

# Enhancing Train Travel with Augmented Reality for Smartphones: The “Tales on Rails” Project

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**Abstract.** The project “Tales on Rails” describes the research and development of an augmented reality game that can be played on trains with smartphones. The project addresses tourism changes in the digital age; the ubiquitous use of smartphones alters a tourist’s travel experience, from accessing timetables to conveying cultural and historic information or transforming traditional souvenirs. “Tales on Rails” tested a smartphone application allowing tourists to play a game about a crime story on the route between the cities of Lucerne and Interlaken, which is operated by the Swiss railways company zb Zentralbahn AG. The game directly references the environment outside the train on this route as well as cultural themes about the region. The game’s progress is linked to the position of the train, successively unlocking its content on the route. The game is tailored for use by 20 to 30-year-old leisure travellers, and optimized for a group experience in which two to four players collaborate on solving the game; thus, group dynamics during the gaming experience could be investigated. The game features a technologically ambitious program with augmented reality game elements, while minimizing negative impacts on playability by environmental influences such as seasonal and weather conditions. The technical complexity of the concept could be expanded in future iterations. The project “Tales on Rails” was released in July 2019 as fully functional game application in the Google Play Store and the Apple Store.

**Keywords:** Gamification in Tourism, Tourism, Digital Experience Tourism, Augmented Reality Game, AR Game, Digital Souvenir.

## 1 Introduction

Tourism is directly affected by digitization [10], including Augmented (AR), Virtual Reality (VR), the Internet of Things, and Artificial Intelligence, which are increasing technological complexity and changing the industry [9]. The greatest impact on tourism is associated with mobile technologies [10]. Through the emergence of an “experience economy,” the use of play and games has become increasingly important [4,3]. AR technology for smartphones has led to a comprehensive expansion of gaming into everyday life, as mobile AR devices add a digital layer to the physical world [5]. Such games can result in collaborative gameplay, strengthen personal contacts, and allow players to discover events, have fun, and learn together [5].

In order to benefit from these opportunities, the tourism sector needs to adapt its marketing strategies and plan to implement technological innovation [2]. For zb Zentralbahn AG (ZB), a subsidiary of Swiss Federal Railways (SBB), the question arose as to how the potential of mobile and location-based gaming could be used to create an incentive for increasing tourism travel on the ZB panorama routes. Such pervasive games extend into the physical realm in an exciting and commercially promising way [8], and they also appear to be especially suitable for addressing the target group of 20 to 30-year-olds, for whom social interaction, participation, and co-creation of experiences (also occurring in virtual worlds) play an important role in their leisure activities. The target group is familiar with internet-based technologies and spends significant time on their smartphones [16].

This paper presents the empirical results of the project “Tales on Rails,” which researched and developed an AR game application for tourists to use on their smartphones. An iterative design process between the Zurich University of the Arts (ZHdK) and ZB investigated how the travel experiences of the target group could be enhanced. The paper presents the design of a location-based AR game played inside ZB trains, which are in motion as the game progresses. It provides insight into the design process, as well as the limitations faced when optimizing the user experience of AR gaming in a moving train. It describes how the application was accepted by the target group, how the behavior of travelers in the train was affected, and where the challenges in the technical implementation lay. The results of iterative prototyping and playtesting were evaluated through surveys and interviews with laypeople and experts in a final analysis.

## 2 Related Work

Related work shows that the defined, limited spaces of compartments in moving trains appear to be an ideal frame for enhancing the experience of group tourism with location-based multiplayer games. “Tales on Rails” derived its design principles from:

**Motivational Design.** Competence, autonomy, and connectedness constitute the theory of self-determination [15], in which the increase or decrease in intrinsic and extrinsic motivation depends on an environment that promotes motivation through individual competences, solidarity, and autonomy [3]. Lazzaro [11] argues that games are played because of the emotions they generate. In research at XEODesign [20], the *Four Fun Keys Model* explains how a range of emotions can be identified and evoked. The model categorizes games that create *hard fun* by presenting challenges while providing the steps to get there; *easy fun* results from interaction, exploration, and imagination; the creation of real-world benefits, or changes in the players’ behaviors creates *serious fun*; integrating a community boosts *people fun* [11].

