MainTrain: a serious game on the complexities of rail maintenance

David Alderliesten [1,2], Kotryna Valečkaitė [2], Nestor Z. Salamon, J. Timothy Balint, Rafael Bidarra

Faculty of Electrical Engineering, Mathematics and Computer Science
Delft University of Technology
The Netherlands

[1] Corresponding author: J.W.D.Alderliesten@student.tudelft.nl
[2] Equal contribution

Abstract. Commuters who travel by train often feel annoyed due to misunderstanding the causes of delays in train traffic. They oftentimes are unaware of the necessity of performing maintenance to stations, tracks, and trains. MainTrain is a serious game developed to teach commuters about rail-maintenance while simulating the difficulty of keeping passengers happy. It is a fast-paced strategy game with a top-down view in which a player can perform maintenance actions on stations, tracks, and trains. By using commuter happiness as a base metric, MainTrain attempts to elicit empathy from players dissatisfied with scheduled maintenance so that they gain a better appreciation of the need for scheduled maintenance. This is coupled with the need to schedule maintenance for several components of a rail network, encumbering a player while teaching them about different aspects of rail maintenance. To examine the effectiveness of the game, the results of a user study are presented.

Keywords: serious game, educational game, rail maintenance.

1 Introduction

Scheduled rail maintenance is a nuisance for any traveler. The additional waiting time created by maintenance can cause a delayed arrival time, missed connections, or even the inability to reach a destination. Some scheduling issues are the result of incidental failures of rolling stock or maintenance issues such as faulty junctions and signaling on semaphores, but many other delays arise due to planned maintenance. These types of scheduling conflicts do not restrict the ability to travel entirely, but do cause routes to have less capacity, less trains which can operate within a unit of time, or a requirement to travel through a different station to reach the desired destination [21].

Although these types of delays are usually announced as planned rail maintenance, many passengers do not understand why such maintenance must impact them. Passengers may be unable to understand what delays and issues arise in a rail network when this maintenance is not performed, thereby becoming unhappy when maintenance is performed on their routes. However, the effects of not maintaining a rail network include derailment, emergency maintenance, and wear and tear of as- sets. All these alternatives could cause bodily harm, more extreme issues with scheduling, or the entire cancellation of routes for a long period of time [20]. Therefore, passengers who deal with scheduled maintenance focus on current unhappiness as opposed to the greater potential unhappiness caused by not doing so.

MainTrain is a serious game meant to clarify and to show the effects of this planned & scheduled maintenance. It is meant to enable impacted customers of rail organizations to understand that, despite their frustration, the maintenance is required and not performing it could lead to longer inconveniences. MainTrain is also meant to expose players to the difficulties and conflicts with scheduling such planned maintenance, evoking possible empathy or understanding as to why they have been impacted while showing them that it was not possible to generate a maintenance schedule which avoids impacting any group of travelers or impact another group in a less negative manner. The main aim of Main- Train is to provide players with the ability to manage a rail network with a selected set of features \regarding rail maintenance, as well as the ability to see the direct impact upon passengers and rolling stock (train cars). Moreover, to avoid extensive and tedious gameplay as it would occur in a real time simulation, MainTrain delivers the full experience in a maximum of five to ten minutes. The focus of MainTrain lies with imbuing an understanding to the players of the complexities of rail maintenance.

2 Related Works

The topic of planning and scheduling rail networks is not one lacking research, acting as the focus of significant algorithmic optimization efforts and decision support tools [4, 6, 8, 14]. Regardless of the effort on operational effectiveness, failures and delays are inevitable. Therefore, a significant amount of research is honed to minimize the passenger dis-satisfaction (a recent review of the work is provided by [16]).

The perception of the train travel quality depends on many quantifiable (e.g. travel time, cost, reliability) and unquantifiable (e.g. comfort, passenger risk aversion) variables [15]. For instance, during a disruption event itself, the negative impact on the passengers' perception can be influenced by the type of information they are provided [18]. Tsuchiya et al. [18] show, that passengers appreciate being informed about the cause of the delay. However, in situations where the operator was responsible (rather than an unforeseen external factor), passengers experienced stronger negative emotions. Among such disruptions are train delays caused by the rail maintenance. Nonetheless, understanding the nature of the disruption alleviates stress experienced by the passenger [9].

Bringing it to serious games, interaction is one of the most important components of learning experience [13, 7]. One of the most effective ways of content-learner interactions have been provided by the relatively new medium of video games. Such games, focusing not only on the entertainment value, have been proven to work in a motivating, enabling manner [2]. Serious games allow people to actively participate and allow repetitive practicing. Even within a context of rail and transport planning, such games have been proven to be an excellent medium to explain com- plex concepts [3] and even explore radical innovations within transport planning [19]. These examples, Synchro Mania [3] and SprintCity [12, 11], do not explicitly deal with railway or rolling stock maintenance. The first one focuses on synchro modality and planning of freight transport. The second one primarily offers the possibility to create 'what-if' scenarios for infrastructure planning to support decision making.

