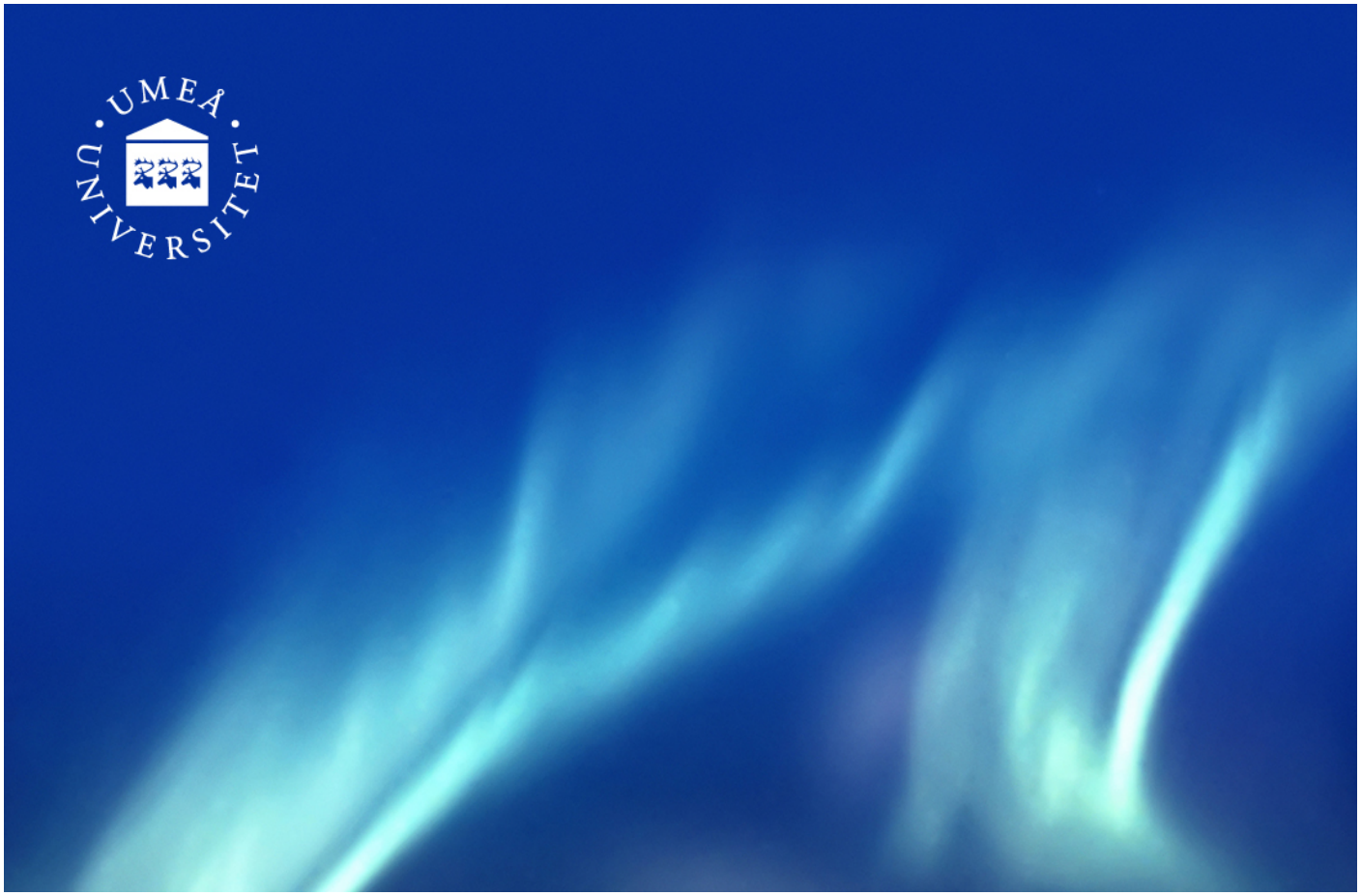

Master Thesis Report

The Impact of Spatial User Interface Integration within Strategy Games

An evaluation of a strategy game's approachability within diegesis and spatial theory

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Abstract

Diegesis and Spatiality are fundamental to visualization techniques in games. The impact of integrating user interfaces into the game world is a contentious issue between minimizing the heads-up display or maximizing functionality above realism. Previous studies have shown conflicting results determining what approach is better, but these studies have focused on conventional genres like the First Person Shooter. Strategy games, or more specifically, the grand strategy genre, is different in perspective and role of the player, as the genre places a heavier emphasis on panel elements than other genres. In this paper, we created two similar prototypes that differed in their focus on integration or superimposition. We then evaluated their impact on performance and the user experiences. The results showed that strictly spatial integration attributed to negative results, but diegetic integration was better received. Additionally, we identified several areas where implementing diegetic interfacing in grand strategy games is different from other genres of games. Finally, we gave recommendations to enhance the strengths and overcome the limitations of diegetic interfacing in grand strategy games.

Sammanfattning

Datorspel är levande världar som strävar efter att spelare ska ha kul. Olika spel har olika fokus på spelupplevelse, men också olika mängd gränssnitt som finns fastsatt på skärmen kontra inuti spelvärlden. Valet mellan fastsättning och integrering beror på genre och preferens, men mycket av nutida forskning fokuserar på mer vedertagna genrer såsom förstapersonskjutare. Strategispel, och mer specifikt, "grand strategy" spel följer inte samma konventioner, då perspektivet och rollen på spelaren är annorlunda. I detta examensarbete evaluerade vi hur en förändring i fokus mellan fastsättning och integrering av spelelement förändrade spelarprestandan och användarupplevelsen. Resultatet visar att strikt placering av panelelement i världen gav dålig användarupplevelse, men att diegetisk integration gynnade upplevelsen. Till sist analyserade vi hur utveckling av integrerade användargränssnitt inom genren var annorlunda gentemot andra genrer, och gav sedan rekommendationer på styrkor och svagheter som genren har.

Keywords: Approachability, Game Design, Diegesis, Design Space, Video Games, Strategy Games, HUD

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Contents

1 Introduction

This paper is about diegesis in games and attempting to understand how changing the *diegetic and spatial* relationship of game elements impacts the approachability in strategy games. To better introduce the reader to the field and terminology, we choose to start with an example.

Imagine a person sitting in the driver's seat of a car. This car has a sophisticated Global Positioning System (GPS) built-in that allows the user to view directions through a pair of glasses. This approach uses augmented reality to display information to the driver's field of view, making the only capable observer of that data the driver, meaning anything observed by the driver is unavailable to anyone else in the car. Suppose the GPS's location is instead on the instrument panel between the two front seats. This approach makes the GPS separate from the driver's view, meaning anyone can view it.

The difference between the two variants is the exclusivity of the information. Suppose the driver is the only one who can observe the directions given by the GPS. In this case, the GPS is not part of the "story", or as we will refer it as, *narratively* or *diegetically* part of the world if nobody acknowledges its existence. Additionally, the glasses offer the possibility of simply sticking information in a *superimposed* manner, like a speedometer, but also display turn arrows at intersections in an *integrated* manner, which come and go when the driver rotates their head or moves away from the intersection. The GPS based in the instrument panel can be acknowledged, talked about, and seen by anyone in the car, making it diegetically part of the world. It takes an integrated role, as it never is stuck in the driver's field of view like the variant with glasses.

Similarly, elements in video games choose between being superimposed: as the health of the player character often is, and integrated: like mountains inside games often are. The latter is part of the navigable environment and functions as interactable elements, while the former takes a superimposed role on the screen. Like our GPS example, elements in games can take an integrated or superimposed role depending on whether a game developer wants that element to be part of the navigable environment or stuck to the screen. Similarly, elements in games can be acknowledged as part of the story or narrative if the developer chooses to make the characters in the game acknowledge the GPS. Each game selects what elements are *non-diegetic or diegetic, superimposed or integrated* as part of the experience, thereby choosing what game elements are for the player and what elements are for the player character.

These decisions can have an impact on how to play the game. The removal of non-diegetic interfacing elements has at least subjectively shown to change how the player thinks when playing a game [1]. Although many papers have shown that relying on diegetic elements instead of non-diegetic elements does not directly contribute to immersion [1–4]. Instead, the implementation and design decisions carry more weight, as the essential thing is that the same information can be conveyed in either approach [2]. Additionally, the coherence and consistency of the world is a factor for immersion [5, 6].

While diegetic elements' correlation to immersion is inconsistent, the field of approachability in regards to *non-diegetic or diegetic, superimposed or integrated* interfacing has not yet been tested. This paper seeks to evaluate how the player's performance, confidence, and differences in strategy (referred to as priority) change when comparing two prototypes that differ in their diegetic and spatial belonging. We seek to do this through Fagerholt and Lorentzon's [5] separation of narrative and world space together with Galloway's [7] *operator and machine acts*. Specifically, one which emphasizes diegesis, integration, and showing information inside the world, and one which emphasizes function above realism and showing data outside of the world. By combining objective quantitative measurements and subjective measurements based partly on approachability principles by Desurvire and Wiberg [8], Gee

(a) Victoria II [13] (b) Europa Universalis IV [14]

Figure 1: Screenshots of two games published by Paradox Interactive. Screenshots by author.

[9], Desurvire and Chen [10], and Blomqvist [11], we seek to determine how diegetic and spatial changes in a game prototype impacts approachability.

1.1 The Company & The Games

This paper is a collaboration with Paradox Arctic, a game development studio owned by Paradox Interactive: a video game publisher, who released their first product in 1999 [12]. They are famous for their grand strategy products *Crusader Kings III, Europa Universalis IV, Hearts of Iron IV, Stellaris, and Victoria II* among others. Their agenda with this paper is to learn how to improve the user experience and player onboarding in their games—as such, finding scientific evidence for what makes their games more approachable is valuable to the future development of their products. Our collaboration means that our paper focuses on their primary genre of games: *Grand Strategy*. Their products are used as references at later points in the paper, which calls for a short introduction:

- *Crusader Kings III* is placing the player in control of a house in medieval Europe or India with the objective to grow one's realm and family strength throughout the medieval period.
- *Europa Universalis IV* is a game that takes place from the renaissance to the enlightenment period of human history and makes the player take control of a nation from that era to make that nation the greatest in the world in this period (see Figure 1b).
- *Hearts of Iron IV* starts in 1936 and gives the player the role of a nation during World War 2 with emphasis on handling the war effort, directing industry, and eventually winning the war.
- *Stellaris* makes the player in charge of a new space-faring race with the objective of handling resources, expansion, diplomacy, and warfare with other space civilizations.
- *Victoria II* takes place during the Victorian era and the industrialization period of human history. The player is in charge of a nation with goals to industrialize, increase literacy, and fight wars (see Figure 1a).

The common theme between all games is war, diplomacy, and expansion of territory. All games make the player take control of large entities, such as nation-states or kingdoms at a time, and all games take place in set periods of human history except for *Stellaris*. The possibility of changing historical outcomes and being part of history is one of the unique

Figure 2: The *Country view* in *Europa Universalis IV* [14] including an associated tooltip. This panel has over 40 buttons and over 100 types of tooltips when all 14 tabs are accounted for. Screenshot by author.

selling points of their games. All of the games feature a birds-eye view of a world with the perspective of a god-like being. The objective of the games is diffuse and determined by the player. For example, a player can choose to expand to become the greatest empire the world has ever seen. However, smaller objectives like consolidating realms are equally worthwhile goals that the player can choose to partake in, giving the games a lot of replay value.

Their games place a heavy emphasis on panels outside of the integrated world, with much of the gameplay taking place inside panels (see Figure 2). Additionally, most panel elements inside their products feature *tooltips*, which are information snippets shown when the mouse cursor hovers the appropriate panel element. The focus is a stark contrast to the First Person Shooter genre that places most of their gameplay inside the world [5].

1.2 Background & Purpose

Video games are a massive multi-billion-dollar industry that generated $174.9 billion globally during 2020 with a 19.6% increase in revenue year over year. 20% of that, or $34.2 billion came from boxed or downloadable games on the personal computer (PC) [15]. As the industry is expanding, the importance of approachability and to onboard new players has grown correspondingly. We think this is especially true for the grand strategy genre of games, as a grand strategy game features many complex rules and large quantities of on-screen information that may be too overwhelming for new players. Overall, player retention for grand strategy games is low and persistently cumbersome, as expressed by one of their developers at Paradox Interactive. One of the critical features of their games is how to present data to the player in a structured and approachable way. Games that do not convey the correct information to the player at the right time and on demand hinders immersion and frustrates the player as they can not understand why their actions are harming their performance [2, 9]. Additionally, grand strategy games place many interactable elements

inside windows separate from the game world and have much of the gameplay taking place inside elements that are stuck in one place on the screen, making the game world more akin to eye-candy than an environment in which gameplay happens. Improving the approachability or onboarding process for players without losing the complexity is a past, present and future issue in grand strategy game design.

1.3 Objective

For us to complete this evaluation, we sought to compare a prototype variant which focused on integration with a prototype that focused on superimposition. With the data from our measurements, we then sought to correlate our measurements with diegetic and spatial theory together with approachability, which meant a couple of research questions had to be answered:

- What is the effect on the player's confidence when comparing variants?
- What is the effect on the player's priority when comparing variants?
- What is the effect on the player's performance when comparing variants?
- How does player performance correlate to player confidence?
- How does diegesis and spatial integration impact approachability in grand strategy games?

2 Theoretical Framework

As part of the evaluation, a literature study formed the basis on which we later developed our experiment setting. The literature study covered the fields of approachability, diegetic and spatial theory, operator and machine acts, immersion, and similar previous experiments. The purpose was to engross ourselves with appropriate terminology and definitions to categorize and distinguish our prototype and grand strategy games later.

2.1 Approachability

The subject of approachability in games is complex, as no prior research was found regarding a standardized method of measuring approachability. Nor seems there to be any research in comparing approachability between games. Desurvire and Wiberg [8] defined *game approachability* as the game unfolding in a way that players understand well enough to continue to explore without giving away too much information and also motivate to investigate and continue playing. Gee [9] states that playing games is a learning process in itself and that games are learning machines that make the player want to continue to learn and hence continue playing. Finally, Juul [6] explained gameplay as to interact with a tree of possible actions, where the purpose of playing is to reach as positive an outcome as possible. In correlating these statements, we think great learning machines can foster the will to continue playing and explore the tree of actions, and make it engaging to reach as positive an action as possible.

