Serious Gaming for Change in Air Traffic Management

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EXECUTIVE SUMMARY

Serious Gaming for Change in Air Traffic Management

Problem area

The Single European Sky Air Traffic Management (ATM) Research program (SESAR) aims to modernize the current (fragmented) European ATM system. To achieve this ambitious goal, several changes are necessary that will have a large impact on the current way of handling air traffic in Europe. Although many changes may present themselves as obvious improvements for the ATM system, stakeholders may be hesitant because they may have difficulty to quantify the costs and benefits of these changes for their own operation and for the ATM system as a whole. Stakeholders can attempt to create a last-mover advantage by waiting with their investments until all others have proceeded with investing, which may obstruct the implementation of the foreseen changes and create deadlocks. To help the introduction of change management in ATM, new approaches are therefore desirable.

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This report was presented at the 26th ISPIM Conference - Shaping the Frontiers of Innovation Management, Budapest, Hungary, June 14-17, 2015.

Description of work

The AeroGame project investigates how serious games can support change in ATM. Compared to pure (fast-time) simulation models, serious games allow for human interaction. Human interaction is important to include when the effects of human behaviour are difficult to model and yet have strong impact on outcomes. This is especially the case for multi-stakeholder innovation and change processes such as the modernisation of ATM systems. In this paper we critically examine the value of serious gaming for supporting change in ATM. The goal is to improve our understanding of how serious games can be used to support change processes.

Results and conclusions

We have designed, built and validated a table top game, work title - AeroGame -, aimed at creating a sense of urgency (awareness goal) among ATM stakeholders (Air Navigation Service Providers, Airlines, Governments) and at the same time collect information on the attitudes of these stakeholders towards change (research goal), which SESAR can use for further elaborating their change vision.

We report on an action research study, which explores how stakeholders can be made aware of the characteristics of ATM innovations using a serious game. The findings provide first – not conclusive - empirical support that games can help make people aware of characteristics, costs and benefits of new technological concepts. Also, support is found that gaming helps to create a more collaborative climate among stakeholders in the introduction of new technologies. As such, serious games have the potential to become a serious tool to facilitate change processes.

Applicability

For academia, this study is relevant because it is to our knowledge one of the first studies which investigates the use of serious gaming to support technology-induced change processes in a complex system-of-systems across organisational, institutional and national borders. This research contributes to our understanding of serious gaming for change in two ways. First, it shows how serious games can be used to support change processes. Second, it provides insights how stakeholders can be made aware of the characteristics, costs and benefits of introducing technological innovations using a serious game.

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Serious Gaming for Change in Air Traffic Management

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Summary

Introducing change in Air Traffic Management (ATM) is a complex activity requiring the collaboration of multiple stakeholders. We report on an action research study, which explores how stakeholders can be made aware of the characteristics of ATM innovations using a serious game. The findings provide first – not conclusive - empirical support that games can help make people aware of characteristics, costs and benefits of new technological concepts. Also, support is found that gaming helps to create a more collaborative climate among stakeholders in the introduction of new technologies. As such, serious games have the potential to become a serious tool to facilitate change processes. This research contributes to our understanding of serious gaming for change in two ways. First, it shows how serious games can be used to support change processes. Second, it provides insights how stakeholders can be made aware of introducing technological innovations using a serious game.

Content

1 Introduction

The Single European Sky ATM Research program (SESAR) aims to modernize the current (fragmented) European ATM system (SESAR, 2012) . To achieve this ambitious goal, several changes are necessary that will have a large impact on the current way of handling air traffic in Europe. Among others, the SESAR Joint Undertaking (SJU) foresees changes in coordination (creating a common view), changes in how aircraft are handled in ATM, an introduction of advanced trajectory management (4DT) and creating a System Wide Information Management (SWIM) network. The ultimate goal is to improve the efficiency, sustainability, cost-effectiveness and capacity of air traffic in Europe.

Although many changes may present themselves as obvious improvements for the ATM system, stakeholders may be hesitant because they may have difficulty to quantify the costs and benefits of these changes for their own operation and for the ATM system as a whole. Changes that may seem insignificant for one stakeholder can have major implications for another. Stakeholders can attempt to create a last-mover advantage by waiting with their investments until all others have proceeded with investing, which may obstruct the implementation of the foreseen changes and create deadlocks (Daams, 2011). To help the introduction of change management in ATM, new approaches are therefore desirable.