On the one side of the spectrum lie games focusing on the economic aspects and optimization of railroad network use. The following examples are not considered serious games, but their core gameplay components illustrate the complexity of the railway design, scheduling and operating objectives. Among these are Simultrans [10], Railroad X [17], Sid Meyer's Railroads! [1]. Within this category of games, the player cannot schedule trains or funnel passenger movement paths but is able to make budgetary decision and can attempt to create a rail network design that most optimally funnels passengers to transfer locations. Looking at even more minimalistic games, such as MiniMetro [5], address the complexity of network design itself. MiniMetro places an emphasis on the design of the network and route capacities, with the requirement to transport a certain number of passengers within a given time limit. The game is open ended, with game difficulty increasing together with the growing rail network.

3 Game Design and Implementation

The purpose of the presented MainTrain game is to provide a player with an understanding as to why planned maintenance is required and why minimizing the negative impact on passengers is a difficult task. These insights are to be provided within the context of a short time period, such as a convention floor or on a station platform while waiting for a delayed train. The main purpose of the game is to:

- inform about the basic types of rail maintenance;
- make the player aware of the (dis)advantages of performing regular rail maintenance; and
- trigger the further interest in the topic.

For this, the game must provide a simple overview of a rail network with the essential features: stations, tracks, and trains. This system is not a representation of a real rail network to avoid overly complex starting conditions and possible player favoritism of known locations.

The core of the game is to perform maintenance tasks along a rail net- work, which is deteriorating over time. The player can perform rolling stock, station, and track maintenance. The player can perform these tasks by selecting the desired component (track element, station, rolling stock), and selecting one of the maintenance options provided. Track maintenance ensures trains can safely and quickly reach their destination, while also preventing accidents and a propagation of track damage. Rolling stock maintenance ensures

that trains are clean and comfortable for passengers, increasing their tolerance for longer journeys and issues that arise while en-route. Station maintenance ensures that passengers are attracted to the idea of train travel and will tolerate longer delays and issues that arise before their journey begins. These three maintenance tasks were chosen as they are easily visible in both the game and real life. Most passengers interact with the trains and stations and can perceive repair being done on track if they pass by the track. Maintaining the rail system allows transporting larger quantities of passengers, as well as keeping them happy. For the first of the two, the user is re- warded by points and system complexity growth. Simultaneously, it is also essential to keep the passenger happiness high: if it drops below a set threshold, the game ends.

The simplicity of possible choices is counterweighted by the size of the provided network. Additionally, the inability to have a full overview of the system state at all times contributes to the complexity of decision making during the game session. Like in real world, situation the system operator needs to perform manual inspections of units. Furthermore, the user is presented with the knowledge at which points in time the routes will likely deteriorate. Making the game complicated is intentional: the player is supposed to feel discomfort as if to mimic the 'actual' situation. An overview of the presentation of these features is present in Figure 1.

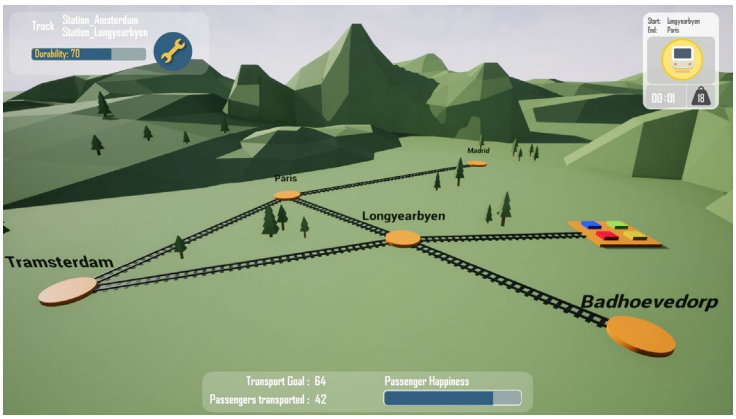

Fig. 1. A sample train layout, with *Tramsterdam* selected. In the upper left corner are stats related to the track reach the station. A train will soon run between two other stations, indicated by the card on the top right side.

3.1 Procedural Rails and Random Route Generation

MainTrain was developed to allow random station generation over time to increase the difficulty of the game for the player. To facilitate this, a method was developed to generate track pieces between randomly generated stations regardless of positions. A simple rail model was placed within the game and the stations were encoded to consist of track start and end points. Track would be generated by replicating the track model multiple times between these start and end points, generating a track that can be randomly created and allows for network expansion. The track's existence, including its length and direction between two stations, was implemented within a central array to allow for the simple addition of trains over the track, meaning they would travel over the procedurally generated rail segments. The players would be provided with an overview as seen in Figure 2.