Regardless of measurability, there have been several principles made to categorize what makes games approachable. Many of these principles do not apply to every game, like story elements in a game like *Tetris*. So it falls under the analyzer to determine what elements make sense to include. A previous paper has used these principles proven to function in creating more approachable game tutorials, with Blomqvist's [11] evaluation showing the principles' function in iterative game-tutorial development.

These principles and heuristics are, in our opinion, good advice and a cohesive way to categorize problems with a game in terms of approachability. However, they are not strict guides in how to create an approachable experience. As Desurvire and Chen [10] puts it, game design is an art and a science.

2.1.1 Games as good learning machines

Gee [9] notes that game developers have found good methods of making people learn and enjoy learning, making several principles which games use to be good learning machines:

- Empowered Learners
  - Co Design
    - Players feel like active agents and don't just feel like passive recipients.
  - Customize
    - Players can customize their experience to fit their playstyle or the game allows different styles of learning.
  - Identity
    - Players become invested in a player character that they can relate to.
  - Manipulation and Distributed Knowledge
    - The player character possesses knowledge and skills that the player does not possess which entices doing something they themselves can't do.

- Problem Solving
  - Well-ordered Problems
    - Players base their problem solving on previous knowledge, and the player having a bad hypothesis impacts their ability to solve later problems.
  - Pleasantly Frustrating
    - Challenges feel hard but doable, and players feel and receive evidence that they are making progress.
  - Cycles of Expertise
    - Players learn patterns until mastered, and then should have those patterns destroyed by introducing new challenges.
  - Information 'On Demand' and 'Just in Time'
    - Games should give the correct information at the right time and when the user demands it.
  - Fish Tanks
    - By playing a simplified version of the game, the player can learn the central game concepts before being overwhelmed by a complex system.
  - Sandboxes
    - Games should have safe havens where they can learn the concept of a game without severe repercussions.
  - Skills as Strategies
    - New tools introduced to players are used as ways of achieving goals instead of just being discrete tools.
- Understanding
  - System Thinking
    - Players make strategies the best when they see how it fits into the overall game.
  - Meaning as Action Image
    - Players do not think through generalities, but through experiences they have had and imaginative reconstructions of that experience.

2.1.2 The Principles of Game Playability

Desurvire and Chen [10] created the Principles of Game Playability (PLAY) heuristics with the goal to frame-in principles that could function to maximize game approachability. These principles were based around the Real-Time Strategy (RTS), Action-Adventure, and the First Person Shooter genres, with the intent to validate products through empirical means. Through analysis of their significance through subjective questionnaires, eight categories, and 48 principles came out significant:

- Gameplay
  - The main character did things that made sense.
- Skill Development
  - The difference between my gaming skills and the skills required to complete a specific task in the game were always balanced.
  - I thought the pacing of new skills and power-ups was perfect in this game.

  - Some skills were complex enough that I spent the entire game improving them.

- Tutorial
  - The tutorial helped me understand features that were unique to the game.

- Strategy & Challenge
  - There were parts of the game where I had to stop and think about what to do.
  - Solving a challenge in the game required skill on my part, rather than dumb luck or just memorizing how what to do.
  - The game/AI was tough enough that I had to keep trying different tactics against it.
  - The game was reasonably balanced. I found there was no single faction or character that was dominant.
  - The game had different AI settings so that it was challenging to all levels of players, whether a novice or expert player.
  - The AI was a good challenge.
  - I've replayed the game multiple times.
  - I would never play this game again.
  - I was always doing different things and I liked it.
  - Any changes that I made in the game world persisted. For example, when I backtracked, I could tell I'd passed through!

- Game/Story Immersion
  - The game was fun because the characters and settings were consistent with the story.
  - I really felt like part of the game.
  - The sound effects made the game better.
  - The sound effects were horrible.
  - The graphics did a good job of creating a distinct look and feel.
  - The story was told as the game progresses.
  - The game's story gave me a good understanding of what I need to do and why.
  - The character I am playing is a character I'd like to be like!
  - I thought the story was deep.
  - I liked the story behind the game.
  - The game was a lot better if you knew the story.
  - The enemies or monsters were believable given the context of the story.
  - The story had nothing to do with the enemies you were up against.
  - During the game, you had to do things that didn't make any sense.
  - There were plenty of things you could do in the game.
  - I played because I wanted to help the characters in the game.
  - The story made the game better.

- Coolness/Entertainment
  - There was something I can't describe about this game that made it great.
  - The game used humor well.
  - I jumped out of my seat a couple of times playing this game.

  - I felt that I had total control over the character.
  - My character and the other characters' personalities developed further the longer I played the game.
- Usability & Game Mechanics
  - You can play the game without reading the manual.
  - The controls were set up like other games I've played.
  - The user interface didn't cause me any problems. Everything was laid out well.
  - The layout of the screen was done poorly. I could not always see all of the information I needed.
  - I did not experience the interface as intruding on the action, or disrupting me in any way.
  - I could always tell what my score/status was.
  - The game kept track of goals and tasks that I needed to do.
- Controller/Keyboard
  - The controls were easy to use.
  - There was some way of showing special rules and commands in-game (an index, help file, special screen, etc.)
  - There were hotkeys available for advanced players.
  - Really good players can do some incredible things in this game.

2.1.3 The Game Approachability Principles

GAP is a set of guidelines that were developed by Desurvire and Wiberg [8]. It is a set of guidelines for game developers which aims to create better tutorials and first levels in games aimed at a more casual audience. It incorporates both Gee's [9] and Desurvire and Chen's [10] principles, forming a total of ten:

1. **Amount and Type of Practice**: The game allows opportunities for sufficient practice of new skills/tools.
2. **Amount and Type of Demonstration**: The gameplay is modeled in more than one way.
3. **Reinforcement**: The game provides feedback on the player's actions.
4. **Self-Efficacy**: Player competent with learned skills and tools after initial training.
5. **Scaffolding**: Failure prevention where help is at first general and later more specific as needed, i.e. Help is provided as needed within the game
6. **Gee's [9] principles**: See Section 2.1.1
7. **Desurvire and Chen's [10] principles**: See Section 2.1.2
8. **Goals of Game Clear**: Ability to succeed at meeting goals, attracts the player's interest.
9. **System Thinking**: Actions and skills learned are useful throughout the game.
10. **Self-mastery**: Player learned new skills and tools to play the game.

When combined, the principles have some overlap in fields, as noted by Blomqvist [11], who expanded GAP to include more principles from PLAY. Since we will not use GAP to evaluate tutorials empirically, we will be treating all principles and heuristics as a large set of guidelines instead. Therefore, Blomqvist's [11] improvements to GAP is redundant for our purpose, with the exception of the additional principle:

11. **Keep it simple**: The game does not put an unnecessary burden on the player, the game encourages the player to learn via experimentation instead of direct instructions.

2.2 User Interface or Game Elements

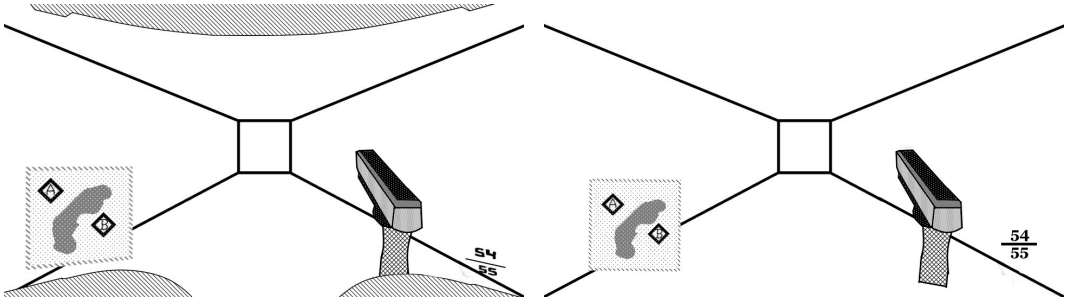
The User Interface or *UI* is a central concept in games. Llanos and Jørgensen [2] described UI in the context of videogames as any features that provide information or assist the player in their interaction with the game, including hardware like controllers and software like audio and visual features. That definition falls under Stevenson's [16] definition, which states user interfaces to be "the way a computer gives information to a user or receives instructions from a user". An issue with using UI as a term is the inclusion of the hardware side of the experience. Since the subject of the paper is on software, the term *game element* will be used instead as per Galloway's [7] definition of software space, although it was referred to as *gamic elements* in the original paper. UI will refer to both hardware and software interfacing and will be largely unused within this paper.

2.3 Heads Up Displays

Heads Up Displays or HUDs are game elements that are *stuck* to the screen. These game elements originated in pilot visors in aircraft and are used in games to display information that the player always needs regardless of where the player is looking [5]. HUDs are commonplace in First Person Shooter games [5] but are present in grand strategy games as well, as these games are full of information appropriate for superimposed panel elements. Grand strategy games like *Crusader Kings III* places a heavy focus on displaying information regardless of the player's position in the world, with the advantage that the information can be reached at any time anywhere. Of course, any game also incorporates information outside of the HUD, and grand strategy games are no different, with plenty of rivers, cities, and armies accessible through the environment. Regardless, the position of the game elements in the world space is in correlation with the concept of information being "just in time". Information given at the right time and on demand is a sign that a game is a good learning machine and makes it easy to learn [9].

2.4 Diegesis & Spatiality

Game elements can be divided into two dimensions: diegesis and spatiality. After an analysis of several First Person Shooter games, Fagerholt and Lorentzon [5] separated game elements in these two axes. It was done to categorize game elements better and enhance games' HUD elements in terms of immersion. Galloway [7] categorized diegesis by separating acts in video games into diegetic and non-diegetic acts. The approach allows actions to be from the player (operator) or the machine (computer) while at the same time separating these actions between diegetic and non-diegetic space. The difference between these approaches is the focus on objects versus acts, and as such, they are not rivaling theories but different approaches to a similar field. We argue that the interactions from Galloway's [7] can be applied to elements in Fagerholt and Lorentzon's [5] model since actions apply to objects. As such, we used Fagerholt and Lorentzon's [5] model as our primary focus when developing our prototype. In contrast, Galloway's [7] theory explained how the player and



(a) A diegetic HUD as can be seen through the distortions on the edges and visibility of the visor (diagonal pattern)

(b) A traditional non-diegetic HUD

Figure 3: Two representations of a First Person Shooter HUD that differ in their diegetic belonging

machinal relationship to these objects changed depending on the approach, and was used in a supplementary role. It is important to mention that Galloway [7] did not mention diegesis as strictly part of the narrative as Fagerholt and Lorentzon [5] did. All actions inside of the world are "diegetic" when referring to Galloway's [7] theory, although these actions might be taking place outside of the narrative according to Fagerholt and Lorentzon [5].

2.4.1 Origins of Diegesis

Diegesis is derived from diegeisthai, which means "to lead/guide through" and which later meant "give an account of", "expound", "explain" and "narrate" [17]. In films, non-diegetic elements refer to portions of a film that are not part of a narrative or the story [7]. A typical example of a non-diegetic element in films is the music or score, as it is meant to enhance the feelings which the movie portrays for the viewer, but not the character. However, it is not always the case that music is non-diegetic. Diegetic music in movies exists and occurs when a band plays in a movie scene, for example.

2.4.2 Diegesis in Games

Galloway [7] adopted the terms "diegetic" and "nondiegetic" (referred to as non-diegetic in this paper) from literary and film theory. Unlike its predecessor, diegetic elements in games refer to the world's total narrative action, including onscreen and offscreen elements. By contrast, non-diegetic elements are part of the game but outside the story or narrative. Unlike movies, games often employ HUDs as helpful elements for the player. The HUD of a game can be a diegetic or non-diegetic element of a game, depending on the implementation (see Figure 3) [5]. Many games employ a non-diegetic HUD meant to serve the player exclusively. However, oddities exist where the HUD is structured in such a way that it looks like an apparatus useful to the player character (see Figure 3a), giving the impression that the player character can observe the HUD, making it diegetic.

2.4.3 Spatiality

Spatiality in games refers to game elements being integrated into the game world or superimposed outside of it [2, 5]. A HUD element is superimposed to always be observable by the player, making the information always available when needed. Integrated game elements, on the other hand, are displayed through the navigable world-environment and are not meant to be accessible at all times but must be navigated to first before the interaction is possible.

A mountain inside a game is often an integrated game element; a health bar is usually a superimposed element. Nevertheless, the migration of traditional superimposed HUD elements into an integrated role has been attempted in games like *Dead Space 3*, where the character's life bar is part of the player character's spine instead of being superimposed on the screen. It is a choice that the developers made to better immerse the players into the world by using fewer distracting elements, which Ignacio [18], lead User Experience designer, described as removing the glass between the player and player character.

Some developers stress the need for clarity for game elements, while some argue that integrating these systems is a more elegant solution that increases player involvement [2, 19]. Strategy games like Paradox Interactive's products *Crusader Kings III* and *Hearts of Iron IV* are typically information-heavy and focus on functionality, using a HUD that is separate from the game world extensively. By comparison, genres like the First Person Shooters integrate more of their game elements into the environment by comparison [2].

Previously, games like *Dead Space* moved away from traditional HUD elements in favor of integrated solutions [18]. It was seen as a more elegant and "natural" way for game interfaces to progress [19]. Llanos and Jørgensen [2] however, state that a minimal HUD is not something that always is desirable, and its ability to enhance the game experience is dependent on the implementation and how natural it plays into the environment. One of the reasons for this is that players accept HUD elements as something valuable and needed when playing games instead of something that is in the way [2].

It does not mean that integrated solutions are inferior, as they can be seen as more elegant than superimposed solutions when applied in a matter which is consistent with the rest of the world [19]. Previous work suggests that integrated solutions are preferred as more immersive by players when asked [1, 19]. Jørgensen [19] states, however, that the preferences between how many game elements are integrated and superimposed depends on the genre.

In a genre like grand strategy, much of the interface consists of non-diegetic elements. We think it is challenging to do it differently since the decisions that players make in a grand strategy game are abstract and apply to the actions of a whole country or nation. It is hard to pinpoint these actions to a diegetic character, so the genre skips the step entirely by incorporating these actions inside non-diegetic panel elements instead, or as Galloway [7] states, place the player one step above diegesis. Based on that statements, we believe the non-diegetic role of the player's character determines how many game elements can be diegetic, as the player character is not a single person, but the spirit of a nation. In these cases, it is more convenient to act as the player and not the player character.