The AeroGame project investigates how serious games can support change in ATM (Nieuwenhuisen, 2013). Compared to pure (fast-time) simulation models, serious games allow for human interaction (Bilsen et al., 2010). Human interaction is important to include when the effects of human behaviour are difficult to model and yet have strong impact on outcomes. This is especially the case for multi-stakeholder innovation and change processes such as the modernisation of ATM systems. Compared to real-time simulation, serious games do not attempt to create an environment that mimics reality; they rather focus on processes and interaction.
A serious game, when well designed, can provide an engaging, experimentation and learning environment, which allows players to grasp the essence of complex socio-technical systems. By trying out different strategies and providing feedback of the effects, stakeholders can get a better understanding of how a system works and how it is affected by their actions and those of others (Hugos, 2010).

In this paper we critically examine the value of serious gaming for supporting change in ATM. The goal is to improve our understanding of how serious games can be used to support change processes.

This paper is structured as follows. First we introduce serious gaming. Second we discuss how serious games can be used to support change processes. Third, the game prototype is introduced. Subsequently, we discuss the research design of this action research study. Finally, the findings are discussed and conclusions are drawn. We end this article with indicating directions for further research.

2 Serious gaming

Serious games, sometimes also referred to as applied games, are more and more accepted as professional learning, change and communication instruments. The core idea of serious gaming is to leverage the power of engagement and learning of (computer) games for real world issues. For this reason, serious games have the potential to be more attractive than other learning means for the participants, and participants will also be more involved during game play. The "serious" adjective refers to the real world issues the serious games are applied for. The goal of a serious game can vary from training, creating awareness, education, exploration, promotion or a combination of these aspects. In change processes, serious games have already been proved to be both effective and motivating (Stoppelenburg et al., 2012). While some view gaming as an activity (e.g. Abt, 1970) others view games as systems (Salen & Zimmerman, 2003). What most activity-based definitions have in common is that game play is seen as an activity in which players pursue a challenging goal by performing actions in a limiting context governed by game rules. Most system-based definitions list the more tangible components of games such as graphical user interfaces, content, game means and rules. We propose to distinguish game systems from game play. When viewed as a system, games can be described in terms of their constituting elements and relationships. Game play can be defined as the observable behaviour of the players when interacting with the game system. Based on the work of Schell (2008) we identify the following building blocks of a game system:

- Aesthetics;
- Story;
- Mechanics;
- Technology.

An important issue in serious gaming are the acclaimed benefits of their use. Besides the obvious benefits also associated with simulation, such as allowing for risk free experimentation, there is little consensus on its effects. In general, researchers agree that serious games have a positive effect on learning processes and engagement. Research, which critically and empirically examines the effects of applying game elements, is scarce (see Wouters et. al., 2009 for an overview). Most research focuses on the effects of simulation on learning processes. The impact of game elements such as turn taking, game rules, and game attributes (e.g. cards, pawns, dices) on group processes are given much less attention. Consequently, the design of serious games is still in its infancy and is more a trade than a scientifically founded approach. As Van Eck (2006) argues “continuing to preach the effectiveness of games may create the impression that all games are good for all learning outcomes, which is categorically not the case” (p.18).

3 Games to support change processes

There is no single proven recipe for implementing changes in organisations, let alone across multiple organisations. Research indicates that as many as 70% of the change programs do not achieve their intended outcomes (Balogun and Hope Hailey, 2004). In the change management literature, however, one can find practical guidance to guide change processes in organisations. One of the most influential change management perspectives is Lewin (1952), later adjusted by e.g. Bullock and Batten, 1985, who argued that change follows a three-stage process: unfreezing current behaviour, moving to the new behaviour, and refreezing the new behaviour. Since its introduction, the framework has been reviewed and adjusted, with stages being divided into more specific steps (see e.g. Bullock and Batten, 1985). Lewin's original theory has also been criticized for its over reliance on planned change. Key assumption being that change can be planned for. As a response of such criticism an alternative approach to organizational change has been worked out that has been referred to as the 'emergent approach'.