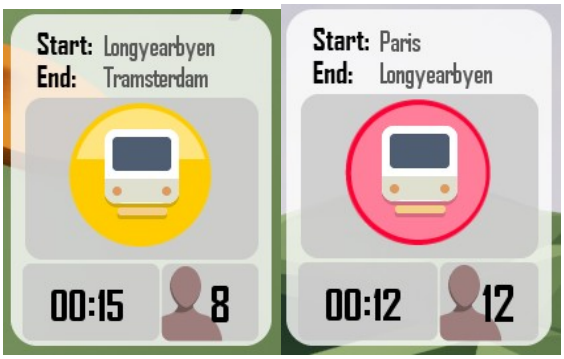

Fig. 2. Train cards with the route information and train properties.

To ensure the player was met with non-linear and unpredictable routing, a method had to be devised to ensure that the routes traveled by the trains within the game are random. Hence, an array of stations was created, and a random timer derived from the game engine determines whether an event should be generated at any random given moment. The routes generated take a start and end station, which can be connected directly but usually consist of at least a single stopover station between them. This utilizes more of the track, requiring more sections be operational to keep a high happiness score. The route uses the track pieces found within the game world to determine the most efficient route to get to the destination station.

Due to the possibility that a track piece is broken beyond the point of allowing a train to traverse it, the routing implementation also accounts for cases where a train cannot reach its destination or must be rerouted during its journey. This was done by continually iterating over the track array within the game world between each visited station and determines a new route to the desired destination if still possible. This solved the issue of random routing, as well as also the issue that could arise in which trains might be routed to move over broken track.

3.2 Passenger Satisfaction Coupling

The measuring of passenger satisfaction requires interplay between multiple variables within the game. These variables include: average cleanliness of stations, the durability of the track segment the train is moving over, and the cleanliness and repair status of the rolling stock itself. To ensure that the player notices the impact of these many variables, simple methods had to be found which could bind all associated variables together and impact a distinct set of variables that the player would notice. The Passenger Count and Passenger Satisfaction variables bind all associated values together to ensure the player is not tracking or noticing the interplay of elements but

does receive understandable feedback when a train is generated to provide hints related to track status. The passenger count value is given when trains are generated and directly influenced by all variables related to the player performance, whereas the passenger satisfaction variable is shown as a percentage bar to provide an overview of passenger timeliness and comfort directly related to the actions of the player.

4 Evaluation

We assess the efficacy of MainTrain by performing a user-study. Testing was performed between groups on two different versions of the game: (i) one without a possibility to lose and without a clear indication of the score, named bare and (ii) one with both of these implemented and visual consequences amplified (i.e. track durability decrease would significantly impact the movement speed of the train) named full. We tested on this difference as the score and visual consequences most directly related to passenger happiness as well as visually explaining the variety of track maintenance. Our user study consisted of twelve one-on-one play-test and interview sessions, which occurred in a setting familiar to the participant (such as their home or office). On initiation, the participant was given no instructions apart from a request to interact with MainTrain. During the session, the interviewer provided only requested directions to the player, all of which were noted by the interviewer. After testing, the participants filled in a questionnaire. This questionnaire focused on user interface design, difficulty and immersiveness of the gameplay, as well as how well the game conveyed its intended purpose. Our user study was carried out with eleven participants from three age groups: 10-20 (1 participant), 20-30 (8 participants), and 30+ (2 participants), all of whom were familiar with computer games.

By examining the qualitative feedback on the questionnaire, we found that adding in a clear indication of score and visual degradation caused some players to feel overwhelmed by the amount of maintenance options available. This is most likely due to the fact that the full game allows the players to ”see” what they could do as well as how those choices affect passengers and the rail network. Interestingly enough, this did not lead to a significant different between how players rated the overall enjoyment of the game ($p = 0.5$). Furthermore, showing player happiness as a scoring mechanism and allowing the participant to fail the game caused a shift in what each participant thought the goal of the game was. In the bare version of MainTrain, half the participants believed the goal was simply to transport people, with only one believing that customer satisfaction was the purpose. However, in the full version, half of the participants noted happiness as a goal, half noted transportation, with one saying that these were the two goals of the game. This makes sense as the full version of the game had happiness tied to success. While this does not mean that the game made the participants empathic to rail maintenance, it is a first step in determining if MainTrain will do so.

5 Conclusion & Future Work

In this paper we presented a game aiming to show the complexity and difficulty of rail maintenance to a varied audience in an exhibition or fair setting. The player is faced with a goal to allow as many passengers to be transported, keeping them happy whilst keeping up the stations, tracks, and the rolling stock.

While the player can theoretically burn through the game and never experience any of the issues - simulations do not reach a high level of complexity, MainTrain conveys the important concepts in rail maintenance, such as the three rail components that must be maintained.

Future versions of MainTrain will aim to introduce some required issues or problems as the game progresses, regardless of player performance (i.e. the breakdown of a train or a natural disaster). At this point in time, the player can play the entire game without experiencing any issues in track maintenance, whereas planned setbacks would ensure the player is shown the desired difficulties and complexities, which exist within the domain of rail maintenance.

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