locative technology come together. All of which create the framework behind future passenger experiences. Nanna Verhoeff alludes to the concept of a 'performative cartography' (Verhoeff, 2012, p. 143), which she essentially sees as the abstraction and manipulation of cartography combined with movement and time. Verhoeff applies this concept to the notion of mobile screens and, crucially, the way in which users of such devices change or alter their relationship to urban geography.

Following ideas such as Verhoeff's, I found that data narratives on their own could be seen as an interesting way to tell a story. However, it is whilst we are moving that our heightened sense of (changing) location and (enhanced) mobility (travelling in a train carriage being an example) brings an important extra sociological dimension. I discuss how this sociological impact of mobility creates a rich potential for storytellers and, importantly, identifies it as perhaps the most meaningful and valuable aspect of technology-based narratives.

In the second half of this chapter, I turn my attention to the narrative approach I took to develop the narratives for the *Fantasia Express*. This is where I use prototyping methods to answer my narrative research question i.e., what types of narratives can be used to engage passengers on a fast-moving train?

5.1. Data Narratives

In this section, I will discuss *data narratives*. Data narratives are foundational to any narrative experience that incorporates locative or other forms of data to provide passengers with unique user experiences. I present several examples to demonstrate the potential of data narratives beyond my core research in public transportation. These examples also provide different tactics that could be applied to trains and lay the groundwork for my later discussions of mobility, living maps, and performative cartography.

Christian Marclay is an artist whom I call a data narrative artist; his films are mashups of clips ordered through the application of data. For example, *The Clock* (Marclay 2010) is a twenty-four-hour film comprising thousands of snippets from other films that show clocks.[13] It is presented at exhibitions in sync with the current time. The data in Christian Marclay's *The Clock* would be the timecode for each clip he has identified, with the addition of the time it represents.

The more obvious example of a data narrative for my research is one that is linked to location. For example, reading about a historical event in the place of that event amplifies the experience and makes it more memorable (Farman, 2020, p. 45). This is a simple example of adding geographic data to a story. Comparisons can be drawn on how data has evolved from the archival data of the early web to the living data that now dominate the internet, especially the social media and mapping apps common to our mobile devices. I would argue that data narratives follow a similar trajectory.

Reading a story related to a location is an example of a data narrative that takes an archival approach. The content has been authored and stored on a database. The story and the location will not change, or at least there is no need for real-time changes (authors might want to update their stories occasionally). Still, as a piece of content with some associated metadata (the GPS location), it can remain unchanged and is effectively an archive.

An example of this type of archival data narrative is *Remember Me* (Totem, 2010), a project commissioned by *Future Everything* that encouraged people who donated items to an *Oxfam* shop in Manchester to leave a voice recording about the history of each object. The new owner could access these stories by scanning a QR code tag with their mobile phone (Fig 31).

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[13] Link to the *Tate* article on Christian Marcley's *The Clock* https://www.tate.org.uk/whats-on/tate-modern/christian-marclay-clock

[…] introduces an opportunity to build an Internet of Old Things based upon stories not data. By attaching a barcode loaded with memories about the clothes and artefacts that visitors donate to the Whitworth Park branch of Oxfam, things will gain a social and cultural value (Remember Me, 2010).

Fig 31 Remember me: Credit *talesofthings.com.*

This type of project marks a creative shift from the top-down heritage approach of contextualising significant historical moments through a location or landmark. It is more of a bottom-up approach to adding context to the mundane and everyday. It is pointing to a new way to disseminate narrative at a peer-to-peer level through the creation of small story experiences from one member of the public to another.

Remember Me is also a commentary on recycling and the stories that can be found in the waste and by-products of society. In 2018 I was invited to run a week-long workshop for students from the School of Architecture in Guangzhou, China. I was one of four artists tasked with leading a team to explore the creative mapping of the city. My workshop was called *The Rise of the Data Collectors*. Its premise was to explore the data we leave as city dwellers and see how it could be collected, sorted, and presented using narrative and storytelling. The brief I gave the students was to consider the ephemeral effects of human inhabitation and to map people and how they impact the city as an alternative to the more traditional maps based on permanent man-made structures or natural terrain. I was inspired by Ellie Harrison, an artist who spent five years documenting and

recording information about nearly every aspect of her daily routine and later wrote the book *Confessions of a Recovering Data Collector* (Harrison, 2009).

> I had a love-hate relationship with data collecting. I found it laborious, frustrating and chore-like, but at the same time compelling, addictive and almost impossible to give up (Harrison, 2009).

The primary outcome of the workshops was an art exhibition where we presented five artworks. One notable piece was created from the student's rubbish. Like the *Totem* project above, each piece was tagged with an autobiographical context. Surprisingly, this developed several narrative approaches. I was expecting the stories to be about the students, and many, like the wrapping for a card they wrote to their partner, were. However, my favourite piece of rubbish was an unused tomato ketchup sachet onto which the student had written, from the object's perspective, 'I am sad that I am perfect, yet discarded'.

This workshop highlighted the human and hidden aspects of the millions of data points collected across the vast networks of urban data. If a single discarded sachet of tomato ketchup can provide such an interesting and poetic story, then it shows the rich potential for data-based narrative storytelling. It is a prescient insight at a time when smart cities collect data from thousands of nodes and sources, but it is cleansed of any emotion.

In an age where we can quantify the precise pollution levels, temperature, decibel levels, crime statistics, hospital admissions, traffic levels, roadworks and potholes, a much quieter voice represents the human stories behind these statistics. By focusing on these statistics alone, we are in danger of removing humanity from our surrounding urban context. Scott McQuire illustrates this in his description of the Centro De Operações Prefeitura Do Rio, which he explains was a partnership between the Rio de Janeiro city government and *IBM*. He states that it:

> […] draws together data streams from thirty agencies. In the control room, urban "management" becomes a matter of optimizing flows of energy, matter and information. Despite the sophistication of the system, one is left wondering what has happened to the capacity to understand the city as a complex of social encounters that are experienced and lived rather than "optimized" and managed (McQuire, 2016, p. 41).

This data reflects the sawdust, symptoms, and effects of human activity, yet as this quote alludes, it strips it of the analogue reality behind each data point. Each of these granular levels of data has the potential to be brought to life through storytelling.

Naho Matsuda is an artist who uses binary sensor data to create analogue art that comments on this connection between clean data and messy humans. She confronts the obsession with smart cities head-on with her project *EVERY THING EVERY TIME* (Matsuda, 2019) (Fig 32).[14] This art project not only sets out to create poetry from a city's datasets, but she is directly commenting on the phenomenon of smart city discourse as the quantified city and bringing a lens to highlight the qualitative city of human interaction. The artwork consists of a mechanical screen with turning letter flaps controlled by urban datasets. This project removes the author and replaces her with an automated, rule-based narrative structure to create random streams of words that appear as poetry.

> With this kind of radical abstraction of data and juxtaposition of various data streams – from air quality to local football club schedules – I wanted to question the values, uses and ownership of certain urban data. I wanted to explore what data becomes when it is a lot more useless; when systems that are built for functional, efficient purposes are dragged into the chaos from which they originally came (Matsuda, 2019).

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[14] Further information about Naho Matsuda's project *Every thing Every time* in 2017 can be found here: https://futureeverything.org/portfolio/entry/naho-matsuda-every-thing-every-time-cityverve/

Fig 32 EVERY. THING EVERY TIME: Credit Naho Matsuda.

EVERY THING EVERY TIME demonstrates a different approach to the authored data narrative examples I have previously discussed. The point I am raising here relates to the automation and manipulation of sensor data and data stores as a source for narrative. This is an example of living data, not archival data, being used to create a narrative.

Another important feature of modern data stores is their ability to use machine learning (ML) and artificial intelligence (AI) to infer and automate meaning and taxonomy from visual assets and text. The following is a good example of how ML And AI reach deep into our private lives. In my personal *Google Photos* account, I can search my library with a free text field that could include terms like a *red dress, child, eight years ago….* The mechanism behind this is a combination of real-time data transfer, automated categorisation, and inferred meaning characterising the modern approach to an operational archive. Today's leading edge of this approach (referring to 2022) can be seen in the use of neural networks and artificial intelligence to create artistic or photorealistic images from text prompts using tools like *Dall-e* and *Stable diffusion.*[15] This has the potential to allow users to create rich visual narratives without any visual skills. In my research field, I think the most significant impact will be using this technology to increase the fidelity of augmented

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[15] Link to a *YouTube* video explaining *Dalle* DALL·E 2 Explained and a link to the *Stable Diffusion* website https://stability.ai/blog/stable-diffusion-public-release

reality models through AI-driven textures instead of the traditional and processor-heavy approach of using 3D software.
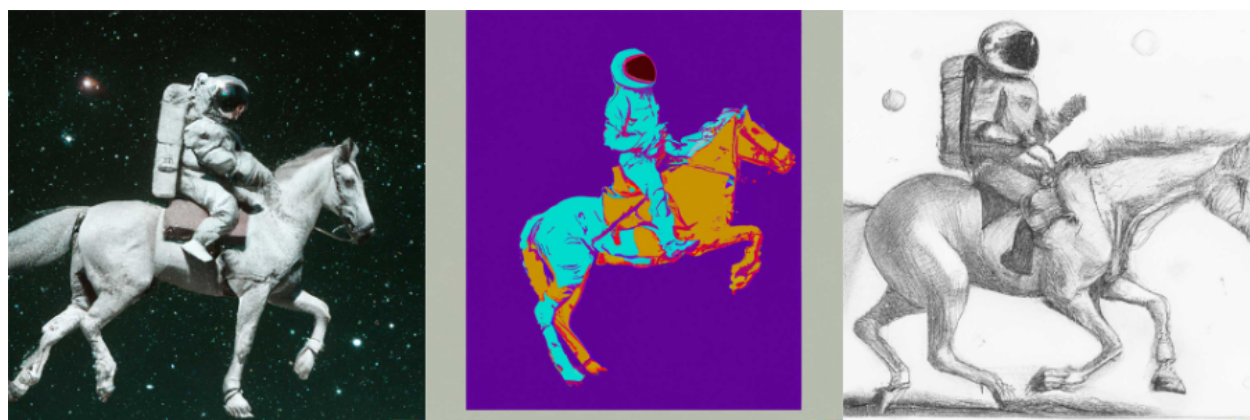
Fig 33 *Dalle* image: Graphic by author.

The text prompt behind the image above; *An astronaut riding a horse in space in a photorealistic style/ in the style of Andy Warhol/ as a pencil drawing.*

In the above, I have discussed data narratives in terms of traditional storytelling techniques and applying a data layer to provide context and amplify the experience. I have mentioned how data and data collection opens the doors from a thematic and critical perspective to reveal insights and narratives around our lived environment. I have then talked about more advanced operational data sets and how, for instance, Naho Matsuda uses the sensor mechanics of smart cities as a way to automate narratives. Furthermore, how this connection to live sensor data also relates to the shift to archival time and permanent reciprocating data transfer. And finally, how applying evolving Machine learning and AI tools to search and understand this data can create a powerful interface for the public to interact with them.

While the previously mentioned examples of art projects offered valuable insight into how, e.g., objects and spaces can be connected to data points, the data elements of all these previous narrative examples have been somewhat cold and technical. The GPS data of a tag of a second-hand item or the time and date a sachet of ketchup became surplus, or the binary data feeds from a city's sensors share this commonality. The stories attached have all come from a human providing the overall authorship. What I was interested in with my research was the ability of the data itself to hold the stories and emotional context. I was interested in the tides of emotional, warm, beating data pouring into and out of social media channels. I previously mentioned the idea of the qualitative city being the city drawn not by the architects but by the physical/ analogue trails of the inhabitants. This emotional data adds to this idea of the qualitative city or what Graham (2013) calls the *digital shadows.*

> (Graham & Zook, 2013) has argued that cities, in particular, are now constituted as much by their digital shadows as by bricks and mortar. Digital shadows are the layers of digital content generated about city spaces from city spaces. These shadows emanate from quotidian uses of social media as plumes of data propagated and transmitted by the connected (Ash, Kitchin, & Leszczynski, 2018, p. 16).

It is a logical step for me to apply the description of the digital shadows of cities to passengers and trains. I am reminded of *Schivelbusch* and his description of steam trains (Schivelbusch, 1986), but with the chimney stack being replaced with the plumes of data from all the passenger's social and network interactions.

The point I want to make is that these plumes of social media data represent a data point that itself is a container of emotion and what I would call soft data. And in this scenario, this soft data is itself the story and the narratives become curated, not authored. In fact, there are two levels of curation, a top-down and bottom-up dynamic. The top-down curator designs the framework, operational archive, taxonomies, and themes that form the interface for the bottom-up creator. This would typically be the user who can then manipulate that system to surface the soft data and create a narrative that is meaningful to them. This is an important change in placing the narrative agency with the user, not the author.

> This situation underlines the extent to which the older politics of representation inherited from the broadcast era is today embedded within a new politics of search. The older 'gatekeeping' functions of editorial teams in filtering information and knowledge are today supplemented, and even supplanted, by the black-boxed algorithms of proprietary search engines (McQuire, 2016, p. 62).

McQuire refers to how authorship is no longer the reserve of mainstream broadcasters. Furthermore, he argues that the algorithms and technology behind search engines allow individuals to create their own highly personalised narratives. This technology applies machine learning and artificial intelligence to understand data and match it to an individual's preferences and behaviours. And it can do this objectively and subjectively based on its content and emotion.

An early example of this is the seminal project. We Feel Fine by Jonathan Harris (Harris, 2005). This shows how, in this case, the artist is setting up a narrative mechanic that allows the user to be the curator. The project searches blogs and social posts every few minutes for the phrases I feel and I am feeling. It then extracts the full sentence, demographic information, time, date, weather

conditions, and sentiment analysis to infer emotional state. This information is visualised in an interface designed to encourage search queries (Fig 34).

> At its core, We Feel Fine is an artwork authored by everyone. It will grow and change as we grow and change, reflecting what's on our blogs, what's in our hearts, what's in our minds. We hope it makes the world seem a little smaller, and we hope it helps people see beauty in the everyday ups and downs of life (Kamvar & Harris, 2009).

While the data narrative projects discussed in this section do not have a direct connection to transportation, their conceptual and technical approaches could be effectively adapted to enhance the passenger experience. For example, *We Feel Fine* could enable passengers to browse the emotional states and stories of fellow passengers, past or present. Another project, *Remember Me*, could allow passengers to leave digital marks and messages on their seats about the reasons for their travel and what it means to them. Matsuda's *EVERY THING EVERY TIME* could also be reimagined to resemble the old station notice boards and applied to train and passenger data.