2.4.4 Models

In their paper, Fagerholt and Lorentzon [5] combines the two concepts of diegesis and spatiality to create this model (see Figure 4). it divides any game element into six categories in terms of how they are applied inside of the narrative and the environment:

- *Diegetic elements* are part of both the narrative and the game world. They are truly part of the world and are represented the same by both the player and player character.
- *Non-diegetic elements* are not part of the narrative or the game world. They are presented in a superimposed manner and serve the player exclusively.
- *Meta-representations* are part of the narrative but are represented to the player differently than how the player character perceives them.
- *Spatial elements* (also referred to as Geometric elements [5]) are present in the game world but outside of the narrative, meaning that they serve the player exclusively but are not superimposed like non-diegetic elements.

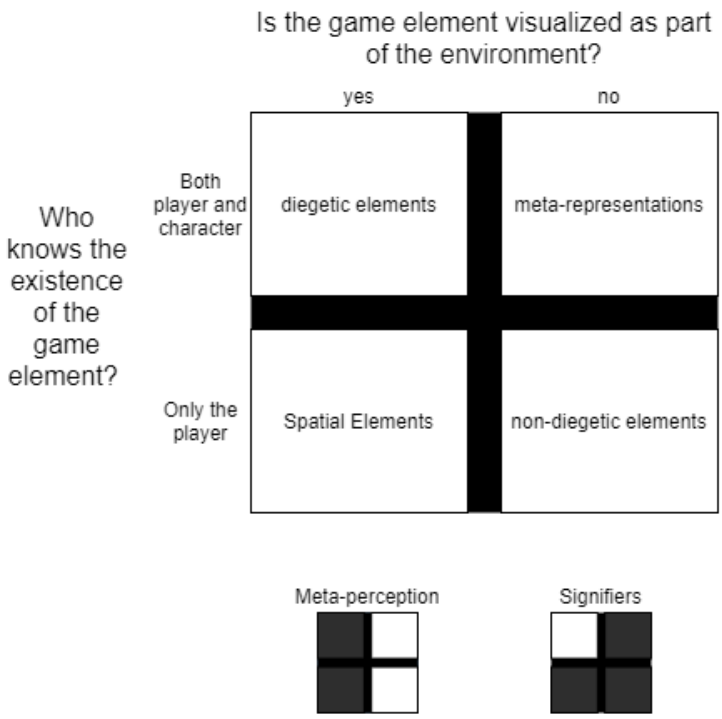


Figure 4: The model dividing the diegesis & spatiality axis into 6 categories

- *Meta-perceptions* are not part of the spatial world and their representations are done in such a way that is meant to serve the player exclusively but at the same time are part of the narrative. Fagerholt and Lorentzon [5] refers to the blood splatter seen in First Person Shooters, where the blood is splattered on the screen but does not literally exist in the player character's eyes.
- *Signifiers* are a subgroup of diegetic elements which don't supply information in a direct matter but give subtle information about other objects which can be used to better understand the intent of its target object.

We consider the model applicable for use in grand-strategy games, but one significant difference between the First Person Shooter genre and the grand-strategy genre is the perspective of diegesis. A First Person Shooter game has the player's perspective inside a person, making the player and the player character essentially see the same things unless non-diegetic spatial elements are applied. As an example, a mountain is usually diegetic, as the mountain is part of the narrative and game world and is seen the same way by the player and player character. Suppose a grand-strategy game strives for realism and tries to represent the world through a satellite image. In that case, we can also definitely say that the mountain is part of the narrative and the game world, but an issue arises when the level of detail of the mountain is not equal to what it would be when looked at from people's perspective on the ground. In this case, the mountain the player sees is different from the mountain of the narrative.

To the best of our knowledge, the model does not describe diegetic elements being represented differently for the player and player character, making the model fail to specify this game element accurately. This representational approach would leave out almost all elements in grand strategy games from being diegetic, as most things would be presented differently from the ground. Therefore, we consider it more productive to think of all grand strategy games as having the perspective of a board game. The diegetic perspective comes from an observer next to the player who can see the pieces on the board but is still excluded

from seeing the non-diegetic and spatial elements excluded from the narrative. This way, from the observer's perspective, diegesis is maintained even though the mountain is not representative of how a mountain would look in the real world, preserving the integrity of the model.

2.4.5 Machine & Operator acts

Galloway [7] holds the view that if photographs are images, then films are moving images, but video games are acts. Without action, games are just an abstract role book, and without the active participation of machines and players, video games only exist as static computer code. It is the active participation of operator and machine that makes a game work, and Galloway [7] argues that some games are played mainly by the machine or the operator, depending on the genre and what type of game it is. According to Galloway [7], the responsibility of both operator and machine are divided into four categories:

- *Diegetic machine* acts are things that transpire within gameplay and are instigated by the machine.
  - Examples include non player characters walking, clouds moving, and trees swaying and pre-determined/scripted sequences.
- *Non-diegetic machine* acts are actions done by the machine that is integral to the entire game experience but not contained within the gameplay
  - Displaying the HUD, dynamic difficulty adjustment while playing, game overs, software crashes, and powering up in Super Mario Bros are examples of non-diegetic machine acts. The HUD is present in this category because of the narrow definition of gameplay [7] uses, stating that non-diegetic machine acts are often incorporated diegetically into gameplay which creates leeway (Referred to as superimposed and integration in this paper). Regardless of the implementation of a HUD element being diegetic or not, they are often functionally the same.
- *Non-diegetic operator* acts are spontaneous acts by the operator with deliberate ends that take place in the preplay, postplay, or interplay. Additionally, some non-diegetic operator acts take place during gameplay. These are games where the acts of configuration are central to the gameplay.
  - Acts that take place during the preplay, postplay, or interplay are pausing, using cheat codes, setting the difficulty of a game before playing.
  - Acts that take place during gameplay are things like choosing attacks in a turn-based role playing game like *Final Fantasy X*.
- *Diegetic operator* acts are instigated within the world of gameplay by the player rather than the software or any outside force. The are divided into move acts and expressive acts. Move acts are to move the camera or character while expressive acts include shooting, using items, and clicking with the mouse.
  - There are limits to what and when expressive acts can be done. Ex: Deceased characters in games can't be talked to anymore after dying.

With these definitions, Galloway [7] argues that games like *Final Fantasy X* is mainly played by the operator through non-diegetic means as there is plenty of menu navigation in that game. Games like *Shenmue*, on the other hand, put more emphasis on simulating the world realistically and are therefore mainly played by the machine. According to Galloway [7], genres like *Real Time Strategy* and other games where the player takes control of an unknown entity fall under having the player controlling and tweaking menus, being one step

removed from the game's diegesis. Galloway [7] states that these types of games lets one enact the algorithm of playing, instead of submitting to the algorithm of play, and classifies Real Time Strategy games like *Warcraft III* as emblematic to non-diegetic operator acts.

In our opinion, the grand strategy genre falls somewhere in-between because of the emphasis on simulation and having a large amount player-like actors with the same objective as the player. The player has, as a whole, only a small role inside the simulated world, and the game can essentially play itself without the player, but when the game requires the player to take an active role, they have to adjust a lot of menus and tweaking as Galloway [7] states.

2.4.6 Rules of games

In their paper, Fagerholt and Lorentzon [5] explained how to blend rules inside games. The rules of a game should be something concrete that makes sense in the world, which means a rule is blended in at best when able to apply real-world reasoning alone. Some rules cannot be applied this way, like how a play session of *Europa Universalis IV* can only last between the years 1444 and 1821 in-game. Once that time is up, the game informs the player that technology will no longer improve, but one can continue playing. Fagerholt and Lorentzon [5] emphasize that when solutions limiting the play area (or in the above case, time) have to be enforced, it should be reified to make sense in the world. For clarity, reification is the act of turning something abstract into something material. A use of reification is seen in *Battlefield: Bad Company*, where instead of using an invisible wall to distinguish where a player has to be, the player receives a notification that if they leave the play area, they are susceptible to enemy artillery.

2.4.7 Removal of the HUD & Previous experiments

Removing the HUD from games is a design choice that some games use to make their games more engaging. It is a design philosophy where the developer emphasizes spatial and diegetic integration as much as possible to increase immersion since the player is not distracted by the superimposed interface [2]. It is, however, difficult to measure a significance between having no HUD and having one in terms of immersion as expressed by Norrman [1], who only found a significant difference between one of the two games tested, which led to the integrated solution as being more immersive. Iacovides et al. [4] found that removing the HUD increased immersion for experienced players inside a First Person Shooter game, suggesting that superimposed elements are helpful for onboarding but hinder immersion for experienced players. Pfister and Ghellal [3] created two versions of the same 2D platforming game where depending on the version, implemented game elements in a superimposed or integrated matter. The two versions were compared using the Immersive Experience Questionnaire (IEQ) [20] and found that the superimposed version was more immersive than the integrated version.

The varying results from different papers put into question what is more immersive or not. We can only speculate, but different papers used different games, game genres, and different implementations. Some tested existing games [1, 4], while some built their own [3].

2.5 Immersion

Much of prior tests [1, 3, 4] has had a focus on immersion and measuring immersion through the IEQ [20]. We think that it was natural for much research to focus on this, as being immersed in playing is generally is a sign of a game being good [20].

Immersion in games is the involvement of a player in a game and is related to the approach-

ability principles through Desurvire and Chen's [10] 17 principles on immersion. Closely related to, or an often included term regarding immersion is Csikszentmihalyi's [21] *flow*, which was used in several of previous papers on diegesis [1–5].

Csikszentmihalyi [21] states that flow is a state of mind described as a total absorption into a game called the optimal experience. It is a state of mind where the player loses track of time and space and fully commits to playing the game. Achieving flow is the process of balancing difficulty with the ability of the player to do a task [21]. In correlation to approachability, Gee [9] describes *Well-ordered Problems, Pleasantly Frustrating, and Cycles of Expertise* (see Section 2.1.1) as techniques games use to become great learning machines. These principles correlate to the increase in difficulty during play which keeps the player playing, just like *flow*. Additionally, a set of principles that Desurvire and Chen [10] established are related to immersion, so we feel it safe to say that immersion plays a part in the overall approachability of a game.

3 Method

To complete our evaluation and answer our research questions, we specified a set of steps for the build-up of the experiment. This section contains the background for the prototype, the implementation, inheritance and relevance of the prototype, the two variants of the same prototype, and our measurement methods.

3.1 Background to Prototype

The origins of the experiment lie in observations over Paradox Interactive's *Hearts of Iron IV*. In particular, the system for visualizing supply and railroads. Supply is a central concept in *Hearts of Iron IV*. Keeping ones WW2 armies up to strength is a central concept of the game, as troops cannot fight effectively in harsh climates without extensive supplies of goods. The supply game mechanic adds depth to the game, as players have to plan their logistics before attempting any military action. Supplies stretch over a weighted node network that can form bottlenecks if there are congestions at any point along the way (see Figure 5a). The starting point is at the player nation's capital city and ends at a "supply province" where the soldiers are stationed. If the link breaks, the game will attempt to find a new route, and if that is not possible, the game gives an alert that the soldiers are under-supplied.

This game mechanic makes capturing "supply provinces" a tactically sound strategy in the game, and yet, from a gameplay standpoint, it is not presented in the best way possible. To view the supply situation, the player has to click on a small button at the bottom-right of the screen (see Figure 5b). When clicked, information situated in a filter gets put on top of the map, which Paradox Interactive officially calls a *map mode*. Map modes are a recurring theme in Paradox Interactive's titles and are used by players for separating information. In the supply map mode, the player can get all information regarding the supply of provinces and how close they are to their supply limit, which is valuable for experienced players.

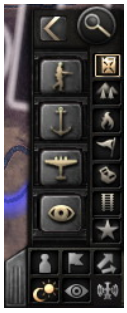
Generally speaking, from our observations playing the game, a player is not expected to spend much time inside the supply map mode. They do other things, like managing their armies, surveying the production of military equipment, and micro manage. Nevertheless, the information the map mode provides is valuable during other parts of playing, as the only other indicator are messages that appear in the view as little icons. We speculated that by visualizing railroads, trains, and trains' congestion, players would be alerted by diegetic means rather than non-diegetic means.

3.2 Prototype Concept

Taking inspiration from our earlier observation in *Hearts of Iron IV* (see Section 3.1), a railroad network formed the basis of our prototype's gameplay. The diegetic goal was visualizing the transfer of goods from one place to another, much like how we would imagine it looking in Paradox Interactive's products. The gameplay centered around managing a portion of a train network, which encompassed balancing the size of the crew, repairing railroads that needed repairs the most, and picking deals that both yielded good profits and were not too far away. The player's goal was to manage the railroad network as well as possible, turning a profit. Pilot testing was, on occasion, used in the development of the prototype. There was no set structure on iterative development, but occasional tests helped alleviate the most common usability issues.

The prototype inherited some functionality from other Paradox Interactive products. The intention of doing so was to make it easier to refer back to the original products. We determined that we could then devote less time to design the gameplay and more to construct

(a) The map mode (overlay) when using looking at supply. The purple arrow signifies the route which supply has to take to reach the target node (supply zone). The green border around supply zones signify that adequate supplies exist, while the yellow zone signifies that the supplies are strained.



(b) Sidebar with map modes. The top right option with the Jerrycan is for supply.

Figure 5: Showcase of navigation and result from selecting the supply map mode in *Hearts of Iron IV* [22]. Screenshots by author.

the prototype. So we created a list of elements that inherited mechanics from their previous grand strategy products:

1. Bird-view perspective as seen in all of the mentioned grand strategy products.
2. Control of time at different steps as seen in all of the mentioned grand strategy products, including pausing (see Figure 7).
3. Game events appearing with dilemmas that the player has to take an active choice in.
4. Money as a resource that can be accumulated indefinitely.
5. The separation of information behind tabs and buttons, like map modes.

3.3 Fundamental Gameplay Elements

This section explains how the prototype functions at large, how to play, winning strategies, and our motivations for our approach towards the prototype. As the prototype replicates grand strategy games, exact calculations were left out from our explanation. It would clutter the paper with things that were not relevant to our research questions.

