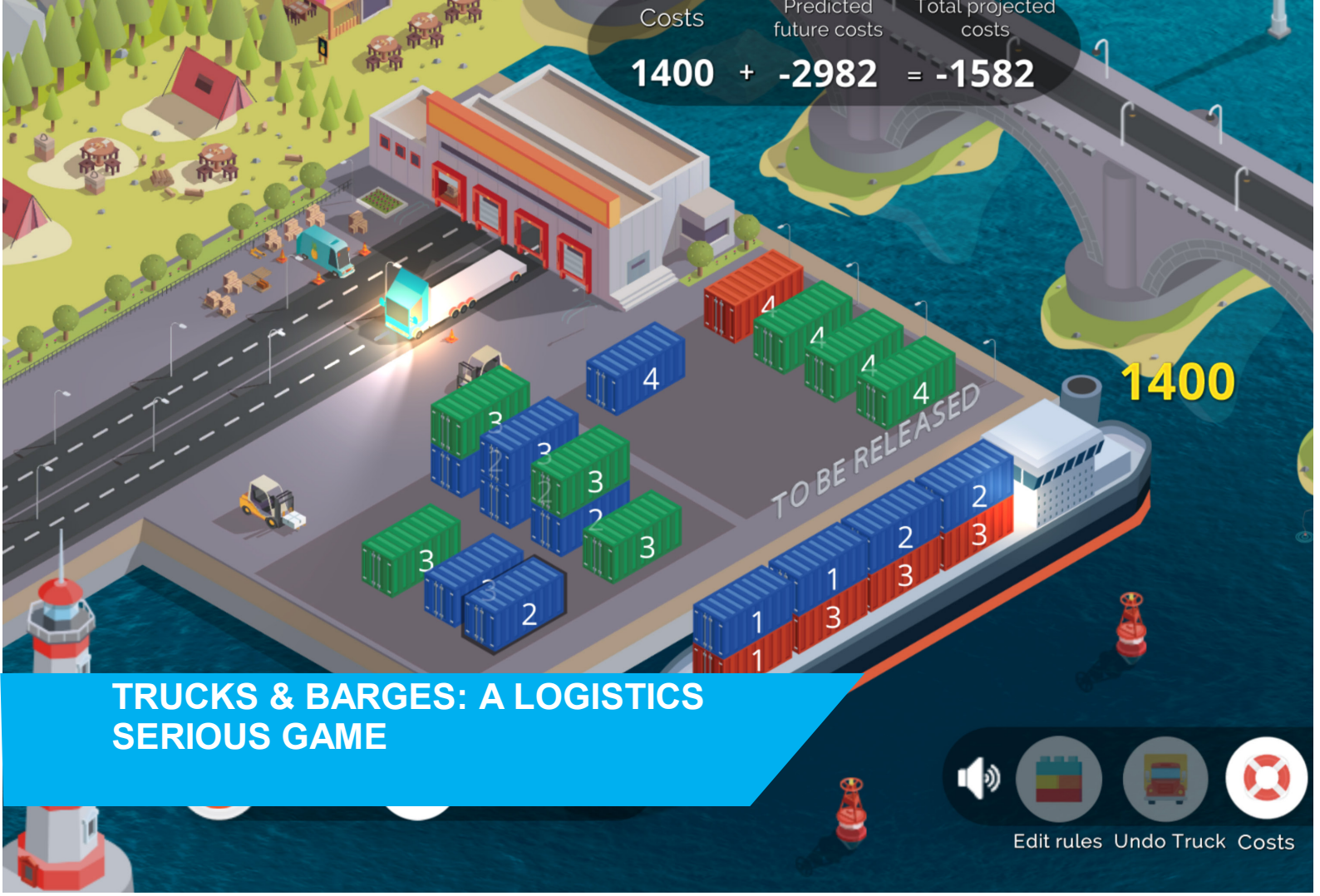


TRUCKS & BARGES: A LOGISTICS SERIOUS GAME

FINAL REPORT

TKI DINALOG
Dutch Institute for Advanced Logistics

SUMMARY

We have designed and implemented a logistics serious game called Trucks & Barges. This single-player game with group competition describes an anticipatory planning problem for the dispatching of trucks, barges and trains, considering uncertainty in future container arrivals. The problem setting is conceptually easy to grasp, yet difficult to solve optimally. The game consists of various types of rounds (game modes) in which the player can either manually plan the containers, use decision support from advanced planning algorithms, or create his/her own planning rules (not requiring any programming experience). These features provide the player a hands-on experience with various levels of decision support as well as algorithm design, which is unique and makes our serious game indispensable in the training of logistics planners of the future!

The game consists of various predefined scenarios (varying in number of containers, container characteristics, and costs structures) that can be modified by a game master. The game can be played within serious gaming sessions (under the guidance of a game master) as well as for fun by individual players. When playing for fun, the player can select a predefined game, and the performance of the player can be shown on a publicly available leaderboard under the selected game. When playing the game within a serious gaming session (e.g., classroom setting), the game master creates a “room”, which consists of (i) a predefined game that can be modified by the game master and (ii) a game scenario that, e.g., defines the types of rounds that are being played and the number of weeks per round. Participants of the session enter the room-key to play the game defined by the game master, and all results can be shown by the game master on a central leaderboard (real-time updates). The game is freely available to any-one, available for various devices, and playable as downloadable app as well as through a web-based interface.