Within this approach change is seen as a learning process, in which an organization anticipates and responds to internal and external changes. The emergent approach puts the emphasis on the readiness for change and facilitating for change (Todnem, 2005) instead of pre-planned steps of change. Despite not advocating pre-planned steps for change, several thought leaders (Kanter et al, 1992; Kotter, 1996 and Luecke, 2003) of the emergent school have proposed a sequence of practical actions that organizations must take to increase change success. Although they vary in number of steps and type, a set of steps are, according to Todnem (2005), shared including establishing a sense of urgency, creating strong leadership, creating a vision, and empowering employees.

In the table below, these steps are summarized and based on our experience with serious games we have indicated how serious gaming can be of help:

Table 1: Change and the role of serious games

Step	Description	Possible role of serious games
1) Create a sense of urgency	Analyse the organization and its need to change (Kanter et al., 1992); Establish a sense of urgency (Kotter, 1996); Mobilise energy and commitment through joint identification of business problems and solutions (Luecke, 2003)	Games can help to communicate why change is needed (e.g. create awareness) and to identify stakeholder attitudes, opinions and interests towards change.
2) Create strong leadership	Support a strong leader role (Kanter et al., 1992), Create a guiding coalition (Kotter, 1996); Identify the leadership (Luecke, 2003)	Games can be used for team forming (e.g. get acquainted with each other's visions and strategic interests)
3) Create a change vision	Create a vision and common direction (Kanter et al., 1992); Develop a vision and strategy (Kotter, 1996); Develop a shared vision of how to organise and manage for competitiveness (Luecke, 2003)	Games can be used to involve stakeholders in creating a mutually shared change vision
4) Enable action	Developing enabling structures (Kanter et al., 1992); Empowering broad-based action (Kotter, 1996); Institutionalise success through formal policies, systems and structures (Luecke, 2003)	Games can be used to train people in the new way of working

In the AeroGame project, the scope of the research was limited to the first and second step. A workshop was organized with domain experts to select a suitable topic for the serious game. The introduction of 4D Trajectories (4DT) was selected as a first assessment of the usability of serious games in ATM due to the challenges for implementation and the suitability for a serious game for change management. A game prototype was developed and tested with stakeholders to see if it is possible to:

1. Create a sense of urgency: make stakeholders aware of the necessity to change and develop stakeholders' knowledge on the concept of 4DT
2. Create a change vision: collect information on stakeholders' motivations, viewpoints and interests in 4DT that can serve as input for the deployment roadmap of 4DT.

4 Game description

Four players play the game under the supervision of a facilitator and a game master. The game has a physical component (game board and cards), and a digital component (the score board). The players interact with each other and with the game board, while consulting the digital score board.

The following roles are distinguished within the game: Air Navigation Service Provider (ANSP), Airport, Military, Government and Airline. The outcome of the game is measured by the values of a set of Key Performance Indicators (KPI):

- Fuel efficiency
- Network capacity
- Predictability
- Cost efficiency
- Safety

Players start by deciding which goals they want to reach in the game. These selected goals are the only elements in the game where the players can differ from each other: there are no other rules related to specific player types. Each goal is expressed as a minimum target value for one of the KPIs. The game rules force a possible increase of the target value in each round. When a KPI reaches or exceeds the target value during a round, the goal has been reached for that round. Reaching a goal in a round translates to additional (bonus) income for the player.

Investing resources in technologies can influence the value of the KPI's. The game is designed in such a way that players cannot realise their goals (i.e. required KPI levels) if they do not seek cooperation with the other players. This is done through so-called synergy bonuses: if multiple players invest in the same technology, the gain increases.

To enable a swift learning curve for the players, all cause and effect relations in the interaction model are modelled using fixed values, i.e. effects of player actions are deterministic. This makes it possible for the players to understand and even predict the effects of their in-game actions. To aid this further, the game is turn-based. Each turn the players repeat a cycle, where they assess the state of the game, discuss and plan their actions, and subsequently execute these actions. This leads to a changed game state, which can be assessed the following turn, and so on. The turn-based character of the game additionally helps the players to comprehend and structure the game and the ensuing discussions.