**Cooperative Games.** Cooperative Games are characterized by players forming a group to coordinate their actions and share their winnings [1]. In live escape games, a popular sub-genre of pervasive games, groups of players solve puzzles in order to escape

enclosed spaces [19], relying on the players' ability to cooperate. "Import-Export Rotterdam" [6] combines reality with VR, since the player's real-world positions affect their positions in a game. "The Escape Train" [13] connects location-based cooperative gaming (solving a crime story during a train journey) with a live broadcast of the game's actions. Asymmetric gameplay demands collaborative communication between players who influence the game in separate but complementary ways, for example, as found in the game "Keep Talking and Nobody Explodes" [7].

**AR-Based Games.** Current AR-based games add a virtual layer upon the physical world with AR-technology, leading to a combination of physical and digital environments. Through this superimposition, real locations can become the background used to tell fictional stories [18] or to even make historical events visible once again [17]. This principle was effectively demonstrated by the location-based AR game "Pokémon Go" [14], in which players competitively collect AR-generated game characters in public spaces. It was also reported that AR learning games resulted in "the enhancement of learning performance and the learning experience," and that "social interactions were encouraged" [12].

Reflecting such design principles, the players of "Tales on Rails" have to decide whether they prefer to master challenges competitively and autonomously for a personal high score, or collaboratively in order to reach a common goal. Building on a wide range of aspects of game motivation design, the group of players explores virtual AR locations, collects information, and solves puzzles. An AR representation of the typical scenery around the train invites them to discover details in a digital world, as well as to compare these elements to their physical counterparts outside the train.

### 3 Creating "Tales on Rails"

"Tales on Rails" addresses the changes of railway tourism in the digital age by providing an optimized solution for a collaborative, multiplayer smartphone game, thus enhancing the travel experience. The game can be played on a scenic alpine train route between the Swiss cities of Lucerne and Interlaken, a connection operated by ZB. The first game of "Tales on Rails" was published as "Die Tote am Berg" [Death in the Mountains], a part of the newly founded ZB series "Crime Line," for which further games are planned. Providing a visually attractive experience of AR-gaming, the game's setting closely relates to the scenic and cultural context outside the train.

#### 3.1 A Digital, Location-Based Game Concept for Group Tourism

"Tales on Rails" both condenses and enhances tourist activities on a train journey: fictional literature, entertainment media, and information about the route merge into an entertaining smartphone game telling a fictional detective story. Since communicative exchange during travel is an essential group tourist experience, the game concept established an AR setting which can be explored by up to four players simultaneously or consecutively, much like several detectives examine the same site. The incentives range

from the search for hidden clues to mere narrative entertainment; the players each decide for themselves whether they reach the goal collaboratively, or whether every player aims for an individual high score competitively.

The initial AR concept for “Tales on Rails” suggested complementing the environment outside the train with a superimposed AR layer on the players’ smartphones, e.g. with precise position data or stickers on train windows as AR triggers. But in contrast to successful AR solutions based on fixed locations for AR triggers [17], the design process revealed that the constantly moving position of the train resulted in an unreliable representation of AR elements, for example, because of shifting lighting conditions. While AR was still identified as an attractive feature for the game, “Tales on Rails” had to ensure reliability for public use.

Consequently, the use of AR shifted from directly complementing the landscape to an indirect, more narrative application. The AR elements were designed to maintain a strong visual link to the scenery outside the train (e.g. through a thorough analysis of the predominantly traditional building styles), but to connect this loosely to the game rather than becoming a necessary condition at a particular time or position along the journey. While the game still relates to the landscape outside, the AR triggers could be placed at the seating groups, thus ensuring reliable AR visualization (Fig. 1).