The purpose of the game is to raise awareness about some of the trade-offs in anticipatory scheduling of synchromodal transport and to educate on how to optimize these trade-offs. The game is designed to provide the player with insight into (i) a typical intermodal planning problem, (ii) the benefits and challenges in anticipatory scheduling, (iii) the benefits of decision support and automated planning rules, (iv) the complexity of the planning problem, and (v) the formalization of automated planning rules. On the other hand, the game also provides the game-master with insights related to the behaviour of his/her participants, their awareness about the trade-offs in anticipatory scheduling, their learning process, and the way they respond to various forms/sources of decision support, automated planning rules and optimization algorithms.

Within this project, we not only developed this game, but also performed research with it. More specifically, by performing various serious gaming sessions, we compared the performance of human players, using various levels of decision-support, with the performance achieved by various algorithmic solutions within the game. Regarding the latter, we deployed a variety of benchmark algorithms, such as exact solution approaches (stochastic dynamic programming), heuristics, Approximate Dynamic Programming, and Deep Reinforcement Learning. We performed three serious gaming sessions: with students, with job seekers, and with logistics professionals. From these gaming sessions, we conclude that the advanced planning algorithms as implemented within the game Trucks & Barges typically outperform the human decision-makers, however, the top tier of humans come very close to this algorithmic performance.

TABLE OF CONTENTS

MOTIVATION 4
CHALLENGE 4
PROJECT 5
RESULTS 6
EXPERIENCE 9
FUTURE 11
PROJECT PARTNERS 12

Dr.ir. Martijn Mes

"…the advanced planning algorithms as implemented within the game Trucks & Barges typically outperform the human decision-makers, however, the top tier of humans come very close to this algorithmic performance"

MOTIVATION

Within the logistics industry, there is an increasing interest in monitoring of the transportation processes and collecting data to improve transportation planning. The collected data can be used for forecasting, predictive analytics, and prescriptive analytics. Techniques from Operations Research, Artificial Intelligence and Machine Learning offer opportunities to translate the information into decision support for human planners and even (partly) automated transportation planning processes. In the area of intermodal transport, these trends have led to synchromodal transport. Synchromodal transport involves the creation of optimal, flexible, efficient, and sustainable transportation plans that allow mode free booking (easily switching between service providers and modalities) and requires a careful balance of time, cost and service levels. The above-mentioned developments offer great opportunities for the sector, but at the same time increases the complexity of the transportation planning processes.

CHALLENGE

The introduction of appropriate decision support for dynamic planning of logistic services introduces the following challenges. First, the role of logistics managers and transportation planners will change. The “planner of the future” must have different capacities than today. This transition starts with changes in logistics education. Second, the full potential of the abovementioned developments will only be realized if the new techniques are fully accepted, which can only be achieved when potential users have experience with these techniques. To summarize the above-mentioned challenges, we need to educate and stimulate a “mental switch” towards decision-support and automated planning within the transport sector. A serious game offers an ideal opportunity to educate the planner of the future, to gain experience with new technology, and to become convinced about the advantages it may bring. More generally, a serious game can be used to educate on the challenges involved in transportation planning, the benefits of decision support and automated planning rules, and the way automated planning rules can be designed. Hence, such a game is more generally applicable to the area of operations management and logistics. In this project, we developed such a serious game, which is the first of its kind.

PROJECT

This project consisted of two parts: a research part and a development part, sponsored by TKI Dinalog and Connekt respectively. The total project consisted of 5 research work packages (indicated by WP-R) and 5 development work packages (indicated by WP-D). Furthermore, the project consisted of 6 phases, each of which has resulted in a publically released working version of the game. The relation between the phases and WPs is shown below.

1

Phase 1: first working version of the game

Come up with a first version of the game that improves the prototype by fixing all bugs, improve navigation and user interface, improve the leaderboard, optimize data management to handle a large number of participants, and improve compatibility with many operating systems and devices.

- WP1-D: User interface, animation and compatibility

2

Phase 2: algorithm design and playing for fun

Design decision-support algorithms for various scenarios within the game, design a framework to ease the formulation and implementation of automated planning rules, and extend the game towards individual/fun use.

- WP2-R: Algorithm design
- WP3-D: Fun and serious gaming

3

Phase 3: implementation of decision support

Implementation of the algorithms designed in WP2-R to serve as benchmarks as well as decision support within the game.

- WP4-D: Anticipatory planning support

4

Phase 4: algorithm creator and game management

Development of a system to create game scenarios including corresponding decision support and benchmark results, and the implementation of an algorithm designer and various playing modes (manual, decision support, partially automated, fully automated).

- WP5-D: Algorithm designer
- WP6-R: Game management system

5

Phase 5: extended decision-making

Perform research on the decision type(s) to add in the game (what is needed in training and education), design of an extended game and algorithms to support the new decision type(s), and implementation of the extended game design.