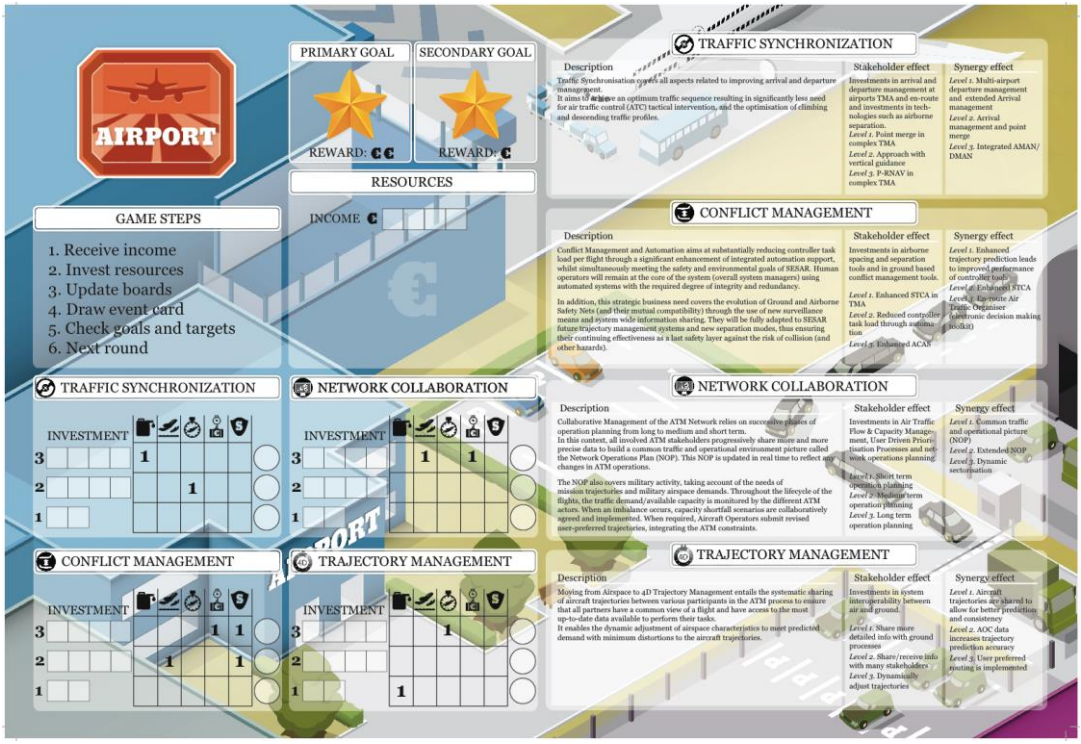

Figure 1: Game board for Airport player

The gameplay is divided in rounds. During each round the same steps are repeated.

1. Players receive their income for this round, which depends on their previous actions and on the state of the game (i.e. the value of the KPI's compared to their target levels).
2. Players are allowed to discuss, plan and execute their actions, which in most cases is investment in the technologies of their choice
3. The effects of the players' actions are computed and executed, changing the game state.
4. An event card is played (discretion of the facilitator). Events represent some (unexpected) condition or state change, valid until the next event is played in the next round.
5. The new values of the KPI's are calculated. These are the results of both the individual player actions supplemented by the synergy bonuses when players cooperate.
6. The values of the KPI's are checked against the player goals. Each player has his own individual set of goals, which was chosen before the first round. These goals are achieved when a given KPI exceeds a certain threshold value. Reaching goals supplements the players' income (this is called the bonus income).
7. The cycle is repeated.

Players are free to discuss strategies, make or break deals and follow their own path during the game. Assets can be leant, or given away to let other players invest, just like in the real world. Eventually, the player with the most assets at the end of the game is declared winner, as long as the group targets have also been met. This ensures that players will seek cooperation while trying to win the game.

The game master guides the game to ensure proper use of the game rules, keeps scores and answer questions about the game rules. The facilitator encourages the social interaction between the players by facilitating discussions between the players and asking players about the reasoning behind their actions. Finally, an observer is present that observes and notes the progress of the game and the behaviour of the players during gameplay. After the game finishes, the observer and facilitator together evaluate the game with the players.