Most representative feelings of people aged 20 to 29
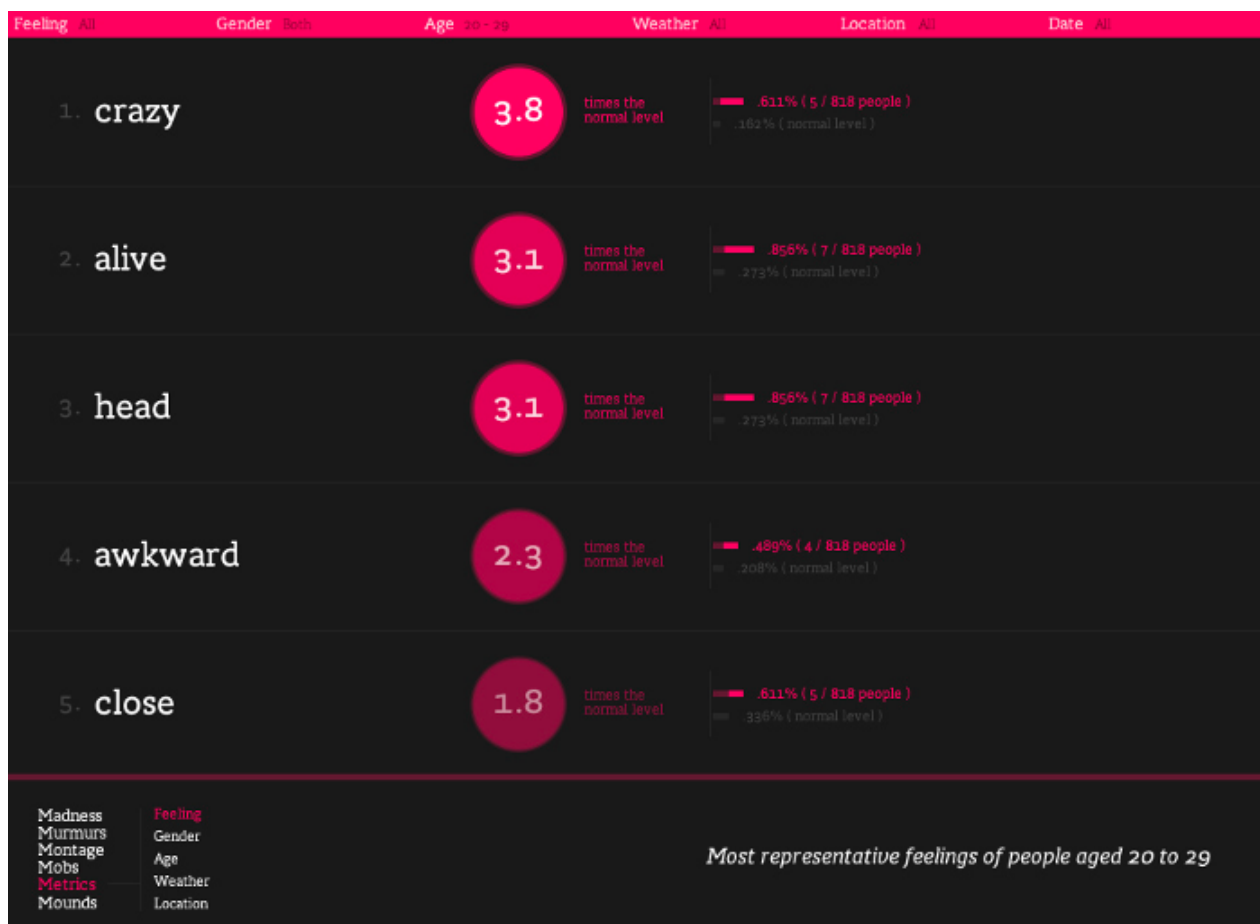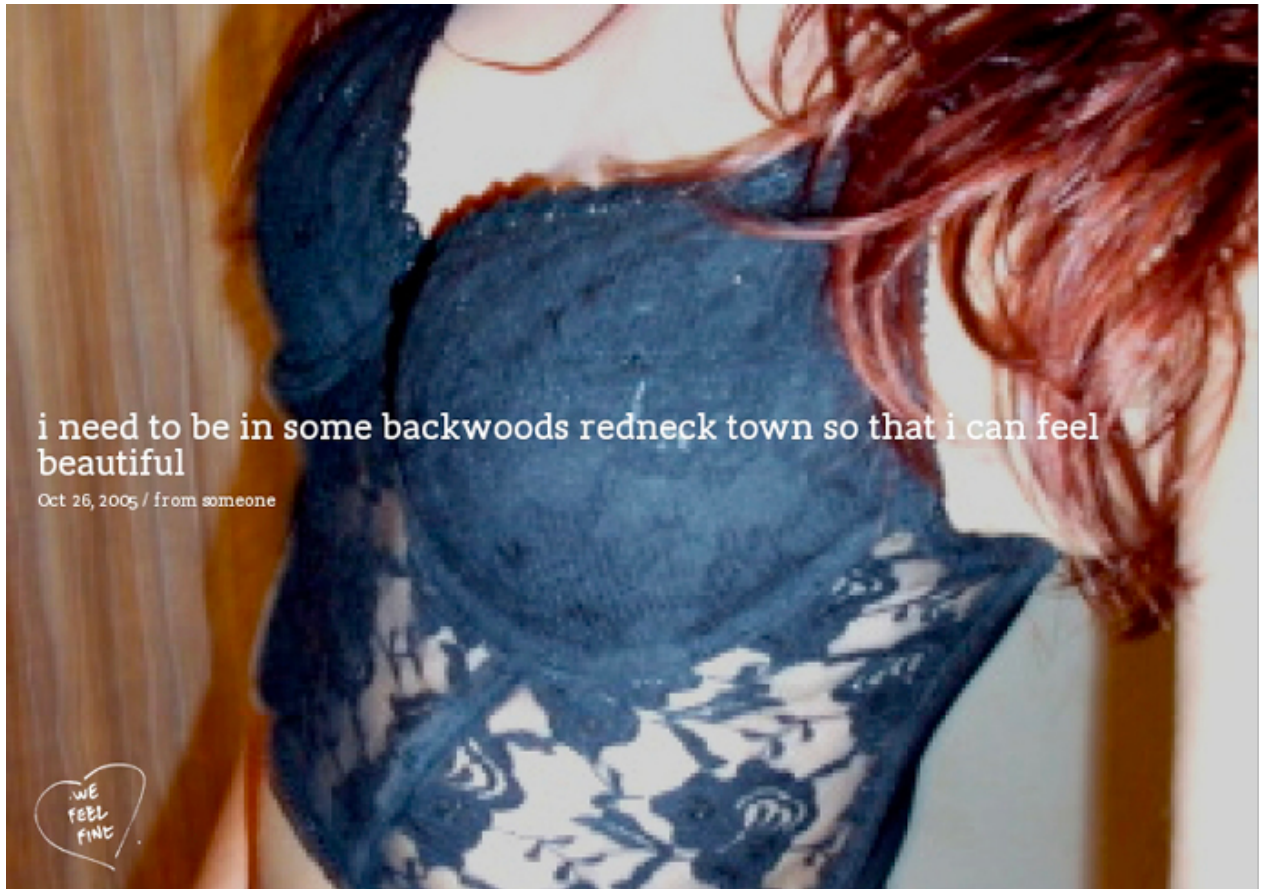
Fig 34 Images of We Feel Fine interface: Credit Jonathan Harris.Travel/Mobility Narratives

In the previous section, I looked at how mobile devices and data can be central to enabling new types of data-based narratives. I have tried to paint a logical picture and framework of how data can create a powerful toolset for innovative ways of telling stories. In this section, I want to expand on some of those ideas and other perspectives that concentrate specifically on mobility, location, the passenger experience, and the context of a train carriage.

Mobility

First, let me discuss the notion of mobility, a term almost as charged as *digital* in the sense that it is so wide and all-encompassing. It can apply to nearly all facets of life, from getting up in the morning to the billions of vehicle miles, the millions of flights or the movement of gas and oil fields (Adey, 2017, p. 21). I need to narrow this broad definition into what it means to my research: the mobility and computational power of our smartphones described by Farman (2020).

> The move from personal computing to pervasive computing, a shift characterised by the move from immobility to mobility, has allowed for online space to interact with material space in unprecedented ways (Farman, 2020, p. 39).

Farman's shift is probably best illustrated in the way in which we have become embedded and embodied in our mobile phones and how that has, in turn, increased our mobility as humans to the point John Urry (2012) describes as a societal shift at the root of how we operate as a society.

> […] those diverse mobilities that, through multiple senses, imaginative travel, movements of images and information, virtuality and physical movement, are materially reconstructing the 'social as society' into the 'social as mobility'(Urry, 2012, p. 10).

So far, my discussion on data narratives demonstrates the potential for taking advantage of technological developments to create new and novel storytelling. The societal shift that Urry highlights in the above quote points to the social impact and importance of mobility combined with data narratives. Sarah Pink also talks about how this societal shift, which sees the evolution of the quality of our camera phones combined with location as an important change from networked visuality to emplaced visuality (Pink, 2011).

> […] we need to focus more closely on the everydayness of media beyond the content, and look at the experiential realities with which it is interwoven (Pink & Hjorth, 2012, p. 153).

Her point is that it is not just the simple combination of image and location but the creative use by the public of filters, stickers, narrative and emojis that elevate this process from data to sociology. This is fertile ground for creativity, and I argue that artists and storytellers need to catch up with this technological and societal shift taking place in front of our mobile screens.

When applied to trains and my area of research. The aspect of mobility I have focused on is the passenger experience. And when you look closer, that experience is predominantly one of waiting. Waiting in the context of train passengers has been a neglected aspect of mobility. The idea that you are mobile yet sat in a comfortable chair looking out of the window as the world passes you by has traditionally been seen as a negative experience as far back as the 1840s (Schivelbusch, 1986). However, technology is beginning to create new, positive, and exciting opportunities that are becoming fundamental to the 'mobility experience' (Kellerman 2020).

> […] today's transport environments are characterised by an increasing plurality of supplementary technologies that 'moderate', 'direct' and, finally, 'tame' the wait (Kellermann, 2020, p. 125).

The sociology of mobility is now such a part of the technology landscape that scholars are re-evaluating the potential and importance of waiting in a train context. I would therefore argue that the *Fantasia Express* is a pioneering approach to what Kellerman calls 'taming the wait'.

The *Fantasia Express* takes the physical and functional aspects of a train journey. It applies a narrative intervention (telling a story that encourages people to look out of the window and discuss the locations they are travelling through). I have embedded a creative experience into a primarily practical one. The current imperative is that everything is designed to make travelling by train as efficient and fast as possible. Journey times or travel time is the UK government's standard metric for calculating rail investment value. This metric is predicated on the simplistic assumption that travel time is wasted time (Lyons & Urry, 2005). This means that the best way to show the value of rail investment is by decreasing journey times, the latter of which frames industry discussions on improving our railways.

I remember a key moment from a presentation I gave to rail executives in which I showed a slide alongside a joking remark. 'There are two ways to make train journeys shorter. One can either spend £100 billion on *HS2*, taking twenty minutes off the Manchester to London route or make the journey more enjoyable, as time flies when you're having fun'. While this can be seen as an unconventional approach to getting the attention of my stakeholder group, it was my response to Lyons and Urry's argument above.

Both scholars argue that with today's technologies and data, travel time can be an incredibly productive time. There is also a significant number of psychological studies to support my flippant remark about ways to make time pass quickly (Allan, 1979; Block, 2014; Converse, Sackett, & Meyvis, 2010; Freedman, Conrad, Cornman, Schwarz, & Stafford, 2014; Maciejewski, 2010).

This brings a secondary point, but one close to my heart as an artist who loves to embed everyday and the ordinary with creative magic. It is the engineers and architects who build our transport infrastructure. There must be more room for artists and storytellers. The architect and urban planner Francine Houben is a lone voice who champions a more creative approach to public works. She lectured engineers and administrators entitled 'The art of integral engineering and the aesthetics of mobility', in which she asks for a more centralised approach to adding creativity and artistry to the civic infrastructure (Charlesworth, 2005, p. 104). In doing so, she argues for design to be given a seat at the decision-making table. The *Fantasia Express* aimed to embed a creative experience as an integral part of an ordinary train journey.

Living Maps

I argued above that mobility provides the technological and sociological framework for all and any practical and theoretical discussion of people's movements and of future passengers. I am now introducing the critical enabler behind personal mobility. Living maps are a concept introduced by the *Rathenau Institute* as a thought experiment further described in the following quote.

> A "living map" is a merger between a territory map and a dynamic localized flows representation creating visual information where places, people, activities, and time are mixed together (Aguiton, Cardon, & Smoreda, 2009).

Living maps are fuelling a revolution in the use and development of maps and mapping, Janet Abrahams and Peter Hall argue, for instance:

> […] mapping technology has split the interface from the database, a split comparable to the liberating effect photography had on the development of painting. Before the advent of aerial photography, satellite tracking, and computerized data-gathering, a map was expected to represent its territory with comprehensive accuracy. Freed of that responsibility, cartographers can manipulate their data into any number of visual representations (Abrams & Hall, 2006, p. 12).

Abrahams and Hall's comparison of mapping technology being comparable to photography's effect on painting is dramatic. But to reiterate a point I made in the introduction to this thesis. In the twenty-seven thousand years of human-made maps, as argued by (Wolodtschenko & Former, 2007), it is only the last seventeen years that we have had the mapping revolution of *Google Maps*. This is not hyperbole but an insight into the importance of maps and what is known as living maps.

Martijn de Waal emphasises how personal mobility is affected by living maps and dynamic mapping experiences by highlighting several real-life examples. He discusses how *Grindr* is a living map offered as a dating app. *Grindr* is the largest all-male location-based mobile network that superimposes a map of the user's location with the profiles of other users interested in a hook-up.

> A new generation of interfaces provides an additional function: the digital traces that city dwellers leave behind can be consolidated and used as a basis for making collective rhythms and meanings clear. Some programmers use these data to create user profiles; this information can then be used by a living map to recommend new

places, services and people. A living map can thus partly lead its own life-the underlying algorithms to determine what one ultimately sees on a map (De Waal, 2013, p. 80).

Here he discusses mobile apps that we do not immediately consider navigation or cartesian but that employ all the technical elements of mapping software. He also discusses how this enables parochial communities that typically gravitate around a specific location to be created anywhere. For example, the dating app *Grindr* is a way to make a gay neighbourhood in all parts of the city by simply filtering the people who happen to be in a location. More generally, the living map and performative cartography enable numerous opportunities for new narratives and new services for people on the move and provide a critical methodology for engaging passengers in moving vehicles through their mobile devices.

> The mobile phone will become an 'experience marker' for 'net-localities': Mobile annotation applications have enabled us to locate things and to be located ourselves, and the availability of GPS and the affordability of mobile devices have fueled the popular adoption of these tools. Now that our devices are location-aware, we are much better positioned to be location-aware ourselves (De Waal, 2013, p. 75).

De Waal is interested in using mobile devices to create digital interfaces with urban environments. Particularly to create digital equivalents of urban areas that attract particular communities. Like a popular coffee shop or diverse neighbourhoods. This is what he arguably means by *net-localities* and being able to locate and, more importantly, be located, specifically how apps can create virtual neighbourhoods by attracting like-minded people roughly in the same area to meetups.

In this context, a train is an interesting and novel place to present location-specific experiences. Most location-aware social apps are designed for urban pedestrians. A fast-moving train carriage is a living map on rails. It is quite distinct from travelling by road. It is centred around the panoramic view of the landscape, a relatively relaxed and spacious carriage and smooth, uninterrupted motion.

This leads me to the final piece of my data jigsaw. I aimed to show above how location data and mobility can create a social and technological revolution in developing and applying dynamic living maps. In the following, therefore, I want to bring us back to the focus of this chapter, which lies in the creative, or even performative, construction of a narrative train journey.