**Fig. 1.** “Tales on Rails” played by scanning the AR marker on the train table (source authors)

Although this approach differs significantly from the original concept, it had positive effects for the further development of the game:

- The attractiveness of an AR game could be accurately maintained, allowing a group of players to explore an AR game location together.
- The indirect link allows for easy playability in both directions of the journey, without making a player’s individual progress dependent on the train’s exact position.
- Reliable AR visuals for a location-based game could be ensured, while the player’s position (i.e. the train) is in motion.

This use of AR therefore does not primarily extend physical reality, but instead enables a special group experience: several player “detectives” can examine a 3D level for clues by simultaneously pointing their smartphones at a virtual crime scene. Accordingly, significant effort also went into relating the players’ actions to one another, and into linking the game’s current status to the train’s position, in order to create a digital group experience that corresponds with the scenic context outside the train. However, initial testing showed three problems: 1) that an unstable mobile phone signal was to be expected, due to geographic and climatic conditions on the route. To remain reliable, the game could not rely solely on positioning systems (e.g. GPS) to retrieve data; 2) the direct exchange of multiplayer data was prone to technical glitches, potentially disrupting gameplay; 3) requiring players’ smartphones to connect with each other could create a discouraging entry barrier for new players.

It has been stated that “current developments in localization technologies still fail to deal with positioning uncertainty” [8]. The framework of “Tales on Rails” was deliberately designed to be as robust as possible, “as not to frustrate players or compromise their trust in the game engine” [8]. Therefore, any data exchange during the gameplay was dispensed with in order to avoid player frustration due to such technical difficulties. After completing the initial installation, the game indicates its start with a tutorial sequence at the beginning of the trip and reaches its core action in the middle of the train journey. Similar to the indirect link to the environment of the AR concept, the exchange of information between players is not conducted through direct mutual data exchange, but instead, by motivating overall group communication. At the same time, close attention was paid to ensuring that the game would not create any disruptions for fellow travellers not participating in the game.

### 3.2 Game Narration, Usability, and Visual Design

The game features a criminal story based on local traditions and fictional events. It describes a rural family drama about the primary character, a wealthy farmer, as well as his son, daughter, and daughter’s husband. Starting with the theft of the farmer’s pride and joy—an unusually valuable bull—the story’s multi-linear plot uncovers the motives of various suspects, and eventually leads to the accidental tragic death of the farmer’s daughter. A police detective moderates the plot and directly addresses the players, who solve the case by collecting story-based evidence, exploring locations, and exchanging clues. The game features two main means of interaction: a multi-linear dialog system communicating the game’s instructions and narratives, and an object-based visualization representing the scenic setting (Fig. 2):

- A 2D interface conveys all instructions and story elements, stores clues and information in submenus, and provides a structure similar to common chat applications for dialogues and interrogations with suspects. The text interfaces are triggered by looking up stored memos, or when a player interacts with a game character.
- 3D interactive game levels are displayed using an AR perspective. By focusing the smartphone’s camera on an AR marker sticker placed at every seating group in the train, a 3D diorama of a game level is displayed.



Fig. 2. Three interface examples showing 3D dioramas, pop-up hints, and 2D story information (source authors)

The players solve the case by collecting story-based evidence, exploring locations, and exchanging clues. For this reason, the gameplay includes various aspects of search and combination games. A newly entered game level (a 3D AR diorama displaying a game location) names a given number of clues that can be found in it, but does not indicate their exact position. Once a player has found a clue by closely searching the level (possibly in exchange with a fellow player), the new piece of evidence is marked in the AR diorama, saved as text input in the evidence submenu, and can trigger further dialogues and questions. This disclosure and storage of information lets players gradually combine the answers to the case (e.g. whether a violent quarrel between the farmer and his daughter could be connected with her death). If a player is able to find all clues to a diorama, this will have a positive effect on his or her ranking.