5 Research design

The research design is based on the participatory action research methodology (Lewin, 1946, Stringer, 1999). Action research aims to contribute both to the concerns of practitioners in an immediate problematic situation and to further the goals of social science simultaneously. An important distinction between more traditional research approaches is that the researcher acts both as an external observer and as a partner in collaboratively solving practical problems.

The game was tested on 30 January 2015 at the premises of NLR in three parallel working groups each consisting of four different stakeholders in the role of airline, ANSP, airport and government. The players were first briefed on the project and introduced to the game. They then were asked to fill in a pre-game questionnaire. Subsequently the group was divided into three subgroups. Each group then played the game for several rounds to learn the game rules and understand how it works using a test scenario. After lunch the group was divided into three, yet different, subgroups in a way that each table had representatives from different stakeholders. After playing the game, the players were asked to fill in a post-game questionnaire. Finally the game was evaluated with the groups (discussion led by the facilitator) and the winners of each game table were awarded a price.

For the evaluation a group of 12 stakeholders was available. These were: 3 airline representatives, 3 ANSP representatives, 2 government representatives, 2 airport representatives and 2 representatives from ATM research institutes. The questionnaires and observers evaluated the game from the perspective of:

Game-based learning: serious games focus on learning in additional to focussing on entertaining people. Several learning techniques (e.g. learning by doing, case based learning, experimentation, feedback, role playing, situated learning, etc.) can be used in games to support players in learning. According to Prensky (2005), the challenge is to blend these learning techniques with gaming in such a way that they strengthen each other. The effectiveness of a serious game has been measured by asking players what they have learned from the game.

Game analytics: games can also be used as a research tool to collect information about stakeholders' attitudes, motives and interests. Asking players about the game and by observing how the game is played (e.g. goals they choose and cooperation they seek, interaction between players etc.) will measure these indicators. It is expected that this information can be used as input for designing incentive schemes and deployment roadmaps.

5.1 Findings with respect to game-based learning

The questionnaire addressed the question whether the player learned from the topic of 4DT by playing the game (see Figure 2).