Performative Cartography

Performative cartography is what I see as the creative strand of mobility and living maps. What Verhoeff describes as 'the visual regime of navigation, that is a specific mode of interaction at 'the intersection of visuality and mobility' (Verhoeff, 2012, p. 133). She refers to the combination of mapping software, mobile devices, and creative applications to create new experiences.

Public transport, for example, has a rich history of abstracting geography to display routes as a visualisation of train timetables. The *London Underground Map* (Beck, 1931) comes immediately to mind (Fig 35). This design was initially rejected for being too radical, but testing proved its value.
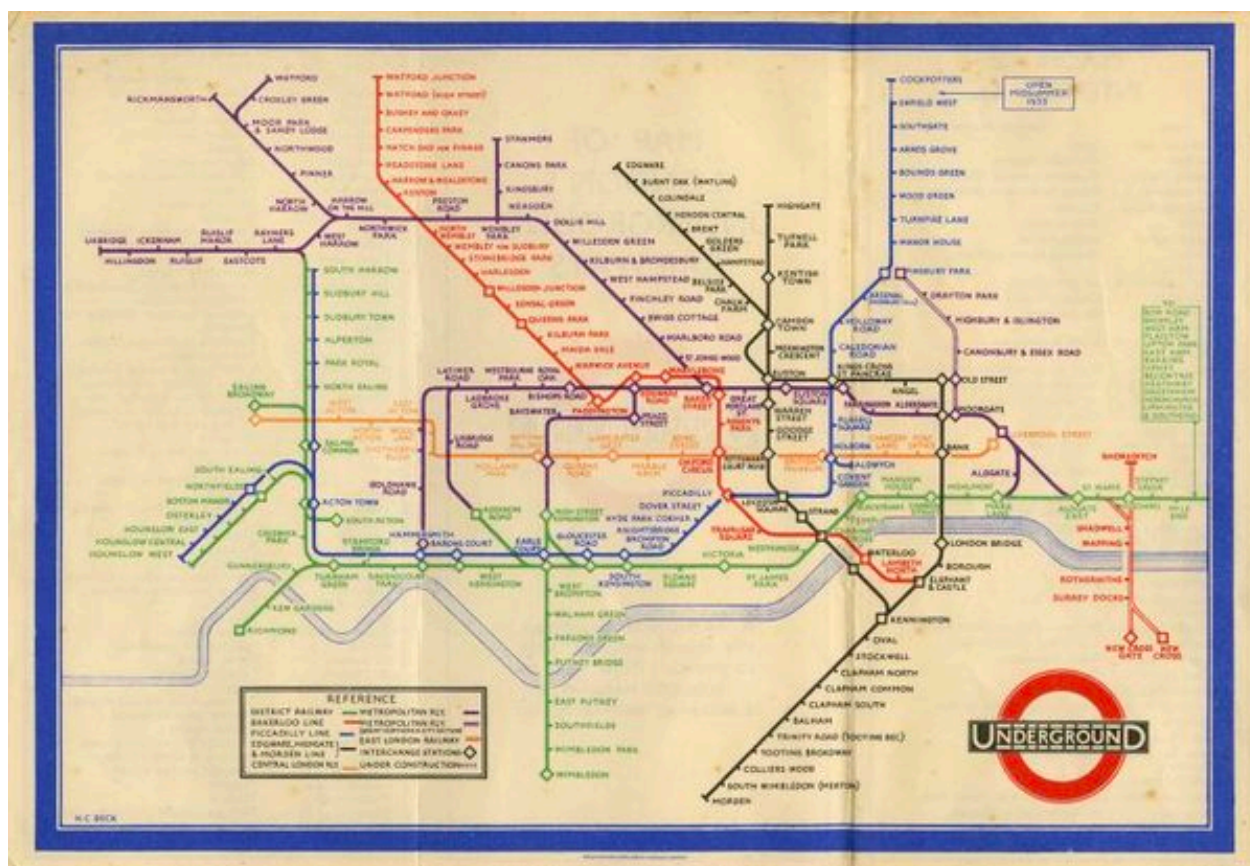
Fig 35 Pocket *London Underground Map* 1933: Credit London Transport Museum.

Performative cartography adds temporal, ephemeral, and democratic elements to maps. Mobility and technology decentralize the process, allowing for personalised creative experiences with GPS and platforms like *Mapbox* and *Google Map*s.

> Mapping has become interactive, social, creative, or ludic, and the making and using of maps is no longer limited to professional cartographers. Amateurs can make or modify maps (Verhoeff, 2012, p. 139).

As Verhoeff alludes, performative cartography is an extension of living maps but is applied increasingly to the public and not the chief graphic designer of a transport authority. It is not only that the user has agency, but the traditional conception of a map as a utility has been usurped. Maps are now used as a social, creative, spontaneous, and playful component of a mobile experience.

The key insights from Verhoeff's thinking for my research are this complete shift of mapping and navigation away from the traditional cartesian approach of following a two-dimensional paper map. She talks of how mobile technologies, screens and cultural practice are now creating a new approach to mapping and navigation fundamental to how we experience pedestrian and vehicular travel.

In my practical research, the core interface design for *Fantasia Express* was an example of how cartographers can manipulate their data into any number of visual representations (Fig 30). She comments specifically about augmented reality but even more importantly for my research is how she describes 'screen practices that not only represent space but also truly make space – operating as performative cartography' (Verhoeff, 2017, p. 435). The *Fantasia Express* addressed the visuality of performative cartography through its interface and place-making through its narrative and the way this connected passengers to each other and the passing landscape. It was one of the first, if not the first creative examples of a mapping service to connect the landscape to passengers on a fast-moving train carriage. However, I do not necessarily see my project as a 'living map' in the sense of it being dynamic and responsive. I would compare it more to the archival data narrative of the *Remember Me* project I discussed earlier. It missed the operational archive connections to other people and other live data sets. It did not give passengers agency or a chance to participate (give feedback); it was primarily a passive sit-back experience (Humble, 2011).

During the conceptual phase, I did consider what a living map might look like in a train context. Some ideas I came up with have more commercial use cases than entertainment. For instance, imagine a passenger on a one-hour commute – opening a recruitment app and looking out of the window to see jobs advertised in the same role that offer financial incentives and uniquely show how much shorter their commute would be (Fig 36). Or seeing that the large country house you are passing is offering accommodation. Or seeing bubbles appear above houses for sale.

Fig 36 Example of Living Map concept for train passengers: Graphic by author.

5.2. Traditional Narrative – The *Fantasia Express*

This section details my thinking and approach to creating the narrative structure and story world behind the *Fantasia Express*. I have titled it traditional narrative because I created a high-level story that could have been executed as a film, play, or book. However, the context (fast-moving train carriage) and delivery medium (mobile phone and location-based VR and AR) created complex narrative challenges. There is also an occasional crossover to some of the other narrative approaches I have discussed, particularly the performative cartography and data narrative sections. In this next part, I will concentrate on the part of the *Fantasia Express* that is best summed up as what eventually became the script.

To help my research and prototyping, I had the support of two narrative specialists, *BAFTA*-winning writer Rosemary Kay and comic novelist Si Spencer (*2000AD*, *Judge Dread*), scriptwriter and script editor, respectively. Philip Wood (*Emmerdale Farm* and *Coronation Street*) helped produce and direct the content and organise the talent and audio recordings using a combination of professional actors and students from *LIPA* (Liverpool Institute of Performing Arts). A concise way to explain the outcome is to imagine a location-based narrated radio play that dips in and out of a passenger's journey with short fictional micro-narratives supported by augmented and virtual reality visuals.

Fig 37 Image of audio recording of narration for *Fantasia Express* at LIPA: Graphic by author.

I imagined the narrative to be a combination of the book *The Hitchhiker's Guide to the Galaxy* (Adams et al., 1980) and the film *Predator* (1987). I wanted to create something with humour that would appeal to adults and children and a story that was centred around the train and the journey.

Synopsis of Fantasia Express story

Below is the synopsis of the story I developed during the first few months of the project. I also used this as a way to describe the story to the writers and the wider team. To give them a clear vision as a starting point for the script and the storyworld development.

> The *Fantasia Express,* or to be clearer, the 14:35 East Coast intercity train from London to Edinburgh, is not what it seems. Passengers are slowly discovering that they have embarked on an alien spaceship that has been sent to Earth to capture our most valuable resource. This precious substance is not our oil, water, rare metals, science, or technology. The aliens see the most valuable substance on our planet as the *relics of human imagination*, the myths and stories we have created since people first gathered around campfires to entertain each other.

In other words, the *Fantasia Express* is masquerading as a legitimate travel company offering passengers a guided tour from London to Edinburgh. However, unbeknownst to them is that by logging and experiencing these stories, they are stealing them for the aliens.

Fantasia Express Story World Narration: Script Extract

Below is a short script extract to highlight the narrative experience's structure. The high-level story is told by two narrators, Bebe Wansix (BB16) and Adie Sevenate (AD78), whilst the individual micro-narratives include a mix of unique characters. The script includes direct dialogue for the actors to record and some notes and directions to help discuss the visual execution of the augmented reality elements and sound design.

SMALL VOICE NARRATOR
It is our pleasure here at Fantasia Express to welcome you aboard. I'm Bebe Wansix, your guide during this experience, so please don't hesitate to ask me for support and advice to make your journey as enjoyable and profitable as possible.

Notes
You can see a photo of Bebe Wansix rising up inside the holographic images: she is a typical human female, looking like a guide or airline hostess, although closer inspection will reveal that some of her features are not quite right. Really observant users will note that although she called herself Bebe Wansix, the model number on her profile is BB16.

When starting this project, I did not anticipate creating the plot of an alien heist story. Of course, introducing aliens on a train journey between London and Edinburgh is far-fetched and perhaps slightly ridiculous, but it did serve a practical purpose and aligned the project with the initial inspiration of the *Bewegtes Land Project*. The concept evolved out of a design process and moulded around the challenges and opportunities of its context. That was to create an immersive narrative-led experience for a two-to-four-hour train journey between Edinburgh and London. The function and form of the project worked in parallel and informed each other. My ambition was for the technology to become invisible and, to paraphrase Clarke (1962), be '[...] indistinguishable from magic'.

From a practical perspective, the story allowed me to answer all the challenges I had identified while researching the idiosyncrasies and imperatives of a long train journey, which I called the *narrative anatomy of a train journey.* I am using the term *anatomy* here as many different parts

formed the body of my proposed train journey. During my research, I spent many long hours travelling between London and Edinburgh with an almost pathological rigour. I did this to gain an understanding of every inch of the track. The primary motivation was to survey the route to identify natural points of interest and places where the landscape could support augmented reality objects.

A side effect of all this time spent going up and down between London and Edinburgh was that I got to observe other passengers and the general rhythms of a long inter-city train journey (It takes approximately four and a half hours). Although a train journey is essentially linear, my story needed to respond to the particular situation of multiple passengers using multiple train stops and unique journey situations. My story or story parts would need to sustain any passenger travelling the entire journey. Still, it supported anyone taking shorter trips and travelling North to South or South to North.

I concluded that I had to make independent stories that responded to the location and worked in either direction (with minor or no amendments) whilst maintaining a long-form story arc. Effectively include a beginning, a middle and last but not least, a flexible story *denouement*, providing a sense of closure to any passenger on whatever journey they took.

The alien heist story, particularly the two tour guides, *Bebe* and *Adie*, provided the mechanic to weave in and out of the location-specific micro-narratives. They provided a flexible story tool (fictional helpers) that I could use to make even the functional elements of the experience, for example, onboarding, help, explanation of technologies and the beginning and end of each micro-narrative, into part of the story.

Another consideration for the script was that holding a mobile phone in front of you to view AR content can quickly become uncomfortable, so I limited the duration of each micro-narrative to sixty to ninety seconds. This meant that each scene needed to be short but punchy. All stories need at least three-story beats (set-up, development, pay-off/denouement), so to create tension, conflict, and character in a relatively short period, I kept the narrative drive of the scenes simple but layered the drama with humour and irony, subtext, complex characters, and multiple thematic strata.

The *Fantasia Express* experience ended ten minutes before each passenger's destination when the *VSHLF* (Virgo Supercollider Historical Liberation Front) boarded the train to arrest the aliens. The passenger was alerted and invited to solve a simple puzzle within an immersive 360 drivers cab experience. This was one of the most popular immersive experiences and one of the more convoluted and confusing narrative elements.

5.3.   Narrative Methodology: Process and Development

This section details the methods and processes behind the eventual *Fantasia Express* script. It covers the initial discovery phase, exploring the route, and researching stories and landmarks. This led to the initial scripts and a series of iterations based on refinement and reacting to the technical team's feedback before creating the final script and production of assets.

The starting point for the project, the one thing I knew from the beginning, was that I needed to create interactions and stories related to the train's location. One of the devices I used to help to get a feel for the length and rhythm of the journey was to source a room, a very long table and a child's wooden train set. I then created a model of the route from London to Edinburgh. This became the nerve centre of the project and allowed my collaborators and me to always have an eye on the bigger picture. It also evolved over the different phases of the project. Walking around the space and discussing parts of the project or standing and contemplating whilst surrounded by all the materials was very useful (Fig 38).

Fig 38 Workspace for Fantasia Express: Graphic by author.

At the same time, I researched other locative media projects and maps. Almost all were designed to provide heritage information about locations and, although interesting, felt dry. They were also focused on an audience predisposed to or who had a prior interest in history or the site. I had the advantage of a large captive audience, but the disadvantage was that they had no latent interest in engaging with my project. This suited me as I felt a bold and more creative approach would make the project stand out and appeal to a wider audience. In my art practice, I noticed that when you present a project that is unusual, or that cannot be immediately categorised, people are more open to trying it.

So even before the *Fantasia Express* became a spaceship, I knew I wanted to look out for quirky, unusual stories or events that had more than historical importance. I was looking for interesting

facts, news stories, myths, and legends. My initial aim was to cast a very broad net, identify common themes and categories, and think of types of interaction.

When the spaceship landed (metaphorically), the simple statement from the story synopsis *relics of human imagination* provided a great perspective to help with this categorisation. Obviously, it meant a large focus on myths and legends. But also, artworks, stories about UFOs and other artistic ideas could fit under that umbrella.

To help with this, I created a spreadsheet using the same MOSCOW method I applied to the user stories in the *interface* chapter. This is a way to prioritise by tagging each story with a Must, Should, Could or Won't label (MOSCOW). The rationale behind the labelling was to consider not only how much I liked the story but also to create a uniform spread of stories across the route. I also included the potential for visualising them and for using immersive technologies.

This document became our single source of truth for a few weeks as I went back and forth between all the various specialists working on the project (technical, immersive, creative and story). The document grew to include notes and ideas as we moulded the list into more of a project-scope document. What united us was the focus on areas that offered the most potential in terms of our available time and budget. From this process, I also created a list of priorities that would help to frame the story development.

I had to consider and decide how much of the story content could be delivered in AR and whether moments of VR were appropriate for the user. I learned during this process that it was essential to not simply assume a certain level of digital competency of the user but to look carefully into the range of users and their respective diverging understanding of AR-associated technology. For instance, young users might not need a tutorial, whereas older users might require assistance.