The game unlocks its content from the start of the train ride—either by the players' completion of a level, or by a countdown defining the maximum amount of time that can be spent on any given level. This time limit guarantees the story's progress and ensures a rough correspondence between the in-game action and the train's position. In order to gain useful information from AR levels or story elements, players need to distinguish relevant from non-relevant clues. To further strengthen the link between game and scenery, bonuses for observations on points of interest outside the train are awarded (either during or after the main gameplay). In multiple-choice interfaces, players are given one-time chances to select the correct answers to scenic observation questions. In doing so, players are able to improve their rank and to unlock optional game levels.

The seven game levels designed in total reflect the regional scenery and its architectural styles. In order to achieve a flawless rendering of the 3D models in AR, the scenes

were implemented with reduced complexity, while strong color and object contrasts were used for high legibility. Each level diorama features interactive characters for dialogues, and hints which can be examined to discover hidden clues.

### 3.3 Technological Framework

Because of the unstable data connection during travel, all relevant game data was integrated into the application upon installation. Even though the gameplay suggests otherwise, the game's progress is not bound to the actual position of the train, but to the detection of the AR-marker, a sticker that is only available on the trains. Placing the stickers on the seating tables yielded the best results, as the AR detection and handling of the smartphones was better than, for example, on a window.

To run the game, operating systems must be equipped with basic AR technologies: ARKit for Apple OS and ARCore for Google. Devices should have a high battery level and performance. The implementation in the Unity AR Engine tested performance, and battery life in relation to the game's complexity, the constraints of AR display, and AR functionality. For optimal focus on game mechanics, the unity plugin Vuforia was used (<https://developer.vuforia.com/>). "Tales on Rails" was developed for mobile phones using iOS 9+ and Android 7+. Since July 2019, "Crime Line" offers an overview over the releases (<https://playcrimeline.ch>) on the AppStore<sup>1</sup> and Google Playstore<sup>2</sup>.

## 4 Evaluation

The application development went through an iterative design process, during which the game was tested in different stages. Through playtesting, all components could be optimized. The tests resulted in continuous improvement and balancing of narration, game mechanics, gameplay, user interaction, usability, and AR stability (Tab. 1). Iteratively, the core idea of enhancing a tourist group's travel experience could be strengthened.

**Participants.** The participants (p) consisted of ZB employees (N=6), ZHdK students (N=28), and further volunteers from the relevant target group (N=30), who registered after a public advertisement was conducted. Participants were divided into play groups (n=2-4). Each participant only played once.

**Measures.** In order to control major phases of development, the project was set up in stages. Evaluation was scheduled at the end of each stage. Within four months, five tests were carried out on trains, and another two tests were done at ZHdK, with a total of 65 participants (N=65).

**Procedure and Data Collection.** All participants were given an individual smartphone and played the game in groups of 2 to 4 people (except Playtest B, which was played

<sup>1</sup> <https://apps.apple.com/us/app/crimeline/id1470944437?l=de&ls=1>

<sup>2</sup> <https://play.google.com/store/apps/details?id=ch.zentralbahn.crimeline&gl=CH>

alone and followed by an interview). After tests A, C, D, E, F, and G, a semi-standardized questionnaire collected quantitative and qualitative data, and had to be returned immediately after answering. During the tests, the participants' behaviors were also observed and recorded. For the subsequent qualitative analysis, the tests, the discussion, and the interview were transcribed. The questionnaires and protocols were evaluated, further development steps were derived from the results, and the game was improved iteratively on the basis of the results, from Playtest A to G.

**Data Analysis.** The quantitative data was analyzed, and the qualitative data was clustered into "Game / Tutorial / Resolution / Landscape / Story / Bugs-Usability / Train / Interaction / Dialogues / Bonus Features / AR / Graphics." Average values were determined, and weaknesses were identified and marked for improvement.