3.3.1 Tabs

The tabs in the bottom left corner of Figure 6 form the central separation of information while containing much of the gameplay, being the equivalent of map modes. Upon clicking a tab, game elements appear on the screen. Upon clicking another tab, the previous game elements disappear, and new game elements associated with that tab appear. The information displayed is the same between variations, although the method for visualization is different. Regardless of visualization differences, the tabs consist of three buttons that separate information (see Figure 8):

- **Rails** contain all information about the health status of rail-lines and how many maintenance crews the player has available. The player upgrades the number of maintenance crews through this tab.

Figure 6: The initial view from the base variant of the prototype. The time controls are situated on the bottom right; the tabs on the bottom left; the money in the top left.

(a) The time window inside the prototype.

(b) The time window inside *Crusader Kings III*

Figure 7: A comparison of the time panel inside the prototype and its original counterpart. The prototype inherited the time window from Crusader Kings III, keeping much of the same conventions. If the boxes are red, the game time does not pass; if it is green, time is passing. The proportion of buttons filled determines the speed at which the game is running.

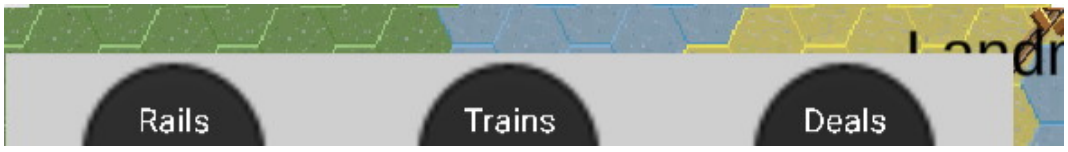


Figure 8: Showcase of the tabs menu. Clicking each button displays new information on the screen.

- **Trains** contain all information about the whereabouts of trains, what they're carrying, how long they have left until arrival, and how many passenger- or cargo trains the player has. The player can upgrade the number of trains of either kind they have here.
- **Deals** contains all information about incoming deals. A deal has a resource type, a target city, a quantity, and an availability duration, which ticks down when time passes.

3.3.2 Money

Money is an accumulated resource and functions as the point system of the prototype. Generating money is done through completing deals, which happens when trains reach their destinations. Players also lose money through daily maintenance costs:

- **Trains** cost a fixed amount to maintain and scale linearly as the player buys more trains.
- **Maintenance crews** cost a fixed amount to maintain and scale linearly as the player buys more crews.
- **Rail health** impacts maintenance costs and train speeds proportionally based on how much health the rail has lost but only occurs if a train is present on that rail.

3.3.3 Time

The game starts in a paused state (see Figure 7a) with nothing open. We decided this to be the best design decision as per Gee's [9] *Sandboxes* (see Section 2.1.1), which meant that the player could explore the game without needing to pause first. Early pilot testing showed that the ability to unpause was not a given; as such, notifications appeared when the user was in the paused state for more than five seconds (see Figure 6).

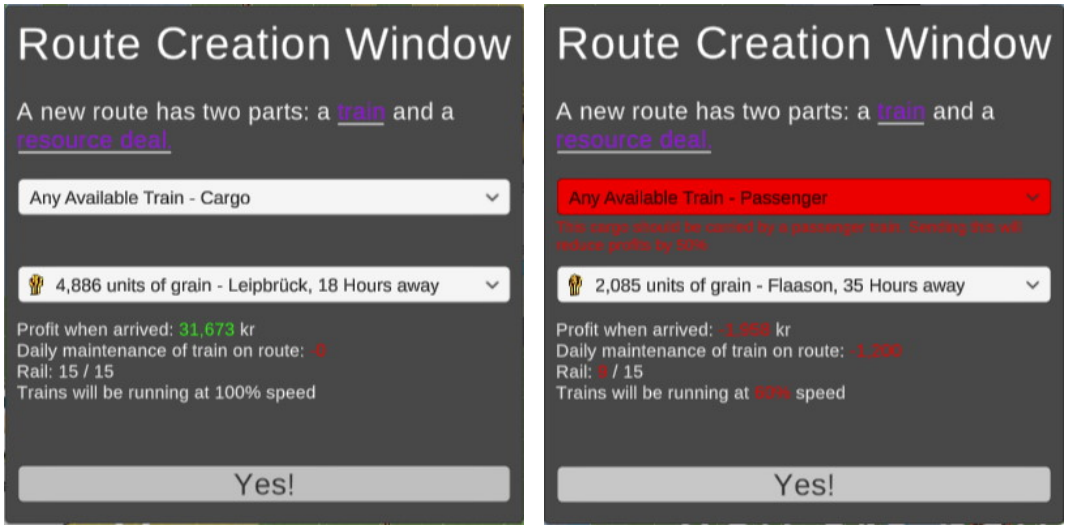
3.3.4 Events

Events are boxes that appear when time passes in the game. The events contain some text about what has happened and offer a couple of alternatives to resolve the situation. Events are either good or bad, and the alternatives give different outcomes depending on the specific event. For example, an event can make the player either lose money or make a rail take damage, but the choice is up to the player.

3.3.5 How to play

Accepting of deals occurs inside a window called the route creation window, which appears when the specific deal has been clicked (see Figure 9). When clicked, the window automatically filled in the correct information, but the player could choose to switch around the preferred train and target deals if they liked. When accepted, a train would start to move towards the proposed deal, given that the game is unpaused. The money then gets transferred to the player when the train arrives at its target.

As the game progresses, the player discovers and upgrades their capacity of maintenance crews and trains to complete more deals at once. The player can upgrade everything immediately or upgrade slowly, but there is no way to remove excess trains or maintenance crews, advising precaution to players. To summarize, the core game loop the player goes through



(a) A favorable deal as noted by the profit and the lack of issues regarding rail health, train speed, and maintenance costs.

(b) An unfavorable deal as noted by the wrong train type, the lack of profit, the poor rail health, and the slow train speed.

Figure 9: The layout of the route creation window. A train gets sent when clicking the "Yes!". The drop-down menus change the target destination and train type.

is to jump between tabs and try to keep as many trains as possible on the road at the same time while keeping rails healthy and the number of profitable deals left out to a minimum.

3.4 Variants of the Prototype

Before the divergence of our two variants, the initial prototype had traits that fitted one variant or the other. The process of creating the variants involved removing, adding or changing game elements to better conform to Fagerholt and Lorentzon's [5] model and Galloway's [7] Operator and Machine acts. This section will explain how each variant conformed to opposing ends of both theories, ending with a comparison of every single game element that was changed.

3.4.1 Variant A - Functionality Above Realism

The first variant (referred to as A for short) attempted to make most of the gameplay occur within non-diegetic panels superimposed on the screen. This meant that most game elements would be treated as **non-diegetic** as per Fagerholt and Lorentzon's [5] model, being neither part of the narrative nor the navigable environment. In terms of Galloway's [7] Operator and Machine acts, most acts pertain to non-diegesis.

There is prior research that supports that the A variant should be superior. Pfister and Ghellal [3] concluded in their comparison of integrated and superimposed elements that their superimposed variant performed better when measuring immersion through the IEQ [20]. Furthermore, Llanos and Jørgensen [2] stated that players accept whatever game elements are in use as long as it can provide them with relevant information at the time. It is, however, pertinent to mention that the A variant is an extreme case. The superimposed elements do not play a supporting role as they would do in other games; instead, superimposed elements form the majority of gameplay and are essential to play. To put it into comparison, playing a First Person Shooter is generally satisfactory without the HUD present, as the player can still perform actions to play the game properly. Playing without the environment is not;

the player needs to see where they are going and looking. The grand strategy genre does not function this way; looking back at Figure 2 as an example, the number of superimposed gameplay features that would disappear would hamper the ability to play.

What stands out with variant A is the ability to ignore the environment completely; the only necessary information is the layout of cities and their connections to each other, which can be represented as a list of city connections or as a still image of the node network. With that said, the line between environment and panel becomes blurry if the map is treated as a still image, as it raises a question: What is the difference between a panel and the environment if no integrated interactable elements exist with the player not able to navigate the environment? As per Galloway's [7] theory, it would mean having a game without diegetic operator acts happening in the environment, or as stated by Galloway [7]: "god games" force the operator to hover the game, being one step from its diegesis already. So, for our decision with variant A, while the prototype's environment did not need diegetic operator acts to function, we felt that zooming was needed if the city labels were too small to be read on some screens. Hence, we kept zooming and camera navigation for our test. In trying to determine a definition, The ability to zoom makes the A variant's environment have diegetic operator acts but only ones that are move acts. The rest of the interface still uses expressive acts as clicking is used.

3.4.2 Variant B - Diegetic & Integrated

The second variant (referred to as B for short) focuses on integrating game elements as spatial or diegetic. According to Llanos and Jørgensen [2], diegetic solutions are seen as more elegant than non-diegetic solutions, although the effect of spatial integration is unknown.

We argued in our observation of *Hearts of Iron IV* that the environment could supplement much of the information that would otherwise need explaining through panels or text. We found some game elements challenging to translate diegetically during the development of variant B, but previous papers allude to this issue. Juul [6] stated that games with coherent worlds are games where nothing stops the player from filling the gaps themselves. Fagerholt and Lorentzon [5] stated that incoherent game worlds force the player to reason from the perspective of the rules set upon them instead of the environment. Finally, Jørgensen [19] filled in the blanks, stating that breaking consistency is more severe than breaking coherence:

> "If the game world does not provide necessary information for the players to act reasonably, they may be frustrated, but if the game world is incoherent, the player may, if necessary, fill out the blanks themselves [19]."

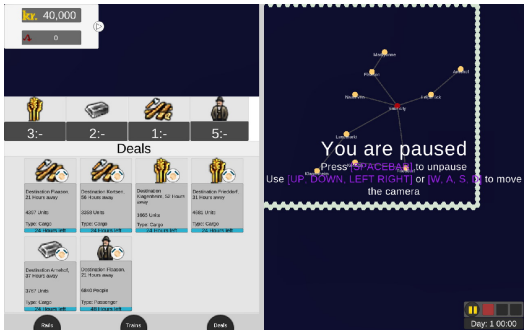
When transforming a game element from a non-diegetic to a diegetic role, thinking of the coherence, non-diegetic elements still serve the player exclusively [5]. So, the nature of the game element has to change from something only the player needs to something the player character also needs. For this reason, we believe that during the development of our prototype, it was tough imagining ways of visualizing elements that had been a non-diegetic element as a diegetic element since we could not imagine how it would look coherently. As an example, the player had to accept deals, which were handled through a non-diegetic element (see Figure 11a). Making deals as diegetic elements was hard because deals had no initial diegetic framework. In our initial prototype, deals were handled as simple button clicks that abstractly accepted and started the deal. Making deals diegetic needed a more convincingly diegetic player character, as they would need to likely receive the deals through a desk environment or something similar.

Such an approach nullifies what makes grand strategy games special, as the player character's perspective usually is not as a diegetic character but as a semi-omniscient spirit that holds sway in the game world. We think it is helpful to look at grand strategy games like board

games to establish where the perspective is coming from, but they are still not actual board games. No hand moves things around, no dice is rolled, and no external environment outside of the game exists.

If we made game elements between variants too different, we were concerned that the prototypes would become too different. As stated, turning some non-diegetic elements into diegetic elements would require re-evaluating the player character's role in the world. So, we opted to transform non-diegetic elements into spatial elements, which had no impact on the narrative of the prototype. We chose only to include signifiers and diegetic elements when these actions were not needed to be induced by the operator diegetically, but the machine as per Galloway's [7] operator and machine acts.

3.4.3 Comparison of Variants



(a) The start screen of variant A. The tabs can not be closed in this variant, making the deals tab open when the starting the game. Half of the screen is reserved for panel elements and the environment detail inside the world is removed.

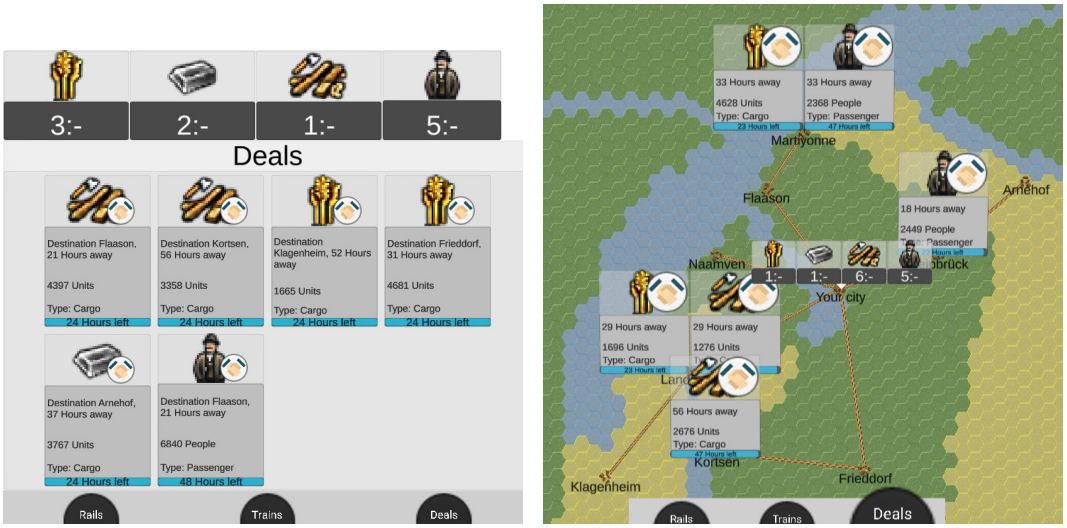
(b) Start screen of variant B. The environment has some cosmetic detail in the terrain. Also, no tab is present by default in this prototype.

Figure 10: Screenshots of both prototypes upon starting each variant.

Our goal was to make the variants as comparable as possible so that the only difference between variants would be the diegetic and spatial differences. As such, some design decisions were made in order to keep the variants comparable:

- **The tab system** was kept the same since it allowed a mostly equal distribution of information between variants. We did not want the players to be exposed to more information at a time in either variant, and neither did we want irrelevant information to be shown at the wrong time. This was to conform with Gee's [9] *Information 'On Demand' and 'Just in Time'* (see Figure 10). An exception was made for diegetic elements, as physically removing these at any point would look odd and not make coherent sense.
- **The number of clicks** to do any action was kept the same, as it could otherwise be a factor for how cumbersome an action is (see Figure 10).
- **The availability of information** was a key point in the development of the variants. Both variants tried to convey the same information, although the visual implementation differed. This is a key problem with diegetic integration in games since non-diegetic text can often be more descriptive than its diegetic counterpart [2, 5].