Throughout the project's progression, I became increasingly aware of the technical team's limitations on creative thinking, prompting me to carefully consider the delivery platform's technical constraints. Initially, I approached primary creative story content with an open mind and a blank canvas approach. However, as the technical scope evolved, I had to adjust the creative narrative parameters and constraints accordingly.

The narrative and script were regularly updated and refined to reflect the available budget (time) and technical feasibility. This was not a surprise; I knew that this was a project mainly into the unknown for everyone.

WORK PACKAGE		Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March
WORK PACKAGE	**CREATIVE (MYU/ISL)**													
WP1	Discovery													
WP3	Storyboard			M1										
WP5	Creative Tech dev													
WP6	Creative Tech dev													M7
WP8	Brand and Design						M5							
WP9	3d High fidelity assets													
	TECHNICAL (POP)													
WP2	Func spec			M2										
WP7	Protoype & test					M4								
WP11	Build and deploy										M8			
WP12	Carriage integration											M9		
WP14	Bug fix											M11		
	BUSINESS EXPLOITATION (MYU)													
WP4	Business, plan, pitch, canvas, value proposition												M10	
WP10	Market research								M6					
	PROJECT MANAGEMENT (MYU/VTEC)													
WP 13	LAUNCH Pre/during/post													
WP 15	Fortnightly Project Meetings						M3							
WP 16	Admin and finance													
WP 17	VTEC support													

Fig 39 L2 plan of grant-funded project timeline: Graphic by author.

To mitigate the script's dependency on what the technical team could deliver. I decided early on to treat the micro-narratives like I was writing for a radio play. The rationale for this was that I wanted to avoid creating scenes that required a strong visual dependency. I felt a radio play decoupled the narrative from specific visual elements. This allowed me to delay making creative decisions until I had a better understanding of what was possible. The compromise was that the micro-narratives would become more passive experiences that you watched and listened to and less interactive.

As the project progressed, I would make suggestions to the tech team, who would present me with a list of issues that would require resolution. Where this was not possible, I would rethink the narrative accordingly. This essentially constituted an iterative process that aimed to make the script shorter and tighter. The early treatments helped with this as the visual elements created a slightly different rhythm to the beats in the script. Towards the end, I brought Si Spence in to edit the final script. He has a background in comic books, and after talking with him, I realised that taking a comic book paradigm is a better story construct than a radio play for this type of narrative experience.

As storytelling in AR is nascent (there are no set approaches, and several platforms are still developing), it was essential to grasp how we needed the story to interact with the software and games engine. There were four main visual ways through which we could position the content of the story (In the carriage, on the table, attached to the window and in the landscape), and these spaces were built into the narrative structure. I was always aware of these four spaces in the storytelling shapes, alternating between them and trying to use them to maximum effectiveness.

I initially came up with approximately fifty possibilities for story scenarios, including interaction options for engaging in the journey from London to Edinburgh, i.e., fifty places on the journey where story options presented themselves; story scenes were developed around these fifty

locations. I then developed around twenty of these in more detail, with a view to them forming part of the story journey. This involved developing the characters, the conflict and tension, and a storyline for all twenty locations, which were integrated into scenes/game opportunities.

The needs of the specific audience dictated the sort of content and the style I was aiming for. The primary audience for this was families, to appeal to a wide age group. I was mindful that young audiences were more likely to take up the option to download the app initially and thus drive the main audience responses. I approached the story contents in several ways. I explored, for instance, the content details (character, story) with a particular kind of audience in mind. Furthermore, I would explore the tone and style of communication. The story world behind *Fantasia Express* emerged from this process, and this is what I turn to next.

5.4.   Fantasia Express Storyworld and Micro-narratives

The term storyworld is commonly used to describe writers' techniques to help them imagine the world their characters inhabit. It is traditionally the story that lives outside the narrative that makes it onto the page as described by Amos Wilder in the following quote.

> So today we look behind the fables and recitals and ask what shaped them. What climates fostered these various fauna and flora (Wilder, 1983, p. 354)?

My storyworld was not only the world of the fictional aliens and trying to understand what motivated them to prize the relics of human imagination. What made them turn to crime and chose our planet? My approach to storyworld is unusual as the experience's format and setting influenced the story, unlike a book or film with a well-established format that is independent or has at least evolved as part of the process to become second nature to the creators. My storyworld, on the other hand, was also the creative narrative response to the restrictions and practical considerations of the technology and the context of the narrative anatomy of a train journey. These did not just present technical challenges but also influenced the narrative. For example, in some instances, a micro-narrative would have a slightly different script dependent on if you approached it from the North or the South.

What I mean by micro-narrative is the self-contained individual vignettes that lived at the heart of the story that were inspired by the research into the locations.; I was pleasantly surprised at how many wild, whacky, and indeed fantastic stories came to light during my background research. The micro-narratives, themselves independent historical finds and myths, formed the bulk of the

immersive elements that punctuated the journey, or in the context of the *Fantasia Express* storyworld, the valuable relics of our imagination.

And this leads me to another important part of the storyworld. The micro-narratives might only appear every ten to twenty minutes of the journey. To join everything up, I needed a super narrative to hold all the independent elements together. As I have already mentioned, this underlying alien heist story had to weave in and out of the individual micro-narratives. This again shows how the creative and the practical evolved together. This was a new and innovative approach to storyworld creation. It was influenced by what Mattelmäki (Mattelmäki, Brandt, & Vaajakallio, 2011) argues about open-ended interpretations when collaborating across disciplines. And was complemented using user stories (Cohn, 2004), which also takes an open-ended and story-led approach to describe and document requirements. This avoided using colloquial or technical jargon and kept a conversational dialogue between the technology (Bailey) and the narrative team (Kay).

Of the fifty micro-narratives initially identified, eighteen were scripted. I then shortened the route for practical reasons to be from London to Newcastle; this left eleven that were taken to a studio to have the narrative recorded. Six of these were developed into finished full-production micro-narratives that formed part of the final prototype.

01 London Ravens*	07 Lambton Worm	13 Flying Scotsman
02 Farmer Giants of the Fens	08 Minions of the North*	14 Sniper piper
03 Wise old oak	09 Zebras of Newcastle	15 Holy island
04 Last Englishman	10 Salmon Queen of Tweedale	16 Polar bears of Inverness
05 Yorkshire Hobs*	11 Hadrian's wall	17 Beginning: on boarding*
06 Angry dragons of York*	12 Border game	18 ending VR experience*

*indicates micro-narratives that made it to the final prototype

Table 2: List of shortlisted micro-narratives.

Micro-narratives That Made it into the Final Build

It took four months from the script's first draft to the final version used to produce the six completed micro-narratives (five AR and one VR). In the following section, I will briefly summarise each of the stories alongside some of the idea development and process.

I tried to give the micro-narratives a lightly satirical perspective; in the same way, many children's tv or film productions contain subtle layers of storytelling that will appeal to the parents. One approach we repeatedly took was reimagining the myths and legends with a modern subtext that commented on traditional beliefs and popular culture.

For example, one micro-narrative that did not make it into the final prototype was called *The Last Englishman.* The inspiration behind this micro-narrative was the story of *Hereward the Wake,* considered the last English nobleman to resist the Norman conquest. Although, ironically, it turned out he was Danish. I wanted to use this idea of subtly making Hereward a comic reference to a Nigel Farage-like character and play on some British stereotypes and the ongoing (at that time, 2019) Brexit debate.

Another micro-narrative not to make it was the *Wise Old Oak*, based on how the oak tree was represented in Celtic cultures and folklore. They perceived its size and age as a sign of noble wisdom. I wanted to use it to reflect the modern-day practice of memes popular in social media. Short statements that appear to be wise but are fundamentally meaningless. An oak tree would appear on your table and narrate mock proverbs but stumble and get them wrong.

> 'Age brings great knowledge. Knowledge comes, but wisdom lingers. In fact, some people tell me it can go on and on' (extract from the script).

Production Insights from Six Micro-narratives (MN)

This section will expand and detail the six fully realised micro-narratives. I will list them as a passenger travelling from London to Newcastle so that they represent the narrative arc and order that a passenger travelling on that journey would have experienced them. I take a narrative perspective; the technical and interface (UX) perspectives are dealt with in their respective chapters (Chapters 3 and 4). The first and last micro-narratives also bookended the experiences and had a slightly different role from the others.
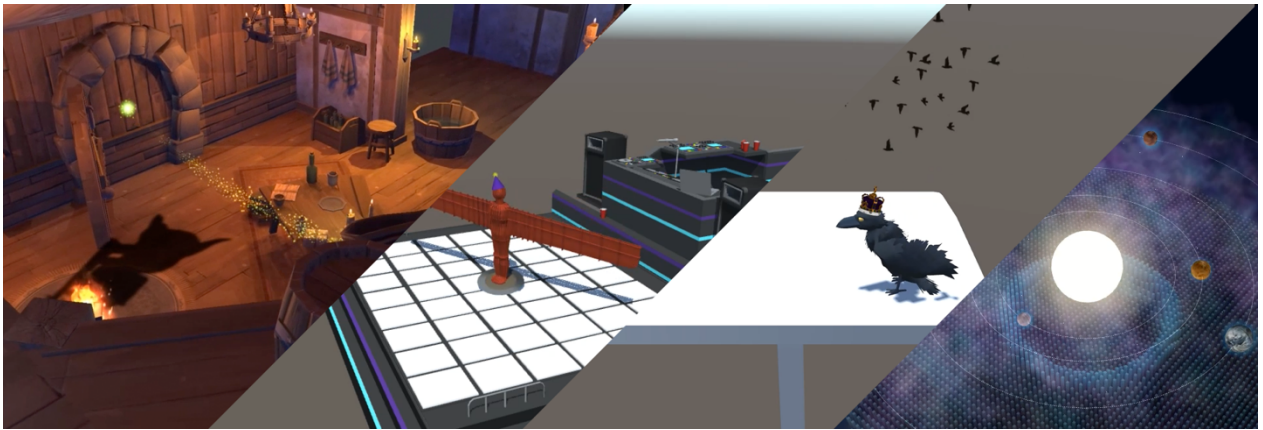
Fig 40 Image of the production process for some of the micro-narratives: Graphic by author.

MN1: Onboarding Process

Triggered: Once the passenger selects the experience from the Wi-fi captive portal page.
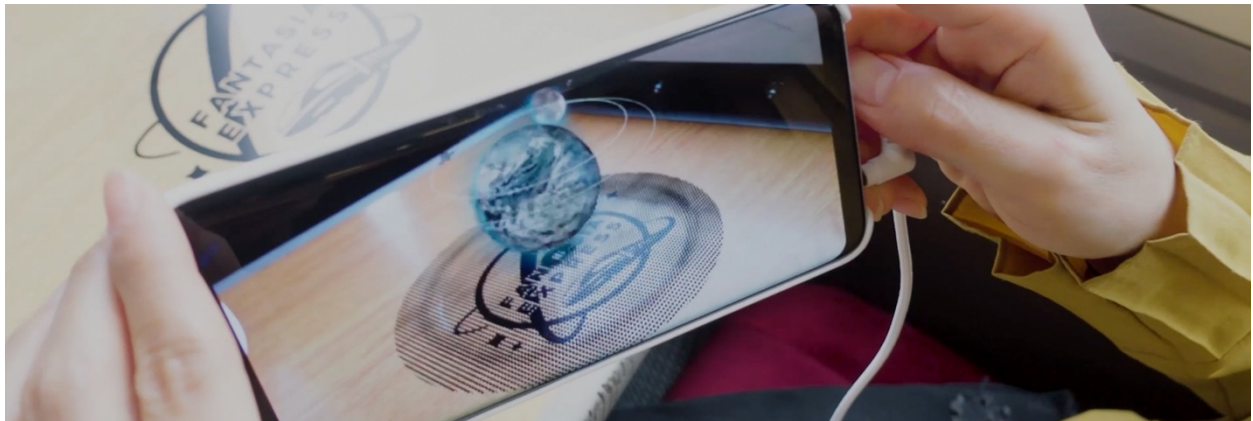
Fig 41 Image of *Fantasia Express* onboarding AR content: Graphic by author.

This micro-narrative had the challenge of introducing the user to the app: including the storyworld, elements of the experience, the app functions, and how to use them. This opening section will be accessed wherever you join the train. This meant addressing both narrative and practical human-computer interface concerns.

It was centred around a holographic animation that starts in space and zooms onto the earth before soaring into the route of the train journey whilst a narrator gives an overview. From a narrative perspective, I wanted the functional elements of this introduction to feel like part of the process. So, for example, adjusting the volume of headphones that would typically be outside a storyworld was integrated as part of the narrative. As detailed below in the relevant extract from the script.

> *Script extract*: A sign with a headphone's logo appears, with a notification: Please adjust the volume of your headphones. A rich, fruity voice, the sort you hear to introduce a film like *Beauty and the Beast* or *Batman*:
>
> BIG VOICE NARRATOR Once, back in the mists of time, many light years away... A notification: Please make sure you can hear the voice of our Professor: Adie Sevenate, before we continue... (Kay 2018: 2)

MN2: London Ravens:

Triggered: About ten minutes outside of London.

Inspiration: The legend that if the Ravens ever leave the Tower of London, the Tower will collapse, and so will the crown.

Fig 42 London Ravens: Graphic by author.

Synopsis: Reimagining that legend with a twist that the ravens have stolen the crown jewels and are on the run. Initially, you see Ravens outside the window, and then one appears in the carriage. Then looking agitated, he suddenly starts rambling defensively about a robbery even though he is wearing a crown. There is an argument with other crows before they decide to head to Stevenage to fence the stolen jewels. Interestingly this was the one micro-narrative where we used the technical approach to show content as though it was outside the window; in the right circumstances, it worked well, but if a passenger did not follow the prompts or moved in certain ways, the illusion was broken.

> *Script extract*: Out of your window, you see a distant black cloud of ravens racing through the skies. (Kay 2018: 6)

MN3: The Yorkshire Hobs

Triggered: Approaching Yorkshire or Lincolnshire.

Inspiration: Hobs are mythological creatures said to live in Northern England and the Scottish Borders. I also took inspiration from Robin Round Cap (Peacock, Duncan, & Townshend, 1897, p. 398), a legend from East Yorkshire.

Fig 43 Yorkshire Hobs: Graphic by author.

Synopsis: A door appears on the table, and the narrator tells the story of a secret relationship between a Yorkshire hob and a Lincolnshire Imp. A disgruntled parent who, after some complaining, eventually comes to accept their son's choice of partner through a nice cake. The narrator mimics the iconic deadpan voice of the playwright Alan Bennet.

> *Script extract:* You said you have nearly finished on that thing an hour ago, love...
> Look at those thumbs of yours going ten to the dozen; my thumbs could never do
> that, even when I was your age. What are you writing, a novelette, a little something
> for the theatre? (Kay 2018: 16)

MN4: The Viking Dragon of York

Triggered: When approaching York.

Inspiration: This takes inspiration from York's long history as a Viking town, Ivar the Boneless attack on York in 866 A.D., and the Viking mythology of dragons.

Fig 44: Viking dragon of York: Graphic by author.

Synopsis: The Vikings are looking for their dragon. An egg appears on the table with a Viking helmet. After some time, a baby dragon hatches and flies away. The train announcer informs passengers of a diversion due to the 'wrong type of Vikings on the track'.