**Table 1.** Results of playtests and identified weaknesses (source authors)

<i>Playtest Session Sample Size &amp; Date</i>	<i>Method &amp; Identified Weaknesses</i>
<b>Playtest A</b>  N=3 (m=2; f=1) p.: ZB Week 11/2019	<b>Methods:</b> Test on the train route, participatory observation, followed by questionnaire  <b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Story (shorten dialogues, harder puzzles)</li> <li>- Gameplay (more breaks, play time and rewards, integrate scenery)</li> <li>- Technology (stabilize AR, fix bugs)</li> <li>- Group experience (interaction, participation, competition)</li> <li>- Usability</li> </ul>
<b>Playtest B</b>  N=1 (m=1) p.: Expert Week 12/2019	<b>Methods:</b> Test at ZHdK, followed by interview with expert in dramaturgy & storytelling  <b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Story (strengthen dialogues, wrong story lines, harder puzzles)</li> <li>- Characters (profile characters, evoke more empathy)</li> <li>- Usability</li> </ul>
<b>Playtest C</b>  N=16 (m=9; f=6; x=1) p.: ZHdK Week 15/2019	<b>Methods:</b> Test on the train route, participatory observation, followed by questionnaire and discussion  <b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Gameplay (better feedback design and entertaining elements, shorten tutorial, bonus feature that relates to landscape)</li> <li>- Technology (stabilize AR, fix bugs, optimize point system)</li> <li>- Usability</li> </ul>
<b>Playtest D</b>  N=9 (m=5; f=4)	<b>Methods:</b> Test on the train route, participatory observation, followed by questionnaire  <b>Identified weaknesses:</b>



p.: target group Week 18/2019	<ul style="list-style-type: none"> <li>- Story (simplify solution, shorten dialogues)</li> <li>- Bonus feature (clear instruction at start, strengthen link to scenery)</li> <li>- Display max. reachable points</li> <li>- Gameplay (placement of clues in dioramas, timing)</li> <li>- Offer analog reward after game</li> <li>- Player interaction</li> <li>- Software bugs</li> <li>- Usability</li> </ul>
<b>Playtest E</b>	<b>Methods:</b>
	Test on the train route, participatory observation, followed by questionnaire
N=11 (m=6; f=4; x=1) p.: ZHdK Week 21/2019	<b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Story (ending abrupt/unclear)</li> <li>- Bonus feature (clear instruction at start, strengthen link to scenery)</li> <li>- Gameplay (placement of clues in dioramas, reduce focus on smartphone)</li> <li>- Shaking movements of train (enlarge trigger for clues to counter cause for nausea)</li> <li>- Software bugs</li> <li>- Usability</li> </ul>
<b>Playtest F</b>	<b>Methods:</b>
	Test on the train route, participatory observation, followed by questionnaire
N = 3 (m=0; f=3) p.: ZB Week 22/2019	<b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Bonus feature (clear instruction at start, strengthen link to scenery)</li> <li>- Gameplay (allow to return to tutorials, reduce focus on smartphone)</li> <li>- Shaking movements of train (enlarge trigger for clues to counter cause for nausea)</li> <li>- Software bugs</li> <li>- Usability</li> </ul>
<b>Playtest G</b>	<b>Methods:</b>
	Test on the train route, participatory observation, followed by questionnaire
N=21 (m=14; f=7) p.: target group Week 26/2019	<b>Identified weaknesses:</b> <ul style="list-style-type: none"> <li>- Gameplay (too little linked to scenery, not location-dependent, reduced focus on smartphone)</li> <li>- Story (solution permits interpretations)</li> <li>- Bonus feature (user instructions too unclear)</li> <li>- Shaking movements of train (cause for nausea)</li> <li>- AR (impractical for more than 2 players)</li> </ul>