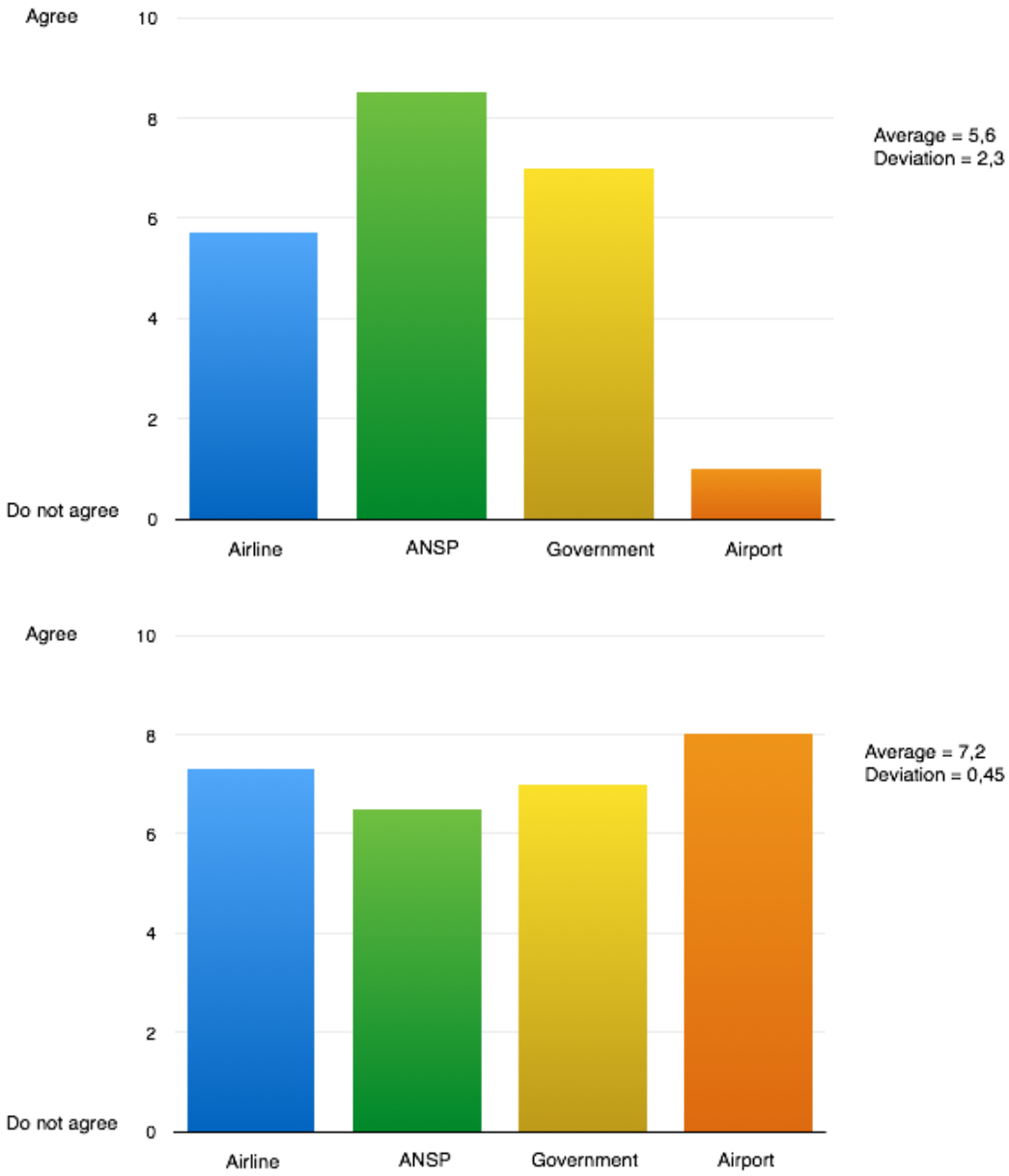

Figure 2: Playing the game improved my understanding of the issues at stake (pre test, upper figure and post test, lower figure)

With an average of 5.6 on a scale of 1 (do not agree) to 10 (fully agree) before playing the game and 7.2 after playing the game, it can be concluded that participants agree that they have gotten a better understanding of the issues at stake regarding the introduction of 4DT.

Participants were also asked to write down what they have learned from the game (Table 2). In general participants indicated that they have learned that they are dependent on each other and need to cooperate if they want to realize their goals. Openly discussing goals with others helps to understand the motives of other stakeholders and also helps to realize their own goals. These reactions show that the serious game has been useful to increase awareness towards cooperation and the impact of decisions of one stakeholder to the others.

Table 2: Lessons learned

Role	Lessons learned
Airport	System is the winner. In real life you just indicate that there is no money for investment, now will ask something. Cooperation: save money and reach target. Interesting to see that low cost airline invests in network capacity.
Airline	Could not reach my goals without talking to other stakeholders. You need to do one step back, before you can do two steps forward. In savings every one is listening, sells better than investments, a bit of grey areas in the 4 investment categories. Game can make people softer: more open to listen to others. Investment decisions of others have an impact.
ANSP	Discussion on primary goals within group helps reaching your own goals. Establish common interest at the beginning of the game. It is necessary to all invest in technology, otherwise it does not work. Understand roles and impact on strategy. Hiding money has been practiced by all partners, exercise in strategy and risk assessment.
Government	More attention to goals of others, look from the perspective of others, find common strategy, agree upfront on quick wins, change/ be flexible on strategy: follow, push, anticipate

Table 3: changes in attitudes towards collaboration and 4DT

Attitude towards	Question	Avg. answer pre-test	Avg. answer post-test
Collaboration	Introducing 4DT is a cooperative effort (with other stakeholders).	8.4	8.7
	Other stakeholders need my organization to successfully introduce 4DT.	7.0	8.0
	My organization needs other stakeholders to successfully introduce 4DT	7.9	8.4
4DT	The benefits of introducing 4DT are higher than the costs	6.1	7.3
	I have a good understanding of what the introduction of 4DT comprises of.	6.2	7.1
	I support time based operations but a full 4DT ATM system is a step too far	4.3	5.1
	I have a positive attitude towards the transition to 4D Trajectories.	7.3	8.3

To determine if playing the game has changed the attitude towards 4DT, participants were asked to answer the same couple of questions before and after playing AeroGame. These results (See Table 3) show that players are more positive after playing the game. While not all answers are statistically significant, this does suggest an important result: playing AeroGame seems to have a positive influence on the attitude and knowledge of 4DT. Participants seem to be more aware of the importance of collaboration with other stakeholders for successfully introducing 4DT and have a more positive attitude of (the transition to) 4DT.