> *Script extract*: I am sorry to inform passengers that there has been a warning of dangerous beasts entering the train. Can all passengers please report any unusual 'creatures' so they can be disposed of (Kay 2018: 20).

MN5: The Angels of the North

Triggered: Approximately ten minutes away from the *Angel of the North* sculpture (Gormley, 1998).

Inspiration: Anthony Gormley's *Angel of the North* statue and Newcastle's reputation for great nights out and strong Northern women.

Fig 45 Angels of the North: Graphic by author.

Synopsis: The *Angel of the North* decides to go clubbing in Newcastle. An engaging narrative aspect of this micro-narrative is that I recorded audio of women talking about being angels on a night out in Newcastle as background audio to the narrative. To explore how adding a local voice might increase the resonance and authenticity of the narrative.

> *Script extract*: Standing silent for twenty years, the angel of steel watches over the people of Newcastle –their tears and triumphs, hopes and hardships and their fun and festivities in the party capital of Europe. Until one day he decides to sneak away and join the dance… (Spencer 2018: 27)

MN6: Alien Train Driver VR

Triggered: Approximately ten minutes from the passenger's last stop.

Fig 46 Image of Alien train driver VR experience: Graphic by author.

This is one of the most interesting micro-narratives as it was the only VR experience and also from its connection to the history of early train simulations and cinema (See Chapter 2). This was an immersive 360 panoramic experience based on footage I captured from the driver's cab of the entire journey from London to Edinburgh and back.

There is a nice coincidence that Robert Barker, an early pioneer, painted his first panorama of Edinburgh in 1788 before the first public showing of a painting of London in 1792. Panoramas had become incredibly popular by the midpoint of the romantic period (Galperin, 2017, p. 16). The train also has a close relationship with the introduction of the cinema. Again, there is a nice crossover with the *Fantasia Express,* in that two of the earliest films were the realistic train of Lumiere's *Arrival of a Train at Ciotat Station* (1895) and the train-spaceship in Melies' *Impossible Voyage* (1904).[16]

My idea behind the virtual train experience evolved from an initial hypothesis about how it would feel to have a train driver's view of the track. There is a loose parallel with some long-haul flights that you can select to view the landscape you're flying over. But I suggest that being a train driver has more of a cultural resonance (at least with the UK public, which is rooted in childhood). The original plan was to sync the 360 film with the passenger's current location. And offer *Google*

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[16] Links to both these films on *YouTube* can be found at https://youtu.be/EqbOhqXHL7E and at https://youtu.be/EKFXsOL84rI

Cardboard devices to have a fully immersive VR headset experience.[17] I also offered a simpler version that relies on a mobile devices' gyroscope to pan through the movie by moving the device around in the air.

In early testing on a train, I noticed that the feeling of simply being in a 360 space that, importantly, also had the physical sensation (movement and noise) of being on an actual train created a powerful feeling of immersion. My original idea of syncing the film's location with the passenger's location did not add anything to the experience. It became an unnecessary and overly complex approach, so it was removed.

The subsequent narrative developments came once I had decided on the Spaceship story; the obvious (to me) next step was to make the train driver an alien. Again, this was a creative and narrative route that also served the purpose of pushing technical research. Not only capturing the 360 footage but also looking at how CGI techniques used in films could be applied to an interactive mobile phone narrative experience. Because this footage was pre-rendered, I could make the visuals much higher fidelity (the fidelity of AR animations is compromised due to data rates and the need to render them in real-time using the processing power of the user's device). The interesting point is that although technically a VR experience using a 360 film. The concept of superimposing CGI onto documentary-style footage is an augmented reality paradigm. It points to the type of experience that will eventually be possible by combining a live camera and real-time digital animation.

I had many creative discussions with the team about how and where this micro-narrative would be triggered. It was not location specific as I had footage of the entire route, so it was more flexible than the other micro-narratives. At the same time, I had been struggling with the challenge of making a satisfactory ending to the *Fantasia Express.* This is when the idea of making the ending about the aliens being arrested and the user helping this process by solving a puzzle in the driver's cab came about.

This was achieved by activating an alert on the user's phone ten minutes before their destination, and that also encouraged them to place their smartphones into a *Google Cardboard* device.

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[17] This is a cheap device (made of cardboard and often given away free) with optical lenses that when combined with a mobile phone creates a very economical VR headset experience. I actually used a better-quality plastic version of this device.
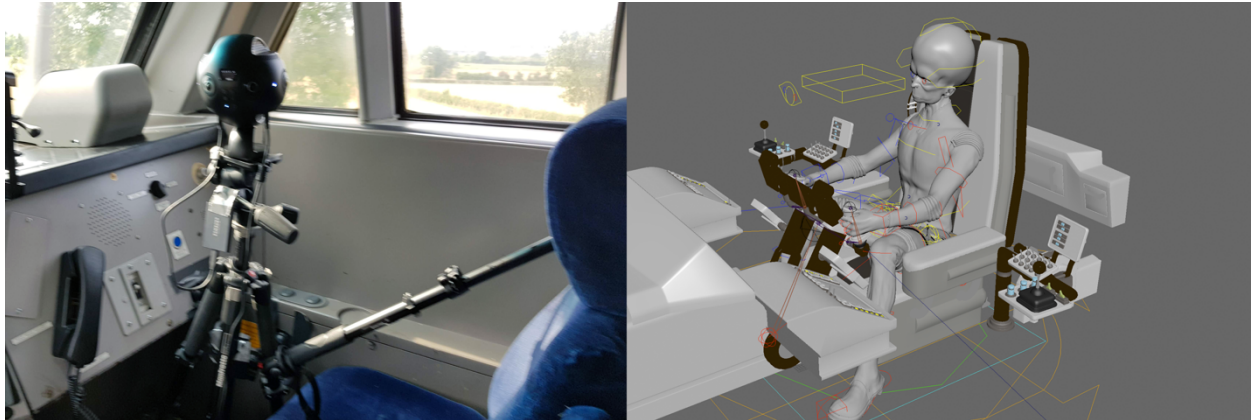
Fig 47 Development of the CGI and 360 VR: Graphic by author.

Initially, people were mesmerised by the visual of the driver's cab, focusing on the view of the train moving along the track and then became surprised to realise that the driver was an alien.

The train driver was the final reveal that the *Fantasia Express* was an alien spaceship. In retrospect, I tried to make this micro-narrative do too much work. Although the experience worked much better than I anticipated, the story needed to be more refined and ended up slightly confusing.

> *Script extract*: This is the VSHLF, and we have reason to believe you are carrying stolen merchandise. Anybody not wishing to spend a lifetime in solitary confinement should don their teleport goggles and head for the driver's cabin to let us on board. You have 3 minutes (Spencer 2018: 27).

The micro-narratives were the culmination of the grandest ambitions of the *Fantasia Express*. Combining technological and creative innovation, it was my equivalent to reaching for the stars and a not-quite-make-it moment. It taught me just how much of a challenge I had undertaken on this practice-based research journey. My original plan was to use my academic research to inform my practical prototypes, and this worked well to answer my XR and interface research questions. However, I could only accommodate some of my theoretical narrative insights into my prototypes. I had hoped each micro-narrative would address different outcomes from my academic research. MN6, MN5 and MN1 worked well and pushed individual ideas, but MN2, MN3 and MN4 repeated a similar format.

Ultimately, the micro-narratives helped answer my narrative research questions, just not using the methods I originally intended. Instead, it was accomplished by a hugely rewarding combination of theoretical research and prototyping.

5.5.   Secondary Narrative Content

Although most of the narrative effort was spent developing the script and the micro-narratives, I also conceptualised and prototyped other types of locative content. This addressed one of the wider research questions for this thesis: What types of immersive and locative content can be used to engage train passengers? More specifically, it addresses the question of non-immersive locative content delivery. This secondary narrative content type also helped address risks and challenges, some of which I anticipated and some as a reaction to circumstances. Furthermore, sometimes these secondary content solutions helped address the research and the project challenge.

Although my thesis has a strong immersive element, the high-level research question was about engaging passengers with their location and making them more present and connected to the physical world and each other through a digital intervention in context with their location. I was not concerned about what technology or approach would best achieve this. As I will discuss in my conclusion and reflection, arguably, one of the most effective pieces of content was not immersive and was developed primarily to mitigate the biggest technical failing of my research (my failure to place augmented reality objects outside the train window reliably).

In the following, I will detail the three secondary-level content types that formed part of the final prototype. These elements did help the story and form part of the narrative but were not scripted and so are secondary not just from an immersive perspective but also from a narrative one. The two things they all have in common are how they relate directly to a locative passenger experience for trains and how they could connect to and be reused across multiple locations.

Some ideas that I explored did not use location as a trigger. This could be in response to weather or based on passing a common landscape feature. For example, a minor train station (the train only stopped at principal stations), going through a tunnel or something more unusual like a solar panel farm (it's surprising how many of those are visible on the route). Identifying different types of trigger mechanics is a recognised multi-layered approach to locative game design. (Gentes, Guyot-Mbodji, & Demeure, 2010, p. 63).

One of the more practical risks I anticipated early on and contributed to prioritising the thinking behind the secondary content was figuring out how many micro-narratives my budget would stretch to. I also still needed to learn how many interventions I would need to maintain the passenger's attention. I needed flexibility in how often and in what locations I could engage passengers. These secondary content types gave me a very flexible and economical approach to populating the route

with as much or as little content as my research suggested. I categorised these secondary content types as visible and invisible, depending on whether they contained a visible landmark.

Visible Secondary Narrative Content: Train Stations and *I-Spy*

As the name suggests, the visible alerted the passenger to an upcoming visual point of interest. There were two types. The first identified the next train station (this included both principal stops and intermediary stations that the train would not stop at) The second was based on the *I-Spy* game, which alerted you to specific landmarks visible from the train window. No additional information except the name was shown on the visible content types.

Invisible Secondary Narrative Content: *Fantasiapedia*

Fantasiapedia was a pragmatic idea, conceived early on to include interesting content with a light touch. It was a simple and economical way to incorporate many of the myths and legends I discovered without integrating them into the primary narrative and storyworld. It also immediately increased the number of points of interest without the time and cost of scriptwriting and developing immersive micro-narratives. I could repurpose content directly from the web in a *Wikipedia*-style format (using text and images) (Fig 48). It also played into the hands of my ideas around creating an experience that would appeal to a broad audience without having to create different versions. This content would interest adults or individual travellers more. Notably, it was also a way to simultaneously engage parents and children in the same experience.

For example, a parent might find this content interesting while their young children are busy looking for other waypoints. I also considered that the parent could read the stories and then tell them to their children. Managing, editing and updating *Fantasiapedia* content was accomplished through a cloud-based content management system (CMS) that was part of the technical development.[18]

This chapter took two distinct approaches (theoretical and practical) to answer the question: what potential new narratives can engage train passengers with locative experiences? At the heart of both was the role of technology in the art of storytelling.

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[18] The CMS was a powerful technical tool we created to allow for the administration and management of all the locative content. It was accessed via the web and had a powerful feature set that meant we could manage journeys in both directions and trigger events on the left and right sides of the train independently.

The theoretical approach allowed me the opportunity to explore at a high level the technical and sociological influences available to storytellers. Technology is blurring traditional ideas of authorship, agency and context. The self-contained traditional experience of reading a book or watching a film in a cinema is being transformed by data and mobility. My research has shown that the modern smartphone, powered by living maps and performative cartography, can be at the forefront of this transformation.

Fig 48 Fantasiapedia content: Graphic by author.

This leads me to the detailed practical research of the *Fantasia Express.* An interesting contrast is how many of the insights from my project were born out of technical and contextual constraints and challenges. My narratives had to adapt to the human context of a train journey and the technological issues of trying to present immersive content in and outside a train carriage. The biggest narrative lesson from this is the importance of prioritising the idea and the story above the technology. My idea was to see how I could connect passengers to passing locations and each other. My story was about an alien spaceship disguised as a train to steal the relics of our imagination situated along the East Coast mainline. This allowed me to adapt and change my tactics creatively to overcome the challenges and still answer my research questions.

Chapter 6
USER RESEARCH

This chapter details the two user research activities undertaken to support, inform, and qualify the *Fantasia Express* project and my research. These were separate from the informal and iterative user testing of the prototypes I discussed in Chapter 4. This user testing, instead, followed a more formal and rigorous standard, including an ethical review.

My user tests were a combination of passenger surveys, personal interviews, observations, and questionnaires. The research activities targeted passengers to understand their thoughts. The initial user testing was used to understand my target audience and to help create empathy as part of the project's discovery phase (following a user-centric design process). The second activity evaluated the final prototype's technical success and impact on passengers.

6.1. Research Ethics

My research and development journey required public testing and interviews of passengers. This required thorough ethical considerations. This was undertaken in two parts.

The first public user research was conducted as part of my grant-funded R&D project. This was conceived and sits outside the *University of Liverpool*; these passenger interviews were undertaken by *Corporation Pop* with oversight and ethical approval by the innovation and research department of *London Northeast Railways* (LNER). Although I had some input as project lead, *Corporation Pop* and the research team at *LNER* are familiar with ethical considerations and had an internal process already in place to undertake, for instance, general passenger interviews. In other words, the project's initial user survey was therefore carried out as part of the funded project by industry partners and was independent of my PhD.

My University PhD research, on the other hand, required public testing of my prototypes and interviews with passengers. This required, of course, thorough ethical considerations. The final public test was more complex and was also more directly related to my research questions and prototype development than the more general initial passenger surveys and interviews. For this reason, I took the lead on this user research and undertook my own ethical approval process with *Liverpool University*. I submitted my ethics application before user testing, which a Central

Research Ethics Committee Chair screened. It was decided that my application had a low risk, meaning it was subsequently sent for review at the faculty level rather than the central level. My application was then passed on to the School of the Arts Research Ethics Committee, which formally approved it.

In both cases, all participants were provided with sufficient information to make a fully informed decision on whether to participate in my research. This included explaining the purpose of the study and making clear that the participation was voluntary, and the data could be withdrawn. In addition, I gave due regard to the respect of participants and confidentiality. The formal approval letter for the final user testing can be found in the appendix 6 Ethical Approval Letter.

6.2. Stage 1: Passenger Surveys

Initial Passenger User Research (June 2018)

As part of the initial discovery phase following a user-centred design process and particularly to help create user archetypes and personas, *LNER* and *Corporation Pop* undertook a paper questionnaire and audio interview of twenty train passengers on 12th June 2018, accompanied by Rhianne Evans, Innovation R&D Lead at *LNER*. The trains used were the York to Edinburgh service, 09:54 (York) – 12:18 (Edi); 09:54 (York) – 12:18 (Edi); and (Edi) 13:30 – 15:55 (York).

Aim of User Research

The aim was to gather qualitative user research by conducting semi-structured contextual interviews and observations. We also wanted to obtain data and observe potential users in the intended environment.

We took this approach to understand the user's context, background, behaviours, needs, pain points, goals and motivations when travelling on a two-hour-plus train journey. This helped me to form realistic personas and behaviours to help validate user-centred design decisions. This observation exercise on an *LNER* train route was crucial to discover user behaviours in the proposed environment.