## 5 Results and Discussion

The ambitious setup of “Tales on Rails” has proven itself, both in its technology and as a game. All test players enjoyed the game and stated it enhanced the group’s tourist experience. All graphical elements (AR-dioramas, clues, 2D interface, etc.) were well

accepted. Through seven consecutive playtests, design weaknesses could be identified iteratively, which led to substantial changes and improvements in all areas of the game. For a better understanding of the plot, the story of the game was significantly shortened and timed to fit into the core segment of the train's journey: the length and amount of dialogue between game characters were reduced, and contrasts between the character profiles were accentuated. The changes in game mechanics resulted in adjusting and increasing the level of difficulty for puzzles, and in the introduction of a competitive ranking system. The usability of the game was constantly improved, both in terms of gameplay processes and the readability of graphical elements. Taking into account that players should be able to follow the course of the game without stress or frustration, the general changes reduced the complexity of the original concept but strengthened entertaining aspects of the game and social interaction among players. Due to these successive improvements, the testers' critique shifted from the application itself to the situation in the train, in which shaking train movements were sometimes perceived as unpleasant (due to a narrow track width and rack sections, swinging and shaking movements of the train carriages can occur).

However, "Tales on Rails" disclosed the contradictory concepts of scenic observation outside a train, while simultaneously focusing on a smartphone application. Even though this contradiction was addressed from the start, the demand for an interesting plot in a high-quality AR game still preserves this conflict in the final result. In order to draw the players' attention away from the smartphone and towards the scenery, various elements were added, such as a bonus feature that rewards observations made outside with a point system. Also, by extending the overall duration of the game's core plot, pauses from the gameplay were introduced to stimulate group communication. It remains to be determined whether the initial conceptual contradiction can be overcome under the given circumstances, or whether introducing an additional experience could solve it: for example, a complementary guided hiking tour at the travel destination could embed a location-based multiplayer game for tourists into an even more intensive overall experience.

The development of "Tales on Rails" discussed the question as to whether an AR game application related to the surrounding scenery could become a digital souvenir, or even replace traditional forms of souvenirs. In game test questionnaires, the majority of the participants indicated that they would not yet recognize any parts of the game as souvenirs at this stage of development. Future extensions of the game could show whether certain game elements could either be digitally extracted from the game or even offered as analog counterparts, in order to function as souvenirs.

Technical tests revealed that neither the exchange of real-time data between players, nor the retrieval of online data for positioning (GPS, actual or stored train schedules, or a mix of both) were technologically feasible under the given circumstances. Such solutions were also found to negatively impact playability by shifting attention towards data connectivity, and away from the communicative aspects of a multiplayer game. The requirement for a direct reference to the train's position had to be reduced to an indirect reference, in order to avoid frustration in the event of a technical malfunction or if players missed the event. However, the consequent solution of indirect, communicative exchange among the players did not result in cooperative game-mechanic benefits.

Tests with groups of 2 to 4 participants showed that an AR sticker is best utilized for only 2 players. It was also found that long-term use of AR leads to high energy consumption of the devices.

## 6 Conclusion and Outlook

“Tales on Rails” enhances the group tourist experience of 20 to 30-year-old travelers with a location-based multiplayer game. The game’s AR feature promotes individual exploration, as well as entertaining, collaborative, and communicative exchange within a group of tourists. At the same time, the project shows the complexity of combining the observation of scenery surrounding a moving train and simultaneously concentrating on the content of a narrative AR smartphone application.

Further assessment in 2019 will evaluate the success of “Tales on Rails” in different seasons and under other weather conditions, provide information on the composition of user groups, and gather detailed feedback on the reception of the story. The outcome of the assessment will define whether the project should be expanded into other parts of the ZB’s network, or transferred into additional “Crime Line” stories with a series of alternative games.

It is planned to test a version of the game from which the AR components have been removed. This would make it possible to determine whether the developed AR concept is actually capable of reinforcing group dynamics in games for travelers. Additional extensions of the game could further strengthen the overlap of digital virtuality and physical reality, which is typical for pervasive games. This could implicate the transfer of elements from location-based multiplayer games to analog souvenirs, or vice versa, such as from a physical souvenir back into the game.

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