Some elements were kept the same between variants as independent variables. These elements were too difficult to implement as diegetic elements and not suitable as spatial elements because they were deemed always to be needed by the player:



(a) The Layout of the deal tab inside variant A. Deals were structured in a grid pattern with prices on the top of the window. The panel included information about the target city, length of the journey, size of deal, type of train needed, and how much time there was left until another replaced the deal. These were non-diegetic elements since they were superimposed to the screen and separate from the environment [5].

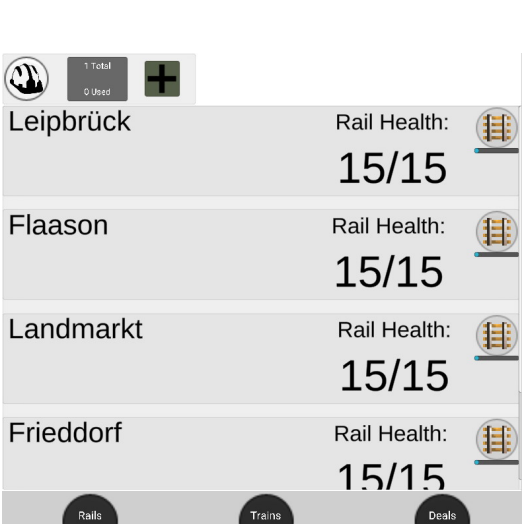
(b) The layout of the deal tab inside variant B. Deals were integrated into the world, with the panel elements located above their target cities, including information about the length of the journey, size of deal, type of train, and how much time there was left until another replaced the deal. These were spatial elements since they were not superimposed to the screen, but were still panel elements separate from the environment [5].

Figure 11: The variational differences of the deals tab.

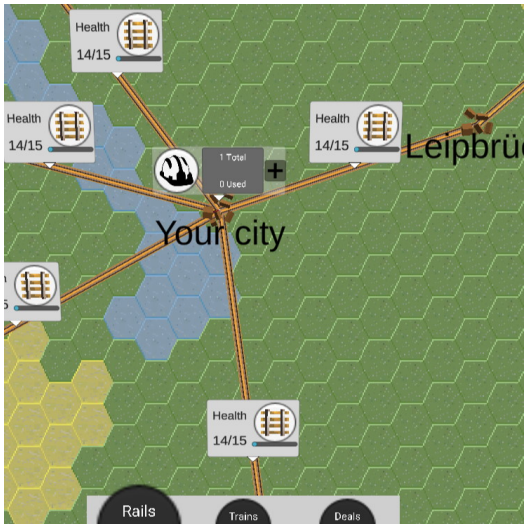
- The time system (see Figure 10) was kept the same as it was an action that the player could undertake at any time, much like how it worked in *Crusader Kings III*.
- The money window was kept the same (although a bit different due to limited space, see Figure 10)
- The "'You are paused" panel that appears was kept because it was essential to communicate basic controls to start playing the game (see Figure 10).

Deals looked like cards in both versions. The contents and spatial belonging of the cards varied depending on prototype (see Figure 11). Variant B could disregard writing out the target city because the cards were situated on top of the target city (see Figure 11b). In contrast, variant A had to descriptively write out the target city to keep the same availability of information (see Figure 11a).

Rails looked like cards in both version (see Figure 12), with the content and spatial position changing depending on variant. Much like how the deal tab functioned, information inside the panels in variant B could be disregarded because the panels were placed above their appropriate rail (see Figure 12b). Variant A had to specify the city location as well as other necessary information instead (see Figure 12a).

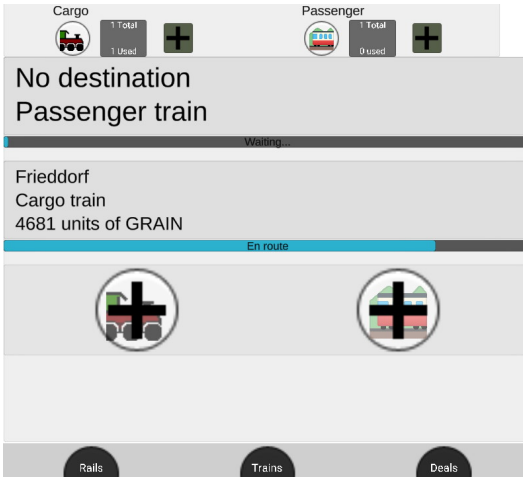


(a) The rail tab window inside variant A. Rails were structured as a list containing target city, rail health, and a button that repaired the selected rail. The maintenance crew panel was situated in the top left of the window. These were non-diegetic elements since they were superimposed to the screen and separate from the environment [5].

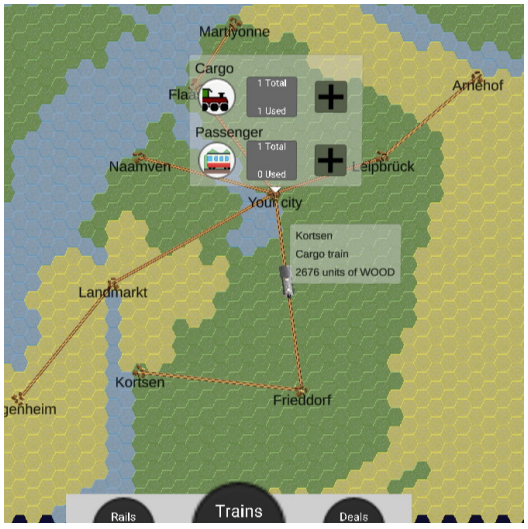


(b) The rail tab overlay inside variant B. The panels were situated on top of their appropriate rail and contained health information, including a button that repaired the selected rail. The maintenance crew panel was situated on the player's city. These were spatial elements since they were not superimposed to the screen, but were still panel elements separate from the environment [5].

Figure 12: The variational differences of the rail tab.



(a) The train tab panel inside variant A. Trains were visualized as list elements and contained information about the type of train it was, how many and what kind of goods it was carrying, and its target city.



(b) The train tab overlay inside variant B. Trains were visualized as a moving image that traversed to the correct city across a rail network. Trains were diegetic elements and were present at all times, but they became physically bigger inside the train tab to distinguish them from the environment. The tab also included a spatial element above each train that outlined the type of train it was, how many and what kind of goods it is carrying, and its target city.

Figure 13: The variational differences of the train tab.

Table 1: The differences between variants and their correlations to both Fagerholt and Lorentzon's [5] and Galloway's [7] papers.

Game element change	**A**	**Theory for A**	**B**	**Theory for B**
Rails in rails tab	Superimposed list items	Non-diegetic elements, requires non-diegetic operator acts	Integrated on top of rails	Spatial elements, requires non-diegetic operator acts
Trains in train tab	Superimposed list items	Non-diegetic elements, changes text with non-diegetic machine acts	Present only if train is in use	Diegetic train objects, spatial panels above trains, moves with diegetic machine acts
Deals in deals tab	Superimposed grid items	Non-diegetic elements, requires non-diegetic operator acts	Integrated on top of correct city	Spatial elements, requires non-diegetic operator acts
Rail repair state	Superimposed progress bars	Non-diegetic elements, requires non-diegetic machine acts	Integrated progress bar & swinging hammer	Spatial elements & signifiers, requires non-diegetic and diegetic machine acts
Rail health	Superimposed text items inside list	Non-diegetic elements, changes text with non-diegetic machine acts	Integrated text items & color change on physical rail	Spatial elements & signifiers, requires diegetic machine acts for color change
Train progress	Superimposed progress bars	Non-diegetic elements, requires non-diegetic machine acts	Integrated train objects	Diegetic elements, requires diegetic machine acts
Physical Terrain	Removed	-	Physical terrain without impact on gameplay	Diegetic elements, static
Physical Rail	Grey Line	Diegetic elements, static	Rail-like lines	Diegetic elements, static
Physical Cities	Cylinders	Diegetic elements, static	City-looking models	Diegetic elements, static

3.5 Questionnaires

There were two questionnaires used during the experiment. The first questionnaire was concluded before the player started playing with one of the variants and consisted of demographic questions and were written in English, although the questions were translated into Swedish as we asked these questions verbally:

1. How old are you?
2. Do you play video games?
   - A1 Yes
   - A2 No
   - A3 Yes, but infrequently
   - A4 No, but I used to
3. Do you play strategy games?
   - A1 Yes
   - A2 No
   - A3 Yes, but infrequently
   - A4 No, but I used to
4. do you use a mouse or a mouse pad?
5. What is the operating system on your computer?

The second questionnaire was given to the player after playing and was supposed to answer approachability questions. The questions consisted of rephrasings of Gee's [9] principles, Desurvire and Chen's [10] PLAY heuristics, and Desurvire and Wiberg's [8] GAP heuristics. aAs Blomqvist [11] applied a similar technique of creating a questionnaire based on these same principles and heuristics, we used some of their questions as well. We also added some additional questions on our own that had to do with the player's perspective, their perceived feeling of completion, and one question targeting Csikszentmihalyi's [21] flow.

The questionnaire consisted of quantitative and qualitative questions. The quantitative questions' answer format were *Likert scales* [23] with five options. There were 30 quantitative questions as part of the survey. All questions were phrased as statements that the player had to agree or not agree with, similarly to what Desurvire and Chen [10] and Blomqvist [11] had done. Five open-ended qualitative questions followed, with the subjects in question being the perspective and the players feeling of completion (see Appendix A).

3.6 Experiment Process

Testing of the variants started with an interest survey that was sent out through social media. Respondents were asked if they were interested in participating in an experiment sometime during a week. The respondents were informed that additional information would come one week before the experiment commenced. The survey outlined the approximate time it would take for the respondent to complete the experiment and what it was about in rough terms. The respondent got to know that they were supposed to play a game for 20-25 minutes (later reduced to 15 minutes), that participation was voluntary, and consent could be withdrawn at any time and for any reason, including during the experiment. Additionally, due to the Covid-19 pandemic, respondents were reassured that the experiment would occur in an online environment through a video call.

As stated in the interest survey, the respondents received a message containing additional information about the experiment. The message was a question if they were still interested in participating, and if so, allowed them to book a time at a scheduling application. These time slots were all 45 minutes long and were made to match the respondents' schedules to ours.

The same morning the respondents were to participate, a web link was sent with an invitation to a video call and a notification about the respondent's time to participate. Upon meeting the respondent (now referred to as the player), a short questionnaire about the demographic information was asked. A consent form was then sent, which outlined the player's rights to exempt themselves from the experiment. The consent form also included a short introduction to the goal of the prototype (see Appendix A). Upon completing both, a link was sent to the player containing either variant A or B. Every even player number received the A variant; odd numbers received B. The player was then asked to click the link, share their screen, and play the prototype. Before starting, the player was asked if they wanted to re-hear the instructions one more time (see Appendix A). Otherwise, they were allowed to click a "start" button and begin the experiment.

Upon finishing the experiment, the player was instructed to hit "9" on their keyboard. The key displayed a hidden window where an automated background program printed a file containing data about the player's performance. The player was instructed to copy the text and send it to us through whatever means they thought fit. Then, without talking about the experiment, the player answered the second questionnaire. Upon completing the second questionnaire, some verbal questions were asked as part of the observational study, where some discussion was held between participant and conductor, including a showcase of the other variant and some of their thoughts regarding it.

3.7 Data

Three types of data were gathered from the experiment: objective quantitative, subjective quantitative, and subjective qualitative data. Three data gathering methods were used to collect this data:

1. An automated program which ran in the background.
2. A questionnaire with a section for Likert scale [23] questions and a section for open-ended questions.
3. An observational study.

The goal of our gathering methods was to cover as much of play as measurable.

3.7.1 Objective data

As part of the construction of the variants, an analysis of both was made to incorporate analytics during play. Much of the quantitative information was timestamped to measure how play changes as time went on, but some were based on the total time, while some kept track of the number of times something occurred. Objective data was divided into performance and priority categories to reflect how some data had an explicit correlation on the scoring system (money) while others did not. This meant that performance data was exclusively about the monetary values correlated with other data, while priority data reflected other differences between variants. In total, we identified three performance measurements and 15 priority measurements across four categories:

- Score

1. Monetary performance over real-world time
2. Monetary, day-normalized performance over real-world time
3. Score at end of experiment

- Time spent inside tabs

1. Deals tab
2. Rails tab
3. Trains tab
4. Untabbed (variant B only)

- Time spent inside speed states

5. Paused
6. Slowest speed
7. Middle speed
8. Fastest speed

- Miscellaneous

9. Number of days reached
10. Number of completed deals
11. Number of rails fixed
12. Number of clicks on the trains tab button
13. Number of clicks on the rails tab button
14. Number of clicks on the deals tab button
15. Number of events shown

The sole purpose of the automated program was to record quantitative objective data, so we chose to delegate much of the objective quantitative data to our automated program as possible so that the observational study could focus on gathering subjective qualitative data.

The objective data was our strongest potential indicator in finding differences between versions as it was not built on subjective opinions on either the player or analyzer. We deemed finding significance within this data as the most credible to our paper; however, as the data was not based on the approachability principles and heuristics [8–10], any correlation to approachability was harder to do.

3.7.2 Subjective data

The subjective data was made to measure the player's confidence and the prototype's approachability. The results from the questionnaires were the player's subjective data and contained both quantitative and qualitative data (see Appendix A), while data from the observational study was qualitative data.

3.8 Analysis method

As there were three sets of data, we employed different methods of analyzing data. In particular, student's t-Tests for our continuous, quantitative data. For our subjective quantitative data, Frost [24] suggested that parametric tests like t-Tests give nearly equal false-positive rates for *Likert scales* [23] compared to the non-parametric *Mann-Whitney U test*. However,

this only applied if the sample size was large enough; as such, we thought our sample size was too small to accommodate this requirement. Since *Likert scales* subjective, discrete, ordinal, and limited range also violates assumptions needed in t-Tests [24], we chose to evaluate subjective data through the magnitude of difference, means, and standard deviation of groups.