Target Audience; potential user profile

- *LNER* travellers

- Daytime / Off peak travellers

- Long journey travellers via train 3-4 hours

- Short journeys travellers via train 1-2 hours

- Families

- Friends

- Students

- Couples

- Owners of a smartphone

Interview Strategy with Target Audience

- Interview a minimum of twenty potential users on the LNER East Coast train route and station platforms.

- Interview families with young adults and children sixteen and under - consent from the parent/guardian present.

- Interview groups of users, i.e., friends travelling together.

- Interviews to take place in off-peak times.

- AR application trial (on the train only).

- AR headset (on the train only).

Summary of Initial Interviews and Questionnaires

One interesting result of this research that countered what we expected was that passengers were much more interested and open to wearable immersive technology, particularly wearing a VR headset. We initially thought that passengers would find this both uncomfortable and an invasion of their personal space and privacy. However, this research result led directly to prioritising the VR train driver micro-narrative being shortlisted and then developed for the prototype.

Another significant result was discovering that most people tried to connect to the onboard Wi-Fi. This again framed our design process and led to a detailed exploration of the technical opportunity to use the captive portal (the screen that appears on people's laptops or phones when they select the train Wi-Fi) to access and promote the *Fantasia Express* or, in fact, any train experience. I

researched the feasibility of this working directly with *iComera* (the company responsible for *LNER* Wi-Fi and onboard entertainment), and we had a plan to use this for the prototype; however, in the end, we chose to go another route that had less risk.

- Many were open to trying the headsets.

- Some liked the idea of hands-free.

- Headsets could be more appealing to a younger audience.

- Some adults felt silly wearing a headset and mentioned that holding it to your face rather than putting on a full strap would be nicer - less bulky.

- Motion sickness using headsets was mentioned.

- Many had a seat preference when travelling.

- All interviewed noticed the view outside scenic views/countryside.

- Some mentioned not liking having a restricted view of the window.

- Most connected to Wi-Fi but sometimes had trouble connecting.

- There were a few frustrations with the train journey itself. Most tended to be around no charging points, people in their seats, toilets, and general personal space invasion.

- Many had yet to hear of AR or had not used it before.

- Some were aware of VR.

- Many adults said they do not play games on the train; however, children do tend to play.

- Many pass the time on the train in their own way.

- Reading was the most popular for passing the time. Other popular activities were listening to music, watching videos, and chatting.

- There were more iPhone users than Android from whom we interviewed.

Final Live Testing Passenger User Research

The final live testing took place over two weeks, from February 18th to March 1st, 2019.

I used the first week as a dress rehearsal with the intention that any last-minute technical and procedural issues could be addressed before the full public test on the second week. In addition, it

was a way to ensure my test methodology was suitable for a busy train carriage's practical and logistical considerations.

A typical day would involve taking the three-and-a-half-hour journey from London Kings Cross to Newcastle, having a one-hour break and then taking the Newcastle to London train back. I would take this trip three days each week. For most of these journeys, I would be accompanied by staff from *LNER* to help with the testing.

Objective of Research

I had five main objectives for the dress rehearsal public test during week one.

1. Bug testing and technical performance on the route in both directions.

2. Feasibility of testing approach in a live environment.

3. Frequency and rhythm of waypoints.

4. Informal conversations with passengers and rail staff.

5. Opportunities to make final tweaks based on feedback and my experience of using the prototypes in a live environment.

I had three main objectives for the final public test in week two.

1. Test the technical feasibility of the prototypes

2. Understand how this type of engagement affected passenger's behaviours

3. See how people felt about the XR content, specifically

Test Setup

I used eight Samsung Galaxy S8 phones connected via Wi-Fi to another device that acted as the onboard media server (Fig 49). These devices delivered the content and location data to the phones, and each could support five phones within the range of a single carriage. They were effectively creating two independent sets of prototypes.

In addition, I had eight pairs of headphones and 8 VR headsets that passengers would place their phones into at one of the waypoints.

Fig 49 Final live testing rig: Graphic by author.

Week One: (Feb 18th, 20th, 22nd, 2019)

Test team: Alastair Eilbeck, Phoebe Eilbeck

This was the first opportunity to test the completed prototypes on the entire route and was planned to test both the software and the testing procedure and methodology. I would test one day and then work with the team the next day to address any issues before re-testing the following day. It was surprising that despite extensive testing of all the constituent parts how many new problems came up when testing the system along an entire three-and-a-half-hour journey.

The most unexpected challenge related to the proposed testing method as it became clear just how difficult it can be to test a system like this on a busy inter-city route. This was a surprise as during the development, I had undertaken many journeys on the same route without experiencing this level of passenger density.

The opportunity to provide kits to passengers and observe them became very difficult as there needed to be more spare seating capacity, and the only practical way to recruit and talk to people was by standing in the carriage. This created problems as I became an obstruction to passengers and train staff. I originally intended to have three or four people in a carriage undertake the entire system per journey to give a test group of approximately twenty people. However, this needed to be reduced given the working environment.

I re-evaluated the testing approach, as it would be impossible to get more than a handful of people to test the full system, so I devised a two-tier method instead. I still went ahead with the full testing when the opportunity arose; however, I needed a more agile way that required less effort on behalf of the public and the testers. The most obvious solution was providing a shorter experience that

gave passengers a taste of the key immersive elements. To achieve this, we created a standalone WebApp that provided shortcuts to the immersive content so that the testers could quickly demonstrate the project alongside explaining some of the contexts.

Fig 50 New Webapp that placed shortcuts to all the XR content: Graphic by author.

In terms of the prototype itself, several usability issues surfaced primarily minor tweaks that helped optimise the experience. However, during the testing, I noticed that we had all the components of a game mechanic. In addition, observing some ad-hoc tests with passengers showed that including a points-based system to interact with the waypoints would help keep people's attention.

> Gamification is a developing approach for encouraging user motivation, engagement and enjoyment in non-gaming, computer-mediated environments with an early collection of empirical work supporting its potential for beneficial effects in certain contexts (Seaborn & Fels, 2015, p. 47).

I tweaked the design so that users would receive points when they accessed content. The amount varied depending on the type of content accessed (AR micro-narratives gained the most points, and the more common and simpler *I-Spy* content received the least). I then added a running total within the visited sites list. The ability to make quick changes even at this late stage of development vindicated my design process and production approach. Having both responsibility and authority is key to being able to make quick decisions.
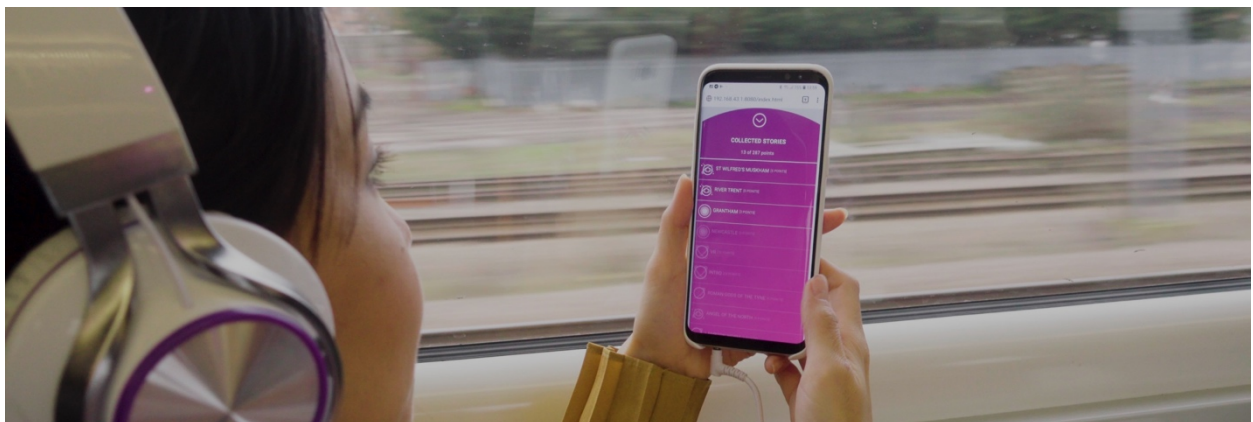
Fig 51 Showing addition of gamification to interface: Graphic by author.

Week Two: (Feb 25th, 27th, Mar 1st, 2019)

Test team: Alastair Eilbeck, Naho Taniyama and various *LNER* staff

This was the week of full public testing, with the methodology based on week one. The plan was for me to undertake observations of the complete prototype whilst *LNER* would test the cut-down prototype on passengers. Including surveys (See appendix 7 Final Passenger Survey)

- It was a varied mixture of demographics and an equal mix of people in their teens, twenties, and thirties.

- Universally positive of the concept and how it could be extended.

- 10% of people found the VR headset made them feel uncomfortable.

- 10% people found the story confusing.

- 5% person had not heard of augmented reality.

- 5% people commented that they preferred the non-AR content and the game side of the app.

6.3.   Stage 2: Observation Studies

Observation Study 1: Mother and Two Children Travelling from London to Newcastle on 25/02/19

This showed the potential for locative media and augmented reality in particular and proved the potential of my original hypothesis that this type of solution not only provides entertainment but also encourages a shared family experience. However, it also identified the challenges with targeting children.

I introduced the mother, daughter, and son, and after a brief explanation of the project and introduction to the system, I let them get on with it. I observed them for about an hour. I noticed they all engaged with the opening, but after eleven minutes, the son returned to playing Minecraft, which took his full attention. However, the mother and daughter continued with the system, and even the most basic content *I-Spy* (whereby we give people a countdown to look out of the window for landmarks), promoted conversation. They were engaged and enjoying a shared experience for thirty minutes and then began to lose interest.

It was clear that given the right mix of content delivered at regular intervals (rich AR and simple *I-spy*) that the system has real potential to engage families. However, it was also clear that our hope that people could dip in and out of the system was more problematic with children, who we commonly observed come prepared with iPads and highly immersive films or video games that required their full attention.

Observation Study 2: Young Couple Travelling from Newcastle to York on 27/02/19

This showed the potential for the HTML components, particularly the gamification and *Fantasiapedia* micro-narrative. It also demonstrated another aspect of my original hypotheses: that offering different layers allowed a varied audience to engage in the same application but enjoy a different experience.

I approached a couple in their twenties who were both drinking cans of alcohol and tentatively asked if they would like to participate in the trial. They willingly agreed and one of them quickly noticed the points-collecting aspect of the solution. They became slightly obsessed with claiming as many points as possible. At one point, even being slightly worried during an augmented reality set piece, they might miss the opportunity to collect points. The other was more interested in the stories, and I observed her spending time reading all the textual content and discussing it.

This showed that even without rich AR content, there are still opportunities to connect people with their locations and their travelling companions just through the use of content delivered via HTML. This makes that aspect of our solution much more accessible as it is cheaper to produce, much easier to deliver using existing onboard entertainment infrastructure and viewable on a much simpler mobile device through a web browser.

Fig 52: Live testing week two: Graphic by author.

I chose surveys to validate my approach (which it did) and hopefully gain some unexpected insight. The standout surprise was that my initial survey showed passengers thought wearing a VR headset or similar device on a train was acceptable, and this was corroborated in the final test as the VR experience was the most popular. This was contrary to my own thoughts and other research I had read (Williamson, Mcgill, & Outram, 2019, p. 11). In terms of my PhD. However, I reflected that the results of my surveys did not contribute significantly to new knowledge or my project.

However, several aspects of my public testing were crucial to my research. Firstly, being able to observe a variety of different people interact with the *Fantasia Express* helped me to understand the potential of a narrative-based experience for passengers. Secondly, the unexpected difficulties associated with testing passengers on a busy train made me realise that more time and resources need to be allocated to this in any similar future projects. My ability to react quickly to this challenge by making changes to the prototypes and to my testing strategy was a vindication of the whole technical strategy I had applied.

Finally, and most importantly, having to test my prototypes on a scheduled train service affected almost all the areas I looked at in Chapter 2. Without the pressure of a live public test, I would not have gone to the lengths I did to understand the technical and logistical requirements of integrating XR into a train carriage.

Chapter 7
CONCLUSION: Findings, Public Impact, and Reflection

My PhD started as an investigation into using immersive technology to connect passengers to their locations and each other in imaginative and engaging ways. I also felt quietly happy that I had seemingly smuggled an artistic and creative project into a technical and engineering-based call for innovation within the rail industry. However, what I came to realise over the five years that followed, was that combining immersive technology with location and content – that was contextual to both– turned out to go well beyond the spatial confinement of a high-speed railway carriage and my practical development of the *Fantasia Express*.

In the last two years of my PhD, I reflected on and analysed my early literature reviews and the results from my practical prototyping and public tests of the *Fantasia Express.* I found patterns and new lines of enquiry that led to several key themes taking shape within the context of my research questions. Abstract terms, such as living maps, living data, augmented presence, digital presence, and hybrid space, became much clearer. This, in turn, helped me mould the structure of this thesis and ultimately provided a narrative to articulate the new knowledge and findings of my research.

The fact that my study took place in a train carriage, where strangers would be mixed together in close proximity for several hours with seemingly nothing else to do than wait for their destination, felt at times a perfect human laboratory, not just as a way to test my practical prototypes, but also, and perhaps more importantly, a theoretical construct. I began to realise that applying technologies that live at the interface of the physical and digital into this construct can be seen as an outlier for how humans might relate to each other more generally in the future.

In this thesis, I have chosen to use this laboratory to test the creative application of immersive technology, interface, and narrative. To explore what happens when these applications relate to a train carriage's location and spatial confines. And to consider the implications of this *hybrid public space* when applied to our physical public spaces more generally. In doing so, I created the central throughline of my research and the first of several findings I will discuss in this final chapter.

7.1. Research Findings

I have ordered my research findings in a similar order to my thesis structure. As alluded to above, the first finding is my headline finding, which I suggest reflects the sum of all my research questions. It is a finding based on my literature review in Chapter 2 and, although influenced by my practical work, is the product of more traditional scholarly research. The subsequent findings directly answer my research questions, objectives and related deliverables mentioned in Chapter 1. These are the result of scholarly research and the practical work undertaken with the *Fantasia Express.*

My first research question (See Chapter 3) explored the creative opportunities and challenges of integrating immersive and locative content within the context of an intercity train. I discovered many more technical challenges than anticipated but found solutions to address the most pertinent ones. From estimating location during GPS dropout, deploying content to passengers' mobile devices when there was no internet, to integrating a technical XR function within the existing onboard I.T. hardware.

I identified a typology of creative augmented reality opportunities within and outside a moving train carriage. I also discovered a strong historical link between technology-based entertainment, the birth of cinema, and the train. A link lost in the early 1900s that has only recently been reimagined with projects like Eurostar's *Odyssey* (2017) and my own *Fantasia Express* (2019).

My second research question (addressed in Chapter 4) explored new interface approaches to engage passengers with locative and immersive media. I found it interesting that answering this question involved spending as much time looking at the underlying design thinking process and methodologies as creating new interface designs. I discovered various interface scenarios to engage passengers with my mobile narrative experience during this process. This type of experience requires an onboarding process, a primary interface connecting passengers to the waypoints along the route and a dynamic ending triggered as passengers approach their destination. I focused most of my time on iterating the primary interface to create a simple and intuitive design that alerted passengers to points of interest both visually and via audio alerts. This resulted in an interface that could be dipped into and out of and that supported multiple content types and levels of engagement. One of the more interesting aspects of my interface research was how I considered strategies to *break* the interface. To design an experience that encourages people to look away from their mobile phones and instead use them as icebreakers for dialogue with fellow passengers or to engage with

the panoramic landscape. This approach countered one of the criticisms of mobile phones as devices that alienate us from the physical world and each other.