One of the questions addressed the perceived need for other stakeholders for 4DT. This question therefore provides insight in the view that stakeholders have on the needs of other stakeholders. When comparing the pre-game and post-game results, participants appear to have a more positive view on the attitude of other stakeholders towards their needs to successfully introduce 4DT (on average 7.9 in the pre-test versus 8.4 in the post-test) with less standard deviation (2.0 in the pre-test versus 1.2 in the post-test). We see that especially the airport stakeholder has adjusted his opinion after playing the game.

When comparing the pre- and post-game results for the last question of this series, a more positive attitude of stakeholders towards 4DT (on average 7.3 in the pre-game questionnaire versus 8.3 in the post-game questionnaire) is seen post-game with less variance (the standard deviation was 2.1 pre-game versus 0.9 post-game). Again, especially the airport stakeholder has adjusted its opinion after playing the game. Because of the small amount of players, the result is not statistically significant ($t(10) = 1.402$, $p = .191$), but still can be considered a strong indicator.

5.2 Findings with respect to game analytics

Player's actions were captured using a digital effect viewer (see Figure 3). On the left side of the effect viewer one can see which stakeholder invested in which technology in which round. The right side of each figure shows the joint effects of the groups' investments in technologies on the Key Performance Indicators (KPIs). The blue line is depicting the realised value and the grey line is depicting the target values for a specific KPI in a specific game round.

Initially, on all tables the group discussions about what to invest and what not to invest in was led by only one of the stakeholders. This first changed to a more individual investment plan and turned in a true group decision to the end. This is in line with the expected effects of the individual goals and common targets.

In the early rounds, players invested their resources in those solutions that were most beneficial to their goals. After a couple of rounds however, the players created new investment types. They started to invest in the solutions of other stakeholders, borrowed money from each other, and introduced conditional investments. All these investment strategies have their equivalents in real-life. In one case a government stakeholder was asking the other stakeholders to invest in a certain solution. The other stakeholders were hesitant about this, because this meant they would have no buffer to mitigate for any unsuspected events. The government assured the other stakeholders that he would compensate for any negative effects coming from the events. The other players kept him to this promise. Although just an example, such observations show that serious games have the potential to break the ice between stakeholders and to create trust.