4 Results

In total, we gathered 15 people to participate in the experiment, with 14 out of the 15 players eligible for analysis. Looking at the demographics for the sample, all had prior experience in playing games apart from one. The outlying participant had no prior experience playing games and did not perform as well nor followed a similar trend that other players did, so the sample was homogenized to people who had previous gaming experience. The excluded player belonged to the test group that was larger than the other, which finalized our sample size to an even seven for each group.

Three from each group responded that they had prior experience playing strategy games, with each player choosing what they thought a strategy game was. Three players from the group playing variant B used a laptop touchpad, while only one player who used a touchpad played variant A. Four players had *Mac OS* installed on their computers, all of which played variant B. The mean age for people playing variant A was 32.3 years old, while the mean age for people playing variant B was 26.4 years old.

4.1 Objective results

The objective results consist of performance and priority measurements. The difference between the two was the focus on money or direct correlation to money. This was done because we explicitly stated that the goal for the player was to make as much money as possible (see Appendix A). Most measurements were, in varied ways, dependent on luck. Therefore, money became a convenient way of measuring the collective performance of a player.

4.1.1 Performance

Every time money changed, the automated program noted the real-world time and amount of money. Combining all results produced a graph with accumulated money over real-world time (see Figure 14a). The trendlines followed each other closely, although the coefficient of determination, also known as R^2, for both groups was low, with performance outliers existing for both groups.

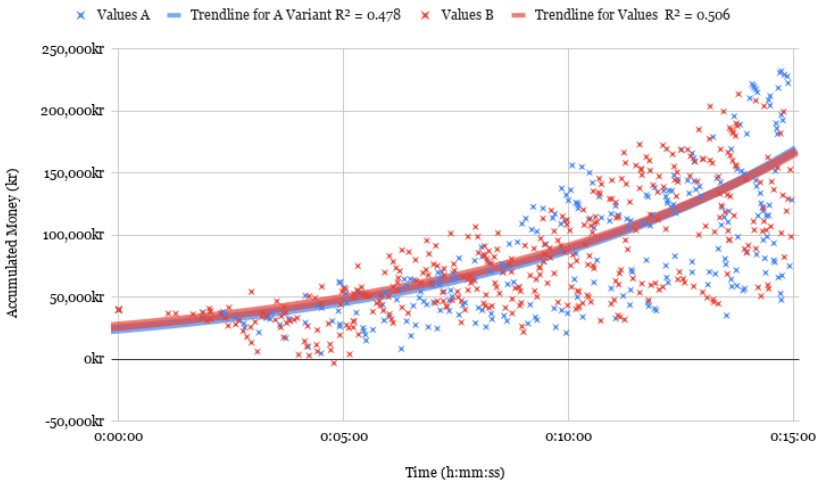
As players could increase the game-time speed during play, a normalized graph formed the average performance independently of how many days had passed (see Figure 14b). Players who sped up while playing exhibited more robust growth than their counterparts, with the trendlines not following each other as closely, yielding an even lower R^2 value.

Using a Student's t-test, the last amount of money recorded before the test concluded was used to measure significance between groups. Assuming the data is compatible with a two-sample t-test with equal variance, we formed our hypothesis:

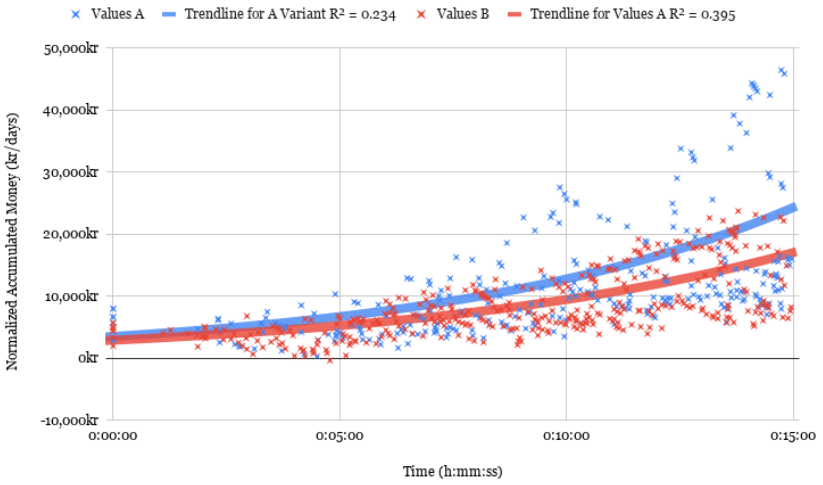
H_0 : *There is no difference in money when measured at the end of the experiment*

H_1 : *There is a difference in money when measured at the end of the experiment*

The test resulted in $0.92 > p$, assuming $p = 0.1$, meaning we could not reject the null hypothesis. There is statistically no difference between groups in this regard, which means that a difference in performance could not be determined.



(a) Monetary performance over real-world time for variant A and B, with exponential trendlines yielding the highest R^2 value. Some players performed better than others and there was no distinguishable difference when compared between groups.



(b) Monetary, day-normalized performance over real-world time for variant A and B, with exponential trendlines yielding the highest R^2 value. Outliers playing variant A contributed to its low R^2 value, but outliers in variant B were more consistent with the rest of the data.

Figure 14: Monetary performance measurements for variant A and B

4.1.2 Priority

Our priority numbers consist of several factors. As the name suggests, it is based on the player's priority or strategy, which means that it is not directly dependant on how well the player's playing but how the nature of play changes. Much like with performance, the data can be analyzed using a t-test, with some caveats for outliers (see Table 4). Once again, we are making the assumption that the data is compatible with a two-sample, two-tailed t-test with equal variance. This yielded results across our three categories: Time for tabs, Time for speed states, and miscellaneous data.

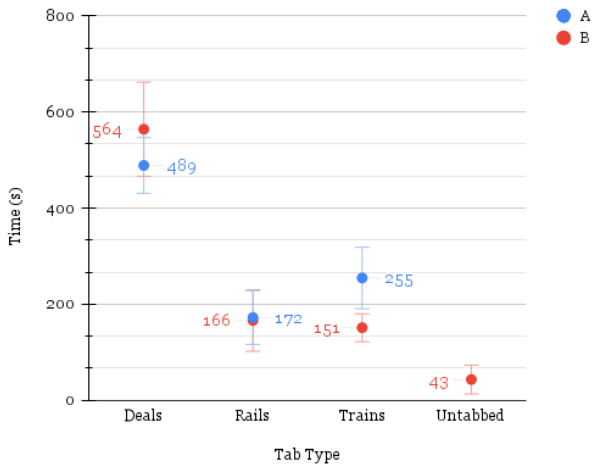


Figure 15: The mean amount of time spent inside tabs, including standard deviation of the mean. The group playing variant A spent more time inside the trains tab and less time in the deals tab. On average, the group playing variant B spent playing the game for 15.4 minutes, as noted by the total, while the group playing variant A only spent 15.2 minutes playing.

Table 2: T-test and standard deviation results of the time spent inside tabs. The t-test is a two-sample, two-tailed t-test assuming equal variance. There is a significant difference between the time spent inside the trains tab between variants.

Measurement	**Deals tab**	**Rails tab**	**Trains tab**	**Untabbed**
T-test	0.1064	0.8527	0.0023	-
St dev for A	59	56	65	-
St dev for B	98	64	29	30
Significance level	None	None	Significant at **99%**	-

The results from our evaluation of time spent inside different tabs show that the group which played variant A spent more time inside the train tab and less time inside of the deal tab (see Figure 15), the difference in time spent inside the train tab was deemed significant with 99% confidence although no significance was found for the deal tab (see Table 2).

Our analysis of the speed states shows that the group playing variant A spent more time in the paused state and less time in the slowest speed, with larger variances between people playing variant A rather than B, although the middle speed and the fastest speed remained similar between variants (see Figure 16). The difference between groups in both times spent paused and time spent in the slowest speed is deemed significant with 95% confidence (see Table 3).

The miscellaneous tests show that there was no significance between variants in any of the

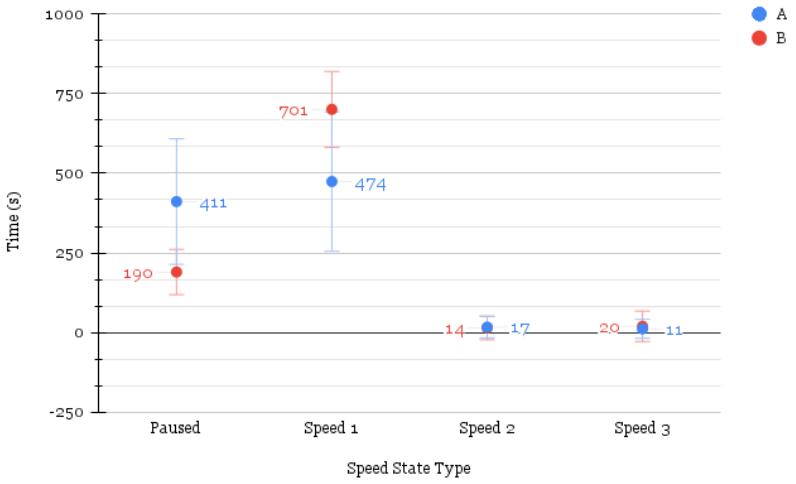


Figure 16: Mean amount of time spent inside speed states, including standard deviation of the mean. The group playing variant A spent more time paused and less time in the slowest speed but also displayed more variability.

Table 3: T-test and standard deviation results of the time spent inside different speed states. The t-test is a two-sample, two-tailed t-test assuming equal variance. There is a significant difference between time spent paused and the lowest speed between variants.

Measurement	**Paused**	**Slowest speed**	**Middle speed**	**Fastest Speed**
T-test	0.0164	0.0335	0.8894	0.7130
St dev for A	198	219	34	30
St dev for B	72	120	38	49
Significance level	Significant at **95%**	Significant at **95%**	None	None

Table 4: T-test and standard deviation results of the miscellaneous measurements. The t-test is a two-sample, two-tailed t-test assuming equal variance. There is no significant difference in any of the measurements.
The group playing variant A had a test person that significantly completed more deals than the others, excluding that participant brings the significance level to **99% with the mean value of completed deals higher with variant B.*

Measurement	**T-test**	**St dev for A**	**St dev for B**	**Significance level**
Day reached	0.1561	3.1	4.5	None
Deals completed	0.4109	11.5	3.3	None*
Rails fixed	0.6783	2.6	3.6	None
Trains tab clicks	0.7835	7.4	7.8	None
Deals tab clicks	0.6652	6.6	10.0	None
Rails tab clicks	0.3970	4.5	4.0	None
Events seen	0.3021	2.1	2.8	None

measurements, although removing an outlier did give significance in deals completed with 99% confidence (see Table 4). Importantly, it shows that some fields of play did not change between variants.

4.2 Subjective results

Unlike the objective data, subjective data was both quantitative and qualitative, but the qualitative data is additionally either from the player or the analyzer's perspective. Data that is from the analyzers perspective is called observational data.

4.2.1 Quantitative

Quantitative answers were subdivided into general answers and questions that asked the player for their opinion when they began and finished playing. The results were compiled into a list where differences in mean and distribution were compared (see Table 5 and Table 6).

There were larger differences between groups for certain questions. The group playing variant A felt that the goal of the game was clearer and was more within their reach of abilities. They also thought that variant A felt more playable without a guide, felt like they performed better while playing, and felt less stuck or interrupted in the game. This group also felt that the game provided, on average, information better at the right time and felt more like they could come up with a good strategy, although the group also felt on average more bored by the game at the end of the playtime when compared to the group playing variant B.

The last six questions were thematically *before and after* questions. Unlike what the name suggests, these questions were all part of the post-playing questionnaire but were split into two perspectives: One for how the player felt at the beginning and one for how they felt at the end. These questions were visualized in three graphs to view the growth or decline over time (see Figure 17). The group playing variant B responded on average less favorably for all six questions, although some of the gaps became smaller between the start and finish.

(a) Results of the statement: "I felt like I understood how to play the game". The difference between groups was 0.71 points initially and 0.41 at the end of the experiment.

(b) Results of the statement: "I felt like I had control in the game". The difference between groups was 0.86 points initially and 0.57 at the end of the experiment.

(c) Results of the statement: "I felt overwhelmed by the game". The difference between groups was 0.29 points initially and remained unchanged at the end of the experiment.

Figure 17: The mean answers of three quantitative questions categorized by asking how the player felt when they began and finished playing.

Table 5: The first 14 questions of the post-playing questionnaire with a comparison of answers between groups including standard deviation, mean, and difference of mean between groups. Emboldened results indicate points of interest in either group being similar or different from one another.

Question	**Mean for A**	**St dev for A**	**Mean for B**	**St dev for B**	**Difference**
I would play this game again if it was available to me.	3.1	0.90	2.9	1.07	0.3
I would play this game over an extended period of time.	2.7	1.11	2.6	0.79	0.1
The game was challenging me without frustrating or boring me.	3.9	0.69	3.4	1.13	0.4
The game's difficulty made me try different strategies.	2.7	1.11	3.3	1.25	0.6
I felt like once I had a tactic set up, new things came up that made me have to change my approach.	2.9	1.46	3.0	1.63	0.1
The goal of the game was clear to me.	4.4	0.79	3.7	1.25	**0.7**
The goal of the game was within my reach of abilities	4.6	0.79	3.6	1.40	**1.0**
The game supported a variety of play styles.	2.7	0.95	3.1	0.38	0.4
The game felt playable without reading a manual or following a guide.	4.4	0.53	3.1	0.69	**1.3**
The way you controlled the game felt intuitive and natural.	3.6	0.79	3.1	0.69	0.4
The interface felt intuitive and visually pleasing.	2.4	0.53	2.9	0.69	0.4
I rarely felt stuck or interrupted in the game.	4.6	0.79	3.7	0.49	**0.9**
I felt like all the tools in the game were useful to complete my task(s).	4.3	0.76	4.1	1.07	0.1
I feel like I performed well while playing	4.0	1.00	2.9	0.90	**1.1**

Table 6: The last ten questions of the post-playing questionnaire with a Comparison of answers between groups, including standard deviation, mean and difference of mean between groups. Emboldened results indicate points of interest in either group being similar or different from one another.