Chapter 5 answered my final research questions regarding narrative. I approached this in two distinct approaches. I was first looking at the potential of the underlying technologies behind locative media and data to create new stories. Secondly, considering the narrative anatomy of a train journey, the story world, and the practical narrative development and production of the *Fantasia Express*.

Finding 1: Hybrid Public Space

Hybrid space is commonly used within digital and immersive contexts to describe a variety of combinations of digital and physical layers. My research is centred around a particular kind of hybrid space whose digital and physical layers relate to each other and are located within place and publicness (for example, in my specific research of engaging train passengers with digital content that relates to their locations). I have argued in this thesis that the social and technological evolutions of smartphones, augmented reality, and mobility constitute key elements of this type of hybrid space and that they will play an increasingly important role in how the public experience the world in the future. Therefore, I have concluded that a new term is needed to accurately articulate this particular aspect of hybrid space, which I have called *hybrid public space*.

A further finding was the notion that hybrid public space has the potential to imbue a digital experience with the characteristics and behavioural norms of physical public space and vice-versa. It offers the potential to consider hybridity with a distinctive socio-technical feature that is more meaningful than the current use cases for augmented reality as simple entertainment or novelty. I would strongly argue that this new space is now a distinct and standalone entity. One that is increasingly seeing industry attention from some of the world's biggest and most powerful companies, like *Google*, *Apple* and *Meta*. Who are, in turn, accelerating investment in the technologies that support hybrid public space. This makes me conclude that it needs to be addressed as a research topic. I would recommend and expect that in the future, more research will be necessary that focuses on the social, democratic, ethical and mobility impact of this new term.

My practical research with the *Fantasia Express* only began to explore public hybrid space. Beyond being location-aware, it represented a more traditional data narrative and archival approach. My theoretical research in this area posed many additional sub-research questions. I found so many interesting narrative and engaging tools that, at their root, employed living maps and immersive technologies to open up meaningful, networked, and communal passenger experiences.

Our smart mobile devices know to, within a couple of meters where they are, employ a high-definition camera, 3D laser scanners (LIDAR), and inertial measurement units (IMU). They can use their own internal or external cloud processing (via 5G) to apply complex machine learning and artificial intelligence algorithms to interpret their immediate spatial surroundings. They know how often and what times their owners frequent their surroundings. They can interpret their owner's emotional state through analysis of their use of the mobile device, which, of course, can be connected to other people in the same physical location simultaneously and in the past.

When I consider the technologies powering our mobile phones and the social context of a train carriage filled with passengers in a state of waiting, I see a lot of potential for engagement with narrative. The first half of Chapter 5 looked at some of the many examples of how technology can provide new ways to tell stories. All of these tactics could be applied to a passenger experience. As I have already alluded to, my practice-based research really does only scratch the surface of this potential. I would have loved to give the passengers more agency to participate to leave a mark. I would have loved to open opportunities for people to connect with other passengers (past, present, or future). To open windows to absent others, to make a train journey have the same public familiarity with strangers that you get from a walk in the park or a football crowd or that point when you come out of the theatre or cinema with a smile and a feeling of solidarity of a shared positive experience.

I discovered so much creative potential to enhance our experience of public space and each other to create the 'community of strangers' (De Waal, 2013), which I believe should be the ultimate goal of hybrid public space.

Augmented reality has a reputation for novelty and entertainment, which is currently the overwhelming use case. This thesis has shown that it has the potential for much more. We may have to wait for AR to become part of our vision, not mediated through a mobile phone screen, to see this fully realised. Still, the concept of being able to access a persistent digital public space overlaid onto our physical public space, I think, will be as game-changing as Schivelbusch describes the transition from the horse and cart to the steam locomotive (Schivelbusch, 1986).

Finding 2: A System Architecture to Improve Rapid XR Prototype Development

The typical workflow in XR is slow, much like the development of native applications for mobile devices. Any change, however small, requires the whole application to be re-exported, updated on an app store, and re-downloaded onto the user's device.

The strategy I employed to make updates faster was to split the prototype into two components; 1) a native AR application installed on the device and 2) a WebApp that lived on a server (potentially the trains onboard media server or on the internet). The AR content had to be a native app, but much of the build, including the main interface elements, did not. Separating all the features that did not require a native app (the non-AR elements) into the separate entity of a Progressive Web Application (PWA) made prototyping much more agile and iterative. PWAs are software built using standard web technologies, including HTML, CSS, and JavaScript, with all the rich functionality of a native app but delivered through a standard internet browser. Their key development advantage is that any changes to the code can be updated almost instantly. This allowed me to make changes on the fly and quickly respond to user issues and bugs. Changing a native app could take a day, whereas I could make a change in five minutes using a PWA approach. In most cases, the primary reason for using a web app is to reduce the barrier to entry for users, as there is no need for them to download an app. Still, in this scenario, the speed of iteration and testing of the prototypes was a prime benefit.

Interestingly, two years after this project, all AR elements could now be presented via a standard mobile web browser using WebAR. This would suggest that my approach to solving this challenge is something that the industry recognised and is now beginning to address.[19]

Having a browser-based experience talk to a native app and create a seamless back-and-forth between the two, I believe, was a genuinely new approach to a mobile XR project which I had not seen before. To create a mobile experience for passengers, selecting an appropriate technical framework is as important as any theoretical human-centred design process.

Finding 3: Making the Development of an Original Interface Part of the Brief

A standard process behind developing interfaces for a new software application is to reference similar projects and to look for conventions that will help familiarise users with a new interface. A lot of interface design is based on minor incremental improvements similar to the Japanese *Kaizen* (Paul Brunet & New, 2003) approach. As part of the early design process behind my interface research, I listed functionality and features I felt necessary to answer my research questions. I also included the phrase 'explore new approaches' in this list and was surprised how this simple addition and the permission it granted changed my thinking and approach to my research.

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[19] Interesting, I have since been working on a number of Web AR projects, in which I fed in some of the lessons learned and limitations discovered from *Fantasia Express.*

This is the point where I undertook the intellectual exercise to explore what I described as an *invisible interface* approach. I have taken this approach to tackle user experience design problems by simplifying and rethinking the system behind the interface and looking at real-world interactions for inspiration, a process of rigorous refinement and lateral thinking (See Chapter 4). The resulting design of a simple temporal interface to connect to location answered my sub-question of whether I could design an interface that is second nature from the moment a user interacts. The design tested very well, but importantly, in light of my initial requirement to explore new approaches, it looked unlike any of the interfaces I had identified as sharing similar functionality or use cases.

I would argue that my thoughts behind the invisible interface, specifically, the process of addressing a UX challenge through the combination of refinement, real-world inspiration and lateral thinking, represents a different process to achieve the same goals as Steve Krug's seminal and self-explanatory book *Don't make me think* (Krug, 2000). In doing so, I have devised and offered a mode of thinking about future interface design, particularly relevant to immersive projects that will hopefully assist future designers in exploring similar challenges.

Finding 4: When to use XR and When to use Other Media Content Types

This finding was on reflection partly by accident and partly by design, resulting from the specific nature of a practice-based PhD. On several occasions, I inadvertently created new knowledge because I could not do what I wanted in the way I wanted to. This finding was in response to my difficulty reliably placing augmented reality content in a moving landscape. The original inspiration behind my PhD was the *Bewegtes Land Project* (2017) and the way passengers looked out of the window to see imaginative and quirky performances in the landscape. However, almost all the micro-narratives I developed for the journey focused passengers' attention on the table in front of them. To encourage people to connect with the panoramic landscape, and as mentioned earlier, I turned to my childhood game *I-Spy* (1945), as a source of inspiration. I had an extensive audit of the track, including video footage from both side windows and the driver's cab of the entire route. I could use this and the copious notes I made of interesting landmarks visible from the train to compile a list of visual waypoints. With the addition of a simple gaming mechanism, I could achieve a similar aim (getting people to connect with the panoramic landscape) without using any immersive technology.

This also gave me an idea about placing physical objects on the route (Giant palm trees, pink elephants) and then using the *Fantasia Express* location functionality to get people to look out for them. This would be cheaper than a fully professionally developed AR production. I mentioned

this to *LNER,* who told me that the tourist boards that represented the various counties along the route might be interested in sponsoring such an intervention.

This finding made me realise that many XR projects are motivated to change people's behaviour and that, sometimes, this fact is lost behind the novelty of the technology. And sometimes, the same behavioural change can be accomplished through simpler, less technical methods. Many projects are defined by the technology over the idea, and I felt it was important with my research to consider as many technologies and techniques as possible.

7.2.   **Public and Social Impact**

Above and beyond my research findings listed above, I also believe that this project highlighted new insights into the public and social impact that my and similar types of mobile experiences can produce. As my user research showed, and also from the numerous conversations I have had with friends, colleagues, acquaintances, and strangers over the last five years. The simple idea of using technology to inform passengers about the locations they pass through has received universal praise. It is a simple idea that I am surprised I could not find any direct examples of.

I introduced nuance, layers of narrative, user experience, and rich, immersive technology visuals. The alien train driver was one of the standout pieces that caught the imagination of passengers and train staff alike. My research shows an appetite for this type of engagement amongst passengers. However, I think the main barrier preventing innovation in the passenger experience is how the UK railways are set up. And the difficulty in presenting a business case when travel time (not the quality of travel) is the standard metric that the UK government use to calculate the value of the rail investment (Lyons & Urry, 2005).

Fig 53 Train inspector enjoying the alien train driver experience: Graphic by author.

But what stands out to me from my research is observing how the public interacted with the *Fantasia Express* during the live testing. The passenger's response reminded me of a phenomenon I noticed accidentally during my first significant public artwork, *Handprint*, In 2008. This installation allowed people to use a hand scanner on the corner of Piccadilly Gardens in Manchester to scan their hands and see them projected in real-time onto the side of the City Tower*,* Manchester's second tallest building (Fig 54). As expected, I observed how this installation created excitement and energy amongst the direct participants scanning their hands; however, what surprised me was how much further its impact was noticeable. The scanner was situated close to a bar and at the corner of a public urban park (Piccadilly Gardens*)* in the city centre. I became fascinated by how the impact of the artwork created different scenarios and reactions. First, there was an obvious reaction of the direct participants scanning their hands, creating a shared dynamic amongst their group. But I noticed that this emanated outwards to the people waiting to have their turn. And then, as I watched the scene unfold, I could see people who had no intention of participating still being affected by the installation—watching either direct participants, the anticipation of people in the queue or the handprints appearing on the building facade.

What I noticed with the *Fantasia Express* was how it brought people together or had an impact or imparted emotion in the wider train carriage that was separate from its form (the core narrative of an alien spaceship). In a train carriage, due to the proximity and intimacy of fellow passengers, we are all unwitting voyeurs. Most of the time, when another passenger catches our attention, it's because they are making a commotion. When we hear someone talking on their phone, it is considered annoying and alienating because we are exposed to one side of the conversation, which is personal and private.

However, an intervention like the *Fantasia Express* is more inclusive because it encourages people to look out the window at landmarks and discuss the locations with their fellow passengers. This fosters a connection between direct participants. It is also much more of an invitation for other passengers to join in or at least feel part of the conversation as it relates to a shared locative experience. It reminds me that when someone has a dog in the park, there is a universal protocol for everyone to engage with the dog and, by extension, the owner. The *Fantasia Express* was acting like an ice breaker for fellow passengers to interact with each other.

For example, I noticed a family travelling together but very much apart, as they were each focused on their own devices, coming together by experiencing the *Fantasia Express* as a shared experience (in the moment). I observed them pointing out the window, discussing the journey's geography, and seeing its impact permeate among fellow passengers. This highlighted a different practice from

the typically individualistic approach of reading a book or watching a film while on a train. This notion of a shared experience/interaction was one of the most important motivations behind my research choice and the *Fantasia Express* project. I have concluded that placing a locative experience in a train carriage makes it possible to animate the whole carriage, not just the people directly experiencing the project.

Fig 54 *Handprint*, Piccadilly Gardens, Manchester 2008: Graphic by author.

I realised that projects like the *Fantasia Express* could help create an atmosphere of a truly shared experience. Or – to re-use my favourite expression borrowed from Martijn de Waal (2014) – help create a 'community of strangers'.

As an artist, I have often described my audience as the people you see on the high street. This is one of the few locations where you can find a diverse cross-section of our society. I have used projects like *Handprint* to directly engage this audience. Not only does this allow me to reach an audience that is under-represented in our more traditional cultural venues, but I am also bringing the art to them to stumble upon. When I originally saw the *Bewegtes Land Project*, part of the inspiration it gave me was that it shared similar properties. I realise many people on the passing trains would have come to see the performances, but I was mindful of those who might have been

taking a normal journey and experienced it by accident. It is this aspect of the *Fantasia Express* that reminds me of a favourite quote of mine.

> Something that changes our way of seeing the streets is more important than something that changes our way of seeing paintings (Debord, 1957).

This reframing of art as something that is part of the fabric of society rather than something that is predominantly experienced in a gallery or on a private wall is a concept that connects my art practice and my academic studies. Guy Debord was a prominent member of the *Situationist International.* This art movement sought to break down the division between artists and consumers and make cultural production a part of everyday life. It is also an art of dialogue, interaction, and 'the organization of the directly lived moment' (Thompsett, F). At a high level, the *Fantasia Express* had similar aims, to present a creative and artistic experience as part of the everyday life of a passenger travelling on public transport to connect them to their surroundings and each other to increase feelings of a directly lived moment.

My research has helped me understand that the publicness of a train carriage is analogous to the publicness of the high street. They are both inhabited by a similar cross-section of society and have organically developed behavioural norms. In many ways, the train carriage offers the potential for more meaningful creative work because a passenger has more time to engage with it than a pedestrian walking along the street. This diverse audience of a high street is rarely seen in an art gallery, a ballet performance, or in the theatre; however, you can reach this audience by train!

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APPENDIX

Appendix A: User Stories and Personas – Interface Chapter

A1. Personas

appendix 1: Personas

Persona 2: Matt (Stayoverer)

Attributes

Age: 23

Experience: Currently working on a graduate scheme

Hobbies: Games, Film and TV, Music

Activities: Goes to 2 music festivals a year, will seek out 'edgy' experiences and travel for them in other places.

Matt is a Stayoverer

Profile: Matt is a graduate who is currently living 4 hours from home in Edinburgh for his first job. He moved away from home for university and never went back. He is a semi-regular user of the trains, using them to make his big journey to home between 6 and 8 times a year. He also regularly travels with friends to destinations at the weekend as he explores the area that he is living in and goes to meet his other friends who are dispersed around UK cities.

Responsibilities: He's free and easy with lots of leisure time and expendable income to engage in his hobbies. He likes learning and travelling to new places. He's a little anxious about his future

Pain Points: Being disconnected from people is a major pain point for Matt, who spends up to 2 hours a day on social media. He doesn't like sitting still and will constantly be seeking information when out and about. He doesn't like travelling

alone, but regularly has to. Money and costly things are also a big pain point for Matt, even though he can afford things he's always conscious of saving money. Staying in on a Saturday would be a major problem for Matt.