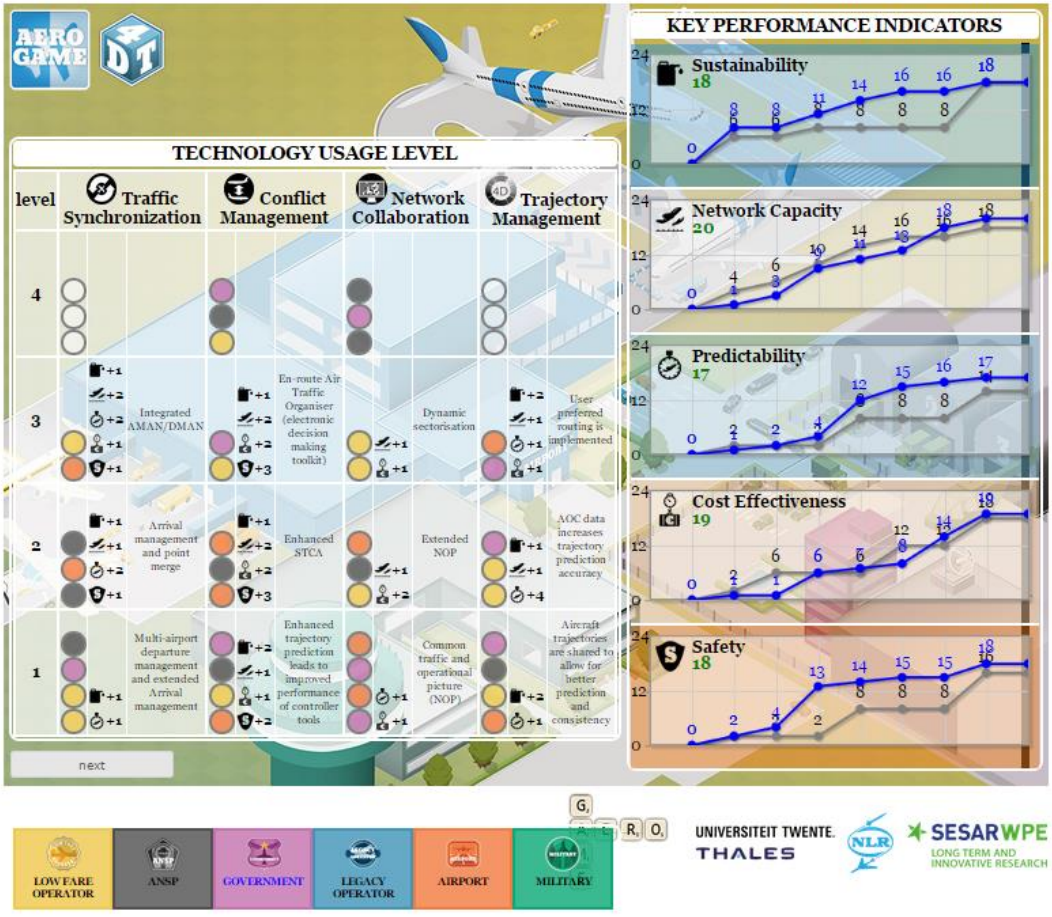

Figure 3: Digital effect viewer

Resources were initially managed in a very open fashion. Players showed their current resource pool, income and profits. Some players became more secretive over time. They tried to hide their resources and tried not to draw attention to themselves when things were going well. They would try to influence the group based on the resources available to each player. Some players actively helped others who were doing badly and took action against others doing well. In one case a player even put his resources in his trouser pockets and acted as if he did not have any. This of course also represents real-life as most companies are not too transparent about their financial state.

6 Conclusions

In this paper we critically examined the value of serious gaming for supporting change in ATM. Change in ATM is interesting from a research perspective because it entails a change process of a complex system-of-systems that spans across organisational, institutional and national borders.

We have designed, built and validated a table top game, work title - AeroGame -, aimed at creating a sense of urgency (awareness goal) among ATM stakeholders (Air Navigation Service Providers, Airlines, Governments) and at the same time collect information on the attitudes of these stakeholders towards change (research goal), which SESAR can use for further elaborating their change vision.

The findings provide first – not conclusive - empirical support that games can help make people aware of the characteristics, costs and benefits of new technological concepts. In addition, we found support that gaming helps to create a more collaborative climate among stakeholders in the introduction of new technologies. As such, serious games have the potential to become a serious tool to support change processes within ATM.

The findings are based on a small data set (12 participants). Furthermore, the participants were invited to play a serious game and were free to attend or decline. Therefore, they were probably positively biased towards serious gaming. To get a better insight into the value of serious games to support change processes in ATM, we recommend testing the game prototype with more participants, who are (as a group) more neutral biased towards serious games, and to test the game other use cases.

For academia, this study is relevant because it is to our knowledge one of the first studies which investigates the use of serious gaming to support technology-induced change processes in a complex system-of-systems across organisational, institutional and national borders. This research contributes to our understanding of serious gaming for change in two ways. First, it shows how serious games can be used to support change processes. Second, it provides insights how stakeholders can be made aware of the characteristics, costs and benefits of introducing technological innovations using a serious game.

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WHAT IS NLR?

The NLR is a Dutch organisation that identifies, develops and applies high-tech knowledge in the aerospace sector. The NLR's activities are socially relevant, market-orientated, and conducted not-for-profit. In this, the NLR serves to bolster the government's innovative capabilities, while also promoting the innovative and competitive capacities of its partner companies.

The NLR, renowned for its leading expertise, professional approach and independent consultancy, is staffed by client-orientated personnel who are not only highly skilled and educated, but also continuously strive to develop and improve their competencies. The NLR moreover possesses an impressive array of high quality research facilities.

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