Question	**Mean for A**	**St dev for A**	**Mean for B**	**St dev for B**	**Difference**
I found it easy to understand how to play the game.	3.9	0.90	3.4	0.79	0.4
I felt like the game showed me what in the game world was changing when I did things.	3.4	1.27	3.1	0.69	0.3
I felt like the game provided the information I needed at the right time.	3.6	1.13	2.7	0.76	**0.9**
It felt like I could teach myself how to play the game without severe repercussions by the game.	4.1	0.69	4.1	0.69	0.0
I think this game made sense.	4.0	0.58	4.0	0.82	0.0
I felt like the game became more difficult as time went on.	2.3	1.25	2.7	1.25	0.4
I was feeling bored by the game when I began playing	2.0	1.00	1.7	1.11	0.3
I was feeling bored by the game by the end of the time limit.	2.7	1.25	2.0	1.15	**0.7**
I felt like this game became more fun as time went on.	3.6	0.53	3.3	1.11	0.3
I feel like I came up with a good strategy by the end of the play time.	3.9	1.21	3.0	1.53	**0.9**

4.2.2 Qualitative

Finally, five questions were open-ended and let the players themselves say things about the experiment. In order to not influence these decisions, a complete collection of the answers in its original form can be found in item A, but a compilation of results were necessary for consensus as well:

- How would you describe your role in the game world?
  - Generally as a train conductor or train company owner. Answers did not change between groups.
- How much of the game do you feel like you know at this point?
  - Generally varies between person, but a general estimation seems to be that people know most things but have a few things that they do not understand at all, namely some concerns about cohesion and consistency of the game world.
- Do you feel like there is things in the game that you still don't understand?
  - Several problems with cohesion and consistence appeared while playing that is both written by players and observed (see Section 5.1).
- Do you have any comments about the experiment?
  - Responses were generally positive towards the experiment and thought it was fun.
- Did you feel like time passed noticeably quicker when playing? Like you lost your grasp on the passage of time?
  - Many players state that they perceived time to go quicker while playing.

4.2.3 Observations

The last section includes the observations seen during play. These results are things that were not captured by other gathering methods. This section is kept general to keep it palatable, which means we follow trends and not isolated cases.

It was desired by players to find trains while playing variant A. It seems that the exclusion of physical trains in the terrain gave many comments about their whereabouts. While playing variant A, the players' initial reactions were often to interact within the environment, click on cities, and see how the camera worked. Interacting through non-diegetic elements was generally less desirable and was done after scouring the environment first. The same result did not apply to our signifiers, as many players did not notice the color change of rails, nor was it universally accepted what the "swinging hammers" did. The swinging hammers were an indicator that a rail was in the process of repairing, but it was occasionally interpreted as an indicator that something needed to be repaired.

The importance of zooming inside variant B was more important than in variant A. It seems that players avoided zooming at all costs, keeping the camera as far out and as centered as possible. People playing with touchpads struggled to zoom because touchpads were more sensitive and made zooming harder. This impacted the people playing variant B more, as they had three participants who played with a touchpad, and variant A's gameplay did not require zooming for navigation. More deals could be viewed at once depending on how far out the camera was zoomed, but zooming too far out introduces overlap between spatial elements, which variant B had plenty of.

Spatial elements, in general, did not seem to contribute much to variant B. Frequent overlaps of panel elements made it so that the players had to zoom in to separate the panels. However,

players preferred to be zoomed out when playing. The spatially integrated panels allowed for some geographical data like target cities or rails to be removed, but it is uncertain how this affected the players' opinion.

Most players did not try to interact with the time window whatsoever. A reminder appeared which told the players how to unpause but not how to change speed. This created outliers in some of the data as they could progress through the game at a quicker pace than their counterparts. After completing the experiment, if the player had not interacted with the panel, they were asked what they thought of it. Generally, players either acknowledged it but did not find it interesting enough to interact with or missed it. There was no observed bias between groups either.

Lastly, a few players exclaimed that they were surprised how fast time went by while playing. Of course, the players were later prompted to say whether or not they thought playing the game made time feel faster, but this refers to the unprompted behavior and serves as additional evidence that the players felt like time progressed quicker than they expected. We could not determine any bias between groups.

5 Discussion

As part of our evaluation, we measured objective data in terms of performance and priority; our subjective data as quantitative questions based on approachability heuristics and principles Desurvire and Wiberg [8], Gee [9], and Desurvire and Chen [10]; and finally, our observational data based on our observations. The results indicate measurable differences between variants, both during gameplay and in the post-playing questionnaire. The group which played variant A perceived it easier to play their variant than their counterparts but also felt more bored by the end. We think that this combination is a sign that variant A was easier to play and master rather than variant B. Surprisingly enough, it did not change the measured performance, which came out inconclusive. However, there was a difference in the amount of time spent in tabs, with people playing variant A spending significantly more time in the train tab than their counterparts. We think this difference came down to the implementation of both variants and our emphasis on keeping the variants comparable.

With trains as diegetic elements, their physical movement allowed the players to know when the trains arrived at their destination regardless of what tab they were inside. Inside variant A, on the other hand, the player had to look inside the train tab to know when the trains had arrived since this information belonged in the tab. We think this difference comes down to the approach that was needed to implement variants A and B. Having trains as diegetic elements allowed more information without needing to implement more gameplay features. Of course, the system to make the trains move inside the environment in variant B was more complicated than in variant A, but supplementing the information that variant B gave required implementing an alert system that could tell the player whenever trains had arrived in variant A. Implementing an alert system for only one of the variants would have hampered the comparability between them. So, our experiment did not offer the same information at the same tabs between variants, but it was due to physical diegetic trains making including that information easier. Worth noting is that this limitation inside variant A did not change the performance according to our measurements. Neither did it make variant A score lower than variant B inside our post-playing questionnaire. We consider this an apparent flaw with variant A as it violates Desurvire and Wiberg's [8] GAP principle: Reinforcement, and Gee's [9] principle: Information 'On Time' and 'On Demand'. Variant A failed to provide good feedback for when trains arrived, and the information was not available when trains were sent, which was the most opportune time to know the status of the trains. It also puts an unnecessary burden on the player, violating Blomqvist's [11] Keep it simple.

Differences in the rail health and rail repair signifiers did not produce a significant result, unlike the integration of physical trains, as there was no difference in time spent inside the rail tab between groups. The signifiers' meaning was ambiguous, with players misunderstanding the purpose or missing the signifiers altogether. Fagerholt and Lorentzon [5] brought up the example of flaming barrels in video games, which have a single purpose: to explode. The signifier has, in that case, a single purpose, with the barrel itself having multiple warning labels to express the danger. We hypothesize that our signifiers, by comparison, were misinterpreted because they were more gradual in the case of the rail health mechanic and because the swinging hammer could both mean that the rail needed to be repaired or was in the process of being repaired.

Diegetic but static elements provided no difference. The realistic-looking cities, rails, and terrain were merely cosmetic, but there was no considerable difference in answers between groups for the question: "I feel like this game made sense."

As for spatial integration, overlapping panel elements was one such issue noted by the group playing variant B. We found that keeping panels readable while also reducing overlapping was tricky to handle. Variant B included a sorting system whereby panels would be sorted to the top of the hierarchy if the player held their mouse over the panel, but that assumes the player was holding the mouse over the element when they were looking. The structured

grid-like manner in which deals looked like inside variant A made comparing deals from a profit perspective much easier, as clicking around a grid-like pattern was simpler than clicking on the correct city situated in the environment. Part of playing the game was to click on each deal and compare profitability before sending them off. So, players often compared all available deals before sending them off, and we believe the structured manner of variant A made that set of actions easier. Still, the only evidence we have is the post-playing questionnaire, and those questions targeted the entirety of the experience, not just specific game elements. Our strongest indicator that there was an issue with the spatial elements was through the question of feeling like the game provided the information at the right time, which held variant A in favor. We believe the overlapping elements made the most significant impact on that question and made variant B perform worse in all other questions.

We find the differences in the amount of time spent at different speed states harder to explain. Although deemed significant, we did not expect a difference, as the time system was one of the unchanged game elements between variants. We speculate that players were more inclined to pause and think when playing A, but our observations also showed that some people never paused regardless of circumstance while some did. Therefore, we theorize that variant A had some people who paused when they wanted to read something new, while some let time pass as normal.

5.1 Cohesion & Consistence

Cohesion and consistency is an important aspect of players approaching a game [19]. We found several issues regarding cohesion and consistency throughout testing, which led people to believe that some rules and systems in the prototypes functioned a certain way, although it was not the case. According to the approachability principles, Gee [9] states that players do not think through generalities but through reconstructions of experiences as per the principle: Meaning as action image, which meant that the preconceived knowledge of the players impacted how they thought a railroad focused game would work. In total, we identified nine issues with the prototype:

1. Rails are damaged equally over time, irregardless of how many trains are sent on them.
2. The expected profit is set upon accepting a deal, but the player receives the money once the train has arrived. The prices may have changed before that train arrives, but that does not change the final profitability.
3. Trains are not going slower when carrying a bigger cargo.
4. The same amount of train carts are used irregardless of cargo size.
5. The economy is randomized each in game day and is not dependent on supply and demand.
6. Trains do not need maintaining.
7. Trains can be sent on rails currently being repaired.
8. Negative money has no repercussions on gameplay.
9. Trains only need to go to destination to complete deal, not back to the original city.

Some of these issues impact each variant to a different degree. The diegetic implementation of trains makes its issues more apparent, as the non-diegetic equivalent abstracts much of the information to the player's imagination. It is, for example, irrelevant if the train only goes to the destination in variant A, as it is represented by the progress bar anyway. The abstraction

of game elements inside variant A is not wholly good either, as our observations show that the complete exclusion of physical trains from variant A also generates some frustration, with some players looking for them in vain. We can not say which implementation is the worse compromise. The favorable subjective results in variant A may have been due to other variables like the spatially integrated elements in variant B, which seemed poorly received by players through observation. Through speculation, we would argue that filling the gaps of information as described by Jørgensen [19] is easier if the target element is non-diegetic, as a diegetic element contradicts any filling with a *true* representation of what something is supposed to appear. As we described previously, diegetic elements in grand strategy games are not genuinely diegetic, as they are representations due to lack of detail, which raises the question of whether it bothers people. To conclude, our diegetic integration of trains required more detail to keep it cohesive with the world, while the non-diegetic integration allowed us to abstractify much of that information.

5.2 Grand strategy games & Diegetic Integration

Overall, turning non-diegetic elements into spatial elements created challenges for sorting and layering the panel elements. However, that did not mean these elements became part of the story, and from Galloway's [7] theory, actions made in these panels were still non-diegetic operator actions. It was more difficult going from a non-diegetic element to a diegetic element since the relationship of that element to the game had to go from something the player needed to something the player character also needed. We created deals from the beginning as something that appeared from nowhere and was interacted with through a simple click. This choice introduced a challenge for us when developing the diegetic variant. Realistically, after clicking, there would be some delay from the player's acceptance of the deal until the train actually could head for its destination. The deal would likely go through a bureaucratic process; loading the train with the goods itself would take time; a scheduled time for departure would need to be set. These diegetic acts were not included initially in the game, making diegetic integration difficult since the same functionality needs to exist for both variants.

Instead, that narrative needed to be created first for that implementation to make sense. Regardless, the actual click of the button would not change even with these diegetic implementations. There would be delays and indicators that things are happening diegetically. However, the player's actions to make these diegetic actions happen in the first place would still be abstracted. For our deal example, signing a physical and diegetic document requires a person sitting at their desk. How would one go about enforcing the bird-view perspective that grand strategy games have in that case? Would it be situated in a computer monitor that sits on the desk of the player character? Would the player character make all diegetic operator acts at their desk, and their non-diegetic operator acts through their screen?

We believe that grand strategy games' lack of definable player character impacts what type of diegetic integration they can do. Paradox Interactive's products do not define the character as a single being, as the player has many roles to fulfill. The games reference the player as a general or king, but the player is, in reality, a semi-omniscient being. Looking at it from the perspective of Galloway's [7] operator and machine acts, no diegetic operator acts are allowed (with an exception to move acts and mouse clicks as expressive acts) because it enforces that a god-like being exerts divine intervention. The only way for diegetic elements to exist in grand strategy games is if the machine is the instigator for those actions, like our trains. We can tell a train to move through a non-diegetic operator act, but it is the diegetic machine act that moves the train. We can, through non-diegetic operator acts, tell an army to move to a province in *Europa Universalis IV*, but it is the diegetic machine act that move the army.

5.3 Limitations of the experiment

Throughout testing, some limitations appeared that might have influenced the results. Some were dependent on development strategy, time constraints, sample issues, or measurement inaccuracies.

5.3.1 Unrepresentative Game Prototype

Some aspects of the prototype were flawed or unrepresentative of a real grand strategy game. For example, player entities are in the scale of nation-states, with other nation-states controlled by the computer. In *Europa Universalis IV*, there are more than 390 playable nations at the start of the game. So, our prototype, with a single player-entity, is not representative of that sense of scale. For a prototype with a larger scale, portions of both variants need re-designing and later re-implementing. The rail- and train lists would likely be unsatisfactory for playing variant A (see Figure 12a, 13a), and the spatial integration in variant B would be unsatisfactory for any general overview by the player. We think that overcoming these challenges is doable for either variant; however, doing so might change the results. We think this is a limitation because each implementation may have an easier or harder time showing the correct information at the right time [9], which is a problem that requires iterations and testing. We recognize that our choices in visualizing elements in either variant may not have been optimal but that a long and iterative development was not feasible to do. It is essential to think about how these differences may come down to diegetic and spatial differences or the implementation itself whenever discussing variational differences.

5.3.2 Issues with the Sample

The sample size of the experiment gave uncertainty to the results. We were fortunate that the mean amount of time spent in the middle and fastest speed states remained the same between groups since a large difference would have yielded very different performance numbers due to our measurements' independence from in-game time. The lack of use for both the middle and the fastest speed state was due to players not discovering and using it initially, not because it was not helpful. An ideal experiment would include a small set of basic camera and time controls instructions before beginning, which would have removed the element of discovery from the crucial element of in-game time and made any potential variability in these speed states more legitimate for analysis. The sample also had a *WEIRD* bias, meaning that the people in our sample were exclusively from a Western, Educated, Industrialized, Rich, and Democratic society [25]. Specifically, Swedish university students and graduates. Meanwhile, 54% of people who play games are in the Asia-Pacific region [15]. We could therefore not be sure the outcomes would stay the same if a global sample was used.