Key Drivers/Motivation: He will seek out things to do with friends, particularly if they are free. One of his key drivers is to save money but to find interesting things to do and share with his friends. He is a story seeker, constantly looking for new things to tell his friends about the experiences he has had.

Validations: His lifestyle and attitudes are highly influenced by friends and social media, wants to be part of a crowd, and will regularly keep in contact with his network of friends this way. Seeks online validation for engaging in quirky activities.

Persona 3: Brian (Train Manager)

Attributes

Age: 57

Experience: Logistics Manager for *LNER*

Hobbies: HAM radios, fishing, golf.

Activities: Trips out to the countryside for walks as many times as she can in the summer and sometimes in winter.

Profile: He has 2 kids in their late 20s that have now moved out to different cities. He sometimes goes to visit them on the train and vice versa. He likes to show his children that he's still in touch with the modern world, with his knowledge of gadgets and apps.

Responsibilities: He needs to ensure the safety and comfort for train passengers. This includes ensuring all facilities are working and that passengers are well looked after by VT staff. He also needs to ensure his staff have the ability to help customers with their needs and that they feel supported in their role.

Pain Points: When the trains are full with standing passengers, it makes it difficult for his staff to perform their duties and assist passengers.

Key Drivers/Motivation: He wants to ensure a consistently high service for all passengers.

Validations: He wants the staff to feel he supports them and looks after their best interests.

A2. User Stories

appendix 2: User Stories

as a…	I want to…	so that…	MOSCOW
TOC (SARAH)	capture information about users on downloading the app	we have a better understanding of the demographics of people using the service	COULD
PRODUCT OWNER	create copies of real objects to put in the foreground	it increases the depth of perception	COULD
PRODUCT OWNER	utilise on-board media servers to download the app to Android device	the user doesn't need access to the Internet	COULD
STAYOVERER (MATT)	experience AR through a headset	I have a more immersive experience	COULD
GLOBAL	Know how long the experiences last	I know the duration it can entertain me	COULD
GLOBAL	have an AR experience when going through a tunnel	can be entertained at any point on my journey	COULD
DEVELOPER	Use best practice AR design	I mitigate against passengers feeling sick	MUST
DEVELOPER	I want to know where a person is on the train	I can provide coherent experience	MUST
DAYTRIPPER (JESS)	see something relevant to my destination	it improves the whole daytrip experience	MUST
DAYTRIPPER (JESS)	input my destination	my experience can be tailored to my journey	MUST
DAYTRIPPER (JESS)	see experiences connected with landmarks on my journey	the experience is connected to my surroundings	MUST
DAYTRIPPER (JESS)	receive notifications when I'm approaching an experience	I know to look for them	MUST
GLOBAL	Work on a specified device	18.09.18 - MYU suggested 3 devices. Galaxy S7, 8, 9. Was originally an S8.	MUST

GLOBAL	Download the app to an Android device	I can use the app on my preferred device	MUST
GLOBAL	be able to get an AR experience in front of me using my device	I don't need to have a clear view out of the window	MUST
GLOBAL	have a clear on-boarding process	I know how to use the app	MUST
DEVELOPER	build an app that doesn't rely on external sources/resources	I can limit points of failure	MUST
GLOBAL	have an experience that loads seamlessly between states	my experience is more immersive	MUST
DEVELOPER	I want to build reusable mechanics	I can focus on quality of the experience	MUST
DEVELOPER	I want to ready use made assets	I don't have to create bespoke content	MUST
DEVELOPER	not use high poly assets	I don't have any compatibility and performance issues	MUST
GLOBAL	Have a limited number of experiences on my journey	I am not overwhelmed by content	MUST
GLOBAL	Have "bite sized" experiences	I'm anticipating the next installment	MUST
DEVELOPER	Focus on delivering the AR experience and app	I can deliver a quality MVP	MUST
DEVELOPER	Receive fully app ready user flows	Can work	MUST
DEVELOPER	Receive build ready design assets that follow consistent native patterns	I can develop better content quicker	MUST
DEVELOPER	be able to mask the windows	I can have a more immersive experience	MUST
DEVELOPER	integrate some external content from MYU	I can deliver content to the user	MUST
DEVELOPER	Know which side of the train I am looking	the experience is tailored to my view	MUST
TOC (SARAH)	see how many passengers have used the service	I can see how many passengers have tried the service	SHOULD

TOC (SARAH)	see what experiences passengers have viewed and their dwell time	I can see if its holding passenger's attention	SHOULD
PRODUCT OWNER	ensure experiences work on a moving train at various speeds	users can enjoy experiences along their journey	SHOULD
DEVELOPER	create a single experience that works with or without a headset	I can maximise the development time on quality interactions	SHOULD
PRODUCT OWNER	ensure virtual objects are not affected by the foreground	the experience isn't interrupted by foreground objects	SHOULD
PRODUCT OWNER	utilise on-board media servers to deliver content	not dependent on mobile device network connection or using the user's data allowance	SHOULD
STAYOVERER (MATT)	save a snapshot image of what I can see to the gallery in the app	we have a shared bit of entertainment to talk about	SHOULD
GLOBAL	have an AR experience move between inside and outside the train	the experience is engaging	SHOULD
GLOBAL	Report an error	If I can't use a feature, I want to report that it's broken so it's fixed	SHOULD
GLOBAL	experience that works going in both directions.		SHOULD
GLOBAL	show informational text content in AR (originally on window)		SHOULD
GLOBAL	see a route map showing my current location	I can see my journey through the experience	SHOULD
MYU	See an experience in or as I approach a train station	the experience is connected to my surroundings	SHOULD
MYU	Use the window as a canvas for an AR experience	to further enhance the passenger experience	SHOULD
MYU	view a Fantasia Express train set when I leave the train	I can continue the experience at home	SHOULD

	calibrate app to a device (as not using AR Core)		
	Do you have headphones / prompt them to add.		
	switch		
	build a test app to switch between apps	11th Oct	
	Waiting page to go to the schedule	Idea replaced by having the table map	
	How many experiences the user has opened on their journey	CP app feedback to MYU app.	
	What percentage of their trip did they use the app		

Appendix B. Stories, Script Extract, Fantasiapedia Stories – Narrative Chapter

B1. Stories

appendix 3: List of 50 Narrative Stories Developed

The initial stories identified and sketched out

Name	MOSCOW
AR Content (Green Ones Are in, Orange are maybes, Reds are nos))	
Minions of the North	MUST
The Hopeful Zebras of Northumbria	MUST
The Sea Monsters of Holy Island	MUST
Out of Train Bodily Experience	SHOULD
The Eternal Battle of Independence at Hadrian's Wall	MUST
The Border Game	SHOULD
The Flying Scotsman of the Lowlands	SHOULD
The Procession of the Tweedale Salmon Queen	MUST
Raining Polar Bears	MUST
Sniper Bagpiper	MUST
Where are the Cows?	should
Mini Fantasia Express	MUST
Flat Content	MUST
Games	MUST
Audio	MUST
The Mammoth of the Fens	should
The Last Englishman of Peterborough	must

The Yorkshire Hob and the Fairies of Lincoln	must
The Angry Dragons of Viking York	must
Animal Infested Train Stations	should
The Farming Giants of Durham	must
The Revenge of the Lampton Worm	MUST
Flying Scotsman	should
Driver POV	SHOULD
The Wisdom of Major Oak	SHOULD
The Hunt for Nessie of the Highlands	could
The Raid Tunnels of London	could
Giphy Randomness	could
The Spiders of the East Coast Train Line	could
The Fantasia Easter Egg: The Key to Happiness	could
Electric Circus of Fantasia	could
Sheep Joke Time	should
The Race of the Hare and the Turtle	could
Urban Ghosts Pac Man	could
Other Scottish Ideas	could
Triggering Content from Outside to Inside	could
Participatory Content	could
The Homeless Ghost of Grantham	wont
The Urban Jungle	wont

Each of the 50 stories listed above had the following additional content (Using the Yorkshire Hobs as an example)

- *Location*: Lincoln

- *Experience type*: AR Story

- *Duration:* 120 seconds

- *AR category:* AR Near

- *Short Description:* (25 Words):

  Where do fairies live in Yorkshire. Trains of course. Be welcomed into their world and hear stories about their eternal struggles in the enchanted forest.

- *Punchy Summary:*

  Meet the Yorkshire Hob and his Fairy Friends who have something important to tell you

- *What Happens?*

  A fairy door appears in front of you, after a moment out pops a little HOB, who invites you inside. Putting on your headset you become small and can see inside the little house. The HOB tells you the story about the fairies (who he doesn't like) when you take your headset off, they are outside the train window trying to get in.

- *What's the Notification at the start?*

  An enchanted realm exists around you. Would you like to meet the fairies

- *What's the reward at the end (i.e., Links to Other Features in the App)?*

  You earn a new carriage for your train, plus 10 coins. Link to Wiki Information about Fairy sightings in the UK. You can take a photo.

- *Skill Earned (courage, wisdom, pride etc.)* Magic

B2. Script Extract: Final Yorkshire Hob Script

appendix 4: Extract of Script for One of the Micro-narratives

Typical Yorkshire Brass Band Music.

NARRATOR

You are now entering God's Own Country! Home of Yorkshire cricket, Yorkshire tea, Yorkshire pudding… and the Yorkshire Hobb – a vicious, malicious, pernicious creation indeed.

ALAN HOBB

Are you still on that computer Barry? What're you doing? Writing a little something for the theatre?

BARRY HOBB

Just chatting to a friend.

ALAN HOBB

As long as it's not one of those dreadful Lincoln Imps!

BARRY HOBB

Course not - us Yorkshire Hobbs never talk to Lincoln imps. (beat – tentative) Isn't it past your bedtime Granddad?

IMP (V/O)
(sing-song voice)
Barry? Barry?

ALAN HOBB

Is that your computer talking to you?

BARRY
(unconvincing)
I didn't hear anything, Granddad.

IMP (V/O)

I got your message, Barry.

We see outside, the IMP slowly appearing.

IMP

Barry, Barry….

ALAN HOBB (V/O)

What's going on?

BARRY (V/O)

Nothing honestly Granddad. You really should go to bed.

ALAN HOBB (V/O)

It sounds like….

IMP

I brought you some pressies Barry. Lincolnshire sausage, fresh and herby. Haslet! Lincolnshire pies, hot and crusty. Nuggets!

ALAN HOBB

Lincolnshire? Have you been conversing with imps Barry?

BARRY HOBB

She's very nice! And the pies are lovely. You should try one! (beat) Come in!

ALAN HOBB

Don't invite it in! What are you doing?

IMP crashes through door.

IMP

Oh Barry!

BARRY HOBB

Oh Impy!

Innocent comedy kissing noises.

ALAN HOBB

Barry, I demand you stop kissing that imp immediately.

IMP

Got to fly, Barry! See you soon.

ALAN HOBB

Mmm these pies are nice. Lovely firm bake.

B3. List of Fantasiapedia Stories

appendix 5 List of Fantasiapedia Stories

- Devils six hills of Stevenage

- Cambridge Giants

- The Last Englishman

- St Catherine's Well

- The haunting of Greestone stairs

- The Barnburgh cat

- Topcliffe UFO incident,

- Dead Man's Chair

- Peg Powler water spirit

- Lambton Worm

- Roman Gods of the Tyne

Appendix C. User Research Chapter

C1. Ethical approval

appendix 6 Ethical Approval Letter

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School of the Arts Research Ethics Committee

19 February 2019

Dear Prof. Koeck

I am pleased to inform you that your application for research ethics approval has been approved. Application details and conditions of approval can be found below. Appendix A contains a list of documents approved by the Committee.

Application Details

Reference:	4616
Project Title:	Fantasia Express
Principal Investigator/Supervisor:	Prof. Richard Koeck
Co-Investigator(s):	MR Alastair Eilbeck
Lead Student Investigator:	-
Department:	Architecture
Approval Date:	19/02/2019
Approval Expiry Date:	Five years from the approval date listed above

The application was **APPROVED** subject to the following conditions:

Conditions of approval

- All serious adverse events must be reported to the Committee (ethics@liverpool.ac.uk) in accordance with the procedure for reporting adverse events.
- If you wish to extend the duration of the study beyond the research ethics approval expiry date listed above, a new application should be submitted.
- If you wish to make an amendment to the study, please create and submit an amendment form using the research ethics system.
- If the named Principal Investigator or Supervisor leaves the employment of the University during the course of this approval, the approval will lapse. Therefore it will be necessary to create and submit an amendment form within the research ethics system.
- It is the responsibility of the Principal Investigator/Supervisor to inform all the investigators of the terms of the approval.

Kind regards,

School of the Arts Research Ethics Committee

sotares@liverpool.ac.uk

0151 795 3133

C2. Final Passenger Survey

appendix 7 Final Passenger Survey

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Fantasia Express Prototype User Experience Questionnaire

Gender:

Contact email:

1. How is your day going today? *(capture current emotional state)*

Please explain your answer

2. Please could I ask what age range you are?

Teens	20s	30s	40s	50s	60s	70 s+above

3. Can you tell me about your hobbies?

Please explain your answer

4. What smartphone/tablet devices do you own?

Please explain your answer

5. What products/apps/services do you use on a regular basis?

Please explain your answer

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6. Where are you travelling to today?

Please explain your answer

7. Who are you travelling with today?

Please explain your answer

8. Where have you travelled from?

Please explain your answer

9. How often do you travel this route?

Please explain your answer

10. How often do you travel via train?

Please explain your answer

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11. Why is it you travel via train?

Please explain your answer

12. What seat preference do you have on the train?

Please explain your answer

13. How often do you connect to the wifi on the train?

Please explain your answer

14. What games if any, do you play whilst travelling?

Please explain your answer

15. Do you use your smartphone/device for entertainment when travelling?

Please explain your answer

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16. If yes, what do you use on your smartphone/devices for entertainment?

Please explain your answer

17. How would you describe the environment on-board an LNER train?

Please explain your answer

18. Did you notice the surroundings more than usual

Please explain your answer

19. What could be improved to help pass time travelling via train?

Please explain your answer

20. What would you say augmented reality is? (Explain AR and pokemon go if needed)

Please explain your answer

AR HEADSET OBSERVATIONS -

We would like to ask the user if they could view a AR application in the AR headset so we can observe their behaviours and movement using the AR app and headset on the train.

21. Have you ever worn a augmented reality headset?

Please explain your answer

22. Did you wear the headset provided?

Please explain your answer

23. What did you think to the experience of wearing the headset?

Please explain your answer

24. What did you think to the AR visuals you saw?

Please explain your answer

FINALLY

25. What are your thoughts on the Fantasia Express? (which parts did you enjoy the most and least)

Please explain your answer

Who can I contact if I have further questions?

Alastair Eilbeck

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School of Architecture, University of Liverpool
Leverhulme Building, Abercromby Square
Liverpool L69 3BX, United Kingdom

E a.eilbeck@liverpool.ac.uk

Appendix D. Supporting Video

D1. Link to project video

The video presented at VIVA on 11/05/2023 includes an overview and chapter-related content.

https://vimeo.com/825623725

Password: viva