5.3.3 Ongoing events

Due to the Covid-19 pandemic, the experiment could not be done in the same testing environment and on the same setup. We observed some concerns with zooming speed when players used touchpads, which would not happen if the same setup was offered.

5.3.4 Inaccuracies of Measurements

When taking our objective measurements, only real-world time was considered. Using in-game time would make the real-world time of the participant dependent on the game speed and could vary between each player. When we conducted the experiment, we saw it as preferable for each experiment to take a similar amount of time instead, as coordination, timing, and scheduling of experiments was more important than usual due to being done through video calls. The flaw was that most measurements were dependent on the in-game time and not the real-world time we used. A measurement solution using both could have yielded additional insight into the data.

During the experiment, the player had to pause the game at the 15-minute mark and then click a button to reveal the objective data panel. This could take additional seconds until the data was copied, and so, some measurements are inaccurate. Any timestamped data like our money measurements could be removed, but the cumulative data like the time spent inside tabs have a small inaccuracy. Looking at Figure 15, the mean total time for variant A and B was 15:24 and 15:16 (mm:ss) respectively.

6 Conclusions

Our experiment compared two variants of the same grand strategy prototype that differed in diegetic and spatial belonging. The first variant was called variant A and focused on placing game elements outside of the world. The second prototype, variant B, integrated as many elements as possible into the world. We compared both variants through objective data based on an automated program and subjective data based on approachability principles and observations. The objective of the experiment was to see if there were approachability concerns that can be connected to diegetic and spatial theory. We determined that performance, confidence, and priority were our measurement points in determining differences in the variants.

We also identified how the grand strategy genre is different from the first-person genre according to the theories of Fagerholt and Lorentzon [5] and Galloway [7]. The unidentifiable player character in grand strategy games disallows diegetic actions from the player, meaning developers that want to make their games more diegetic must do so through diegetic machine actions.

As part of our evaluation, we created several research questions about how diegetic and spatial integration impacts approachability. The research questions targeted different fields of our paper, and is summarized in this section:

> "What is the effect on the player's confidence when comparing variants?"

The players who were part of the group playing variant A responded more favorably in understanding the prototype's goal and their own goal-reaching ability. They felt that the game was easier to play without a manual and felt less stuck in the game. They also felt that they performed better and that the prototype was better at providing the correct information at the right time. However, the group felt more bored after playing when compared to the group playing variant B.

> "What is the effect on the player's priority when comparing variants?"

The players who played variant B spent less time looking at the train tab because the information could be supplemented diegetically. Consequently, the group could submit more deals under the same time frame when outliers were removed.

> "What is the effect on the player's performance when comparing variants?"

Although a measurable difference in completed deals was found, a difference in performance could not be determined due to a lack of homogeneity within each group, and due to differences between groups not being large enough. There was also no significant difference between average end-score for either variant.

> "How does player performance correlate to player confidence?"

The players who played variant A thought they performed on better average than players who played variant B. The group playing variant A did contain outliers that may have skewed the subjective result towards that direction, but nothing conclusive can be said about our prototype. There was also no measurable difference in objective performance between groups to form a correlation.

> "How does diegesis and spatial integration impact approachability in grand strategy games?"

The use of diegesis in grand strategy games could allow information to exist as objects inside the world without providing additional non-diegetic panel elements for communication. Diegetic elements are always part of the environment, and their inclusion made it possible to display information regardless of what tab the player was in. This made it so that information could be transmitted between tabs in a way that would otherwise require the duplication of panel elements that would exist in both tabs. When using the tab-like system, or map mode system in Paradox Interactive's products, diegesis contributes to better reinforcement [8] and giving the correct information on time and demand [9].

Spatial integration allowed the placement of panels inside the environment. Doing so allowed geographical data to be supplemented into the world, but other information needed to be kept as written text. The spatial integration introduced issues with sorting and overlapping panel elements and contributed to the integrated variant being more frustrating to play. The overlapping of elements made it harder to get the right information on time and on demand [9].

The different effects on approachability was due to the implementation chosen for either variant and not strictly the diegetic and spatial belonging of these elements. The diegetic integration of trains comes with extra information that would otherwise not be present if it were non-diegetic. To achieve the same information flow, additional systems need to be put in place in order to accommodate the non-diegetic alternative. It is, however, more challenging to include diegetically integrated systems as the gameplay needs to stay cohesive and consistent, which is easier if the element does not belong inside the narrative and environment. Players are happy with whatever system they receive that can help them achieve their goals, as long as the game provides them with the necessary information they need [2].

7 Future Work

Fagerholt and Lorentzon's [5] model of splitting narrative from environment opens a lot of possible evaluations between different spectrums, and so does Galloway's [7] theory. This paper has primarily focused on applying these theories to games where the player character is undefinable or not part of the narrative, which is often the case with strategy games. With the knowledge of understanding how to create diegetic grand strategy games, future research should evaluate how creating a prototype using as many diegetic machine acts [7] as possible would fare. The process should be reasonably similar to ours with its focus on approachability. However, the two prototypes should strive to make as many systems as possible explainable through the narrative and visualize these systems as diegetic or non-diegetic elements respectively.

Actions, like the non-diegetic operator actions of deals should be replaced with actions that make sense in the perspective, and which yield a corresponding diegetic machine action. Rail repairing should send out a repair crew to the middle of the selected rail instead of the abstract hammer that is whacking the rail. The rail should physically look more damaged instead of changing color. Accepting deals should create some kind of feedback inside the environment, perhaps making the home town cheer.

It should do this to make the diegetic integration easier, as not to fall into the trap of only being able to spatially integrate the element but not diegetically. The new evaluation would not need to compromise non-diegetic elements as spatial elements and instead implement them as true diegetic elements. In our experiment, it was easier to abstract diegetic actions

into text, but going in the other direction, like coming up with a narrative for a simple button click while keeping the prototypes comparable, was far harder.

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A Appendix

Introduction to Test - Original Swedish Version

I detta experiment kommer du att få först spela ett spel i 15 minuter, sedan kommer du få svara på några frågor i ett formulär.

Jag kommer inte att prata under denna tid, men ifall du vill så får du gärna tänka högt medans du spelar, det hjälper mig förstå hur du spelar. Det kommer inte finnas möjlighet till att fråga mig frågor under experimentet, utan det måste du utföra helt på egen hand.

Jag vill förtydliga att den här datan kommer att användas till mitt experiment i vetenskapligt syfte, men att datan kommer senare analyseras och presenteras till Paradox Interactive. Din spelsession kommer att spelas in och kan användas i vetenskapligt syfte, men kommer inte i sin video-form förmedlas till Paradox Interactive.

Till sist vill jag säga att det finns inga psykiska eller fysiska nackdelar eller risker med att utföra experimentet, men du har möjlighet att avbryta experimentet när du vill och av vilken anledning som helst, utan frågor. Vid avbrytande kommer all testdata gällande dig att att tas bort.

Experimentet handlar om det här:

Du tar kontroll över en stads räls nätverk och ditt jobb är att tjäna så mycket pengar som du kan. För att tjäna pengar ska du fullfölja erbjudanden samtidigt som du balanserar kostnader från räls, personal och tåg. Saker kan komma upp och sätta käppar i hjulet för dig på vägen, ditt jobb blir att hantera det här på vad du känner är bästa sättet.

English translation

In this experiment, you will play a game for 15 minutes, then you will answer some questions in a survey.

I will not speak during this time, but if you want, you can think loudly as you play, as that helps me understand how you play. There will not be any opportunities to ask questions during the experiment, rather, your job is to complete the experiment on your own.

I want to emphasize that this data will be used for my experiment for scientific purposes, but that the data will be analyzed and presented to Paradox Interactive at a later date. Your session will be recorded and can be used for scientific purposes, but will not, in its video-form, be given to Paradox interactive.

Lastly, I want to emphasize that there are no psychological or physical disadvantages or risks with fulfilling the experiment, but you have the possibility to cancel the experiment at any time, at any reason, with no questions asked. If you cancel the experiment at any time, all data collected that is associated with you will be deleted.

The purpose of the experiment is this:

You take control over a city's rail network, and your job is to make as much money as you can. To make money, you are to complete deals at the same time as you are balancing costs from rails, personnel, and trains. Things can come up and *put a spoke in your wheel* (metaphorical translation is to disrupt the player). Your job is to handle this in what you feel is the best.

Quantitative post-playing questionnaire

1. I would play this game again if it was available to me.
2. I would play this game over an extended period of time.
3. The game was challenging me without frustrating or boring me.
4. The game's difficulty made me try different strategies.
5. I felt like once I had a tactic set up, new things came up that made me have to change my approach.
6. The goal of the game was clear to me.
7. The goal of the game was within my reach of abilities
8. The game supported a variety of play styles.
9. The game felt playable without reading a manual or following a guide.
10. The way you controlled the game felt intuitive and natural.
11. The interface felt intuitive and visually pleasing.
12. I rarely felt stuck or interrupted in the game.
13. I felt like all the tools in the game were useful to complete my task(s).
14. I feel like I performed well while playing.
15. I found it easy to understand how to play the game.
16. I felt like the game showed me what in the game world was changing when I did things.
17. I felt like the game provided the information I needed at the right time.
18. It felt like I could teach myself how to play the game without severe repercussions by the game.
19. I think this game made sense.
20. I felt like the game became more difficult as time went on.
21. When I STARTED playing, I felt like I had control in the game.
22. When I FINISHED playing, I felt like I had control in the game.
23. When I STARTED playing, I felt overwhelmed by the information given to me by the game.
24. When I FINISHED playing, I felt overwhelmed by the information given to me by the game.
25. When I STARTED playing, I felt like I understood how to play.
26. When I FINISHED playing, I felt like I understood how to play.
27. I was feeling bored by the game when I began playing.
28. I was feeling bored by the game by the end of the time limit.
29. I felt like this game became more fun as time went on.
30. I feel like I came up with a good strategy by the end of the play time.

Qualitative post-playing questions & answers

Q1 How would you describe your role in the game world?

Q2 How much of the game do you feel like you know at this point?

Q3 Do you feel like there is things in the game that you still don't understand?

Q4 Do you have any comments about the experiment?

Q5 Did you feel like time passed noticeably quicker when playing? Like you lost your grasp on the passage of time?

Qualitative Questions & Answers - Original Mixed Language Version

Table 7: Qualitative answers from players in groups that played both variants.

Group	Q1	Q2	Q3	Q4	Q5
A	Logistics manager	80%	No	-	No
	Ägaren av tåg/frakt företag i ett land. Målet var att se till att maxa monetär vinst men också bibehålla infrastrukturen för rälsen runt om i landet.	Vid slutet av speltiden kändes det som att jag förstod alla mekaniker i spelet. Det jag inte har koll på är mängden/skillnaden i random events under spelandet, detta hjälper förstärka ens vilja att fortsätta spela spelet för mig.	Vad som händer när en räls går sönder eller då man får slut på pengar, detta antar jag man får veta då man spelar längre och svårighetsgraden blir högre ju mer tid som går.	Roligaste experimentet jag gjort!	Yeah, it felt like 5 minutes
	Manager, rail road chief, capitalist	Everything	Maybe the map, as it looked the same the whole game. I guess it would change if the railroad broke, but it never did for me.	Fun!	Yes i would say it went for more like 10 minutes instead of 15.
	A manger of transportation of goods and people	60% perhaps	Yes I didn't look up the details of calculations to understand why this was so much more profitable over this for example. Or how much of an impact the damaged railroads had on profit.	Fun to see what you have been working on and I'm looking forward to your results!	Yes the 15 minutes went by quite fast
	Tågmagnat	Det mesta	nä	-	yes
	I was the owner of a railway company that was out to earn money.	About 86%	Sure, some things I am sure I don't get.	Fun experiment and a charming game.	Yes.
	I would say i played as the owner of a railroad	I feel like I know a lot, but I didn't really find a strategy that worked	No , the general rules were easy to understand but what choices were best to make is still a bit unclear	It was a fun experiment, for someone who is not used to playing games involving strategy it was fairly easy to understand what to do.	Yes

Group	Q1	Q2	Q3	Q4	Q5
B	The train manager	Maybe 70%, still dont know why random events happen or if I can do anything to stop them. Example, can i play differently to stop the workers from striking?	Random events, what makes the rails break		Yes, I would say so
	a rail road "manager"	I did not have time to set up any strategies, if i would have played this game in my spare time I would have taken more time to investigate different options.	Yes, If i choose to repair a track while a train is running, does that update what profit i will get from that train?		Yes, it felt like 8 minutes
	As the trainsystem manager	I would say a fair amount	How the profits and etc. for every shippment was counted.	It was fun and went fast	Yes
	To drive income to the train business	Almost everything	I did not really understand the profit numbers, which affected how I played the game		I think so
	as someone who made all the decisions regarding all the trains and "handel"	more than in the beginning	not sure about the time and how long a day was	no, its was fun to participate	yes exactly
	I felt like the train overseer, som sort of "general director of transportation"	A good deal but I still want to know how to "destroy" trains? One strategy to make money was to make more trains, but I was scared to make too many since I did not see a clear way of destroying them if the maintenence became too high.	The economy breakdown was a bit too obscure for me. I would have liked to see a "spreadsheet" over costs and earnings.	The game was fun, it was easy to get into without much of a "tutorial". But I would have liked more feedback when doing things (to make it clearer what was happening/going to happen) and also some prettier graphics wouldn't hurt ;D	Yes, the game was fun. Felt shorter than 15 mins!
	Jag kände mig som boss över järnvägen och att jag hade ansvar för att se till så att min järnväg gick plus.	Tycker jag förstår mig på spelet väldigt bra, men kanske skulle behöva spela lite till för att hitta all information.	det som fanns förstod jag, sen kanske jag hade vlat se mer saker på samma sida. så att man kunde få en bättre överblick. hade även velat kunna ta bort tåg.	det var kul att spela, man blev lite stressad av tiden och pengaförlusten, kanske borde ha pausat tiden när jag läste saker och så för att inte förlora så mycket pengar.	jag kollade inte så mycket på tiden under spelet, men var inne i det så tiden gick fort när jag spelade