- WP7-R: Extended decision-making

6

Phase 6: testing, education, research and valorisation

Development of educational material, testing the game, study player behaviour with the game, valorisation and knowledge dissemination.

- WP8-D: Testing and valorisation
- WP9-R: Educational material
- WP10-R: Research and valorisation

RESULTS

Successful adoption of our serious game contributes to the following KPIs listed by the 2016-2020 program of Topsector Logistiek: (i) reduction of road transport, e.g., by a modal shift to water and rail, (ii) CO2 reduction, and (iii) outflow of qualified professionals in the labour market with a logistics education and thorough knowledge about the innovation themes. More specifically, we contributed to the following three action points of the Human Capital Agenda (HCA) of the Topsector Logistiek.

First, enough intake in education and the labour market: supporting innovative appealing education through practical assignments, real life cases, and serious games. By attractive educational forms, e.g., using serious gaming, students choose courses with economic and social relevance and develop a learning attitude for the rest of their lives. Moreover, more students can be enthused and attracted by drawing attention to logistics using these innovative educational forms that connect to the perception of different age groups starting already at secondary education (VO). Our serious game and educational material is aimed at this broad target group.

Second, continuous development of current and future personnel: lifelong learning can be achieved by the development of experimental and demonstration environments (serious games, e-learning, MOOCS). We contributed to this with the development of a publically available serious game (as an incentive, we can even think about giving out certificates when a player obtains a certain level within the game). This action point further states that it is important to ensure the dissemination of newly developed knowledge from the roadmaps to education (including non-subsidized) and business, the sharing of knowledge between education (including non-subsidized) and the business community, and with other top sectors (see Revision Roadmaps for crossovers with other top sectors). Through the development of tools, games, MOOCS, mini-cases, the use of e-learning and the creation of a digital portal, outcomes of innovation projects are made available to educational institutions and companies in a convenient way. This project is a good example of this, where the initial results of the TKI Dinalog R&D project Synchromodal-IT now end up in educational\training material. Moreover, the action line lifelong learning from the Human Capital Roadmap 2016-2020, states that serious gaming supports explorative learning, which fits well with the experiences of students and younger employees.

Third, extra focus on valorisation and knowledge dissemination: the subject knowledge dissemination is broadly defined here, from connection with R&D research to experiments, pilots, demonstrations, valorisation, business development and innovation. Our project connects to both aspects, as also mentioned under action point 2.

MAATSCHAPPELIJKE RESULTATEN	
CO2 reductie	n.a.
Kostenbesparing	n.a.
Vermeden vervoerskilometers	n.a.
Modal shift tonkilometers	n.a.
Andere resultaten	n.a.

SECTOR RESULTATEN	
Gecreëerde toegevoegde waarde	n.a.
Gecreëerde duurzame arbeidsplaatsen	n.a.
Bereikte bedrijven	6
Bereikte MKB bedrijven	4
Onderzoekers/ studenten nu werkzaam bij bedrijven	0

WETENSCHAPPELIJKE OUTPUT	
Master thesis	0
PhD promoties	0
Wetenschappelijke publicaties	2
Citations wetenschappelijke publicaties	0
Wetenschappelijke seminars, workshops, presentaties etc.	6

The developed game is freely available at www.trucksandbarges.nl as well as in the App Store and Google Play. Upon request, a game master account can be created, which enables you to define your own game scenarios, invite participants to join certain games, and collect the results of the invited participants. Furthermore, the involved researchers organized various workshops at logistics companies on the topics of decision-support, automated planning, algorithm design, and artificial intelligence in logistics, where this game was used to illustrate these topics and to get a hands-on experience with these topics.

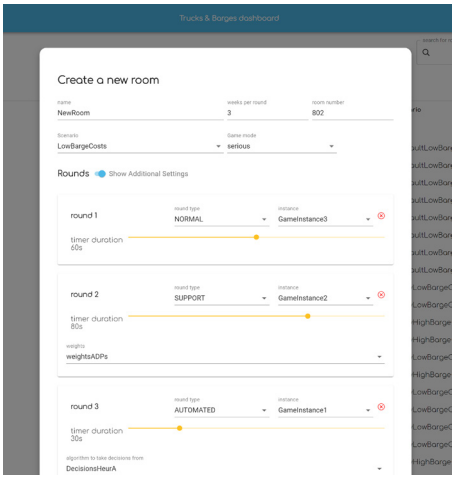
WE ARE PROUD OF

1. A fully functional and freely available game developed with limited budget.
2. An algorithm creator that allows players to create their own algorithm without any programming experience, which is unique in its kind.
3. A game management system that allows game masters (e.g., researchers, lecturers) to create and start their own games.
4. Implementation of a wide range of algorithmic solutions, ranging from intuitive heuristics to deep reinforcement learning.
5. Performed research with the game in various gaming sessions (with students, job seekers, and logistics professionals) comparing the differences between human and algorithmic performance, and studying how humans respond to decision support.

Trucks & Barges

The purpose of the game is to let players gain experience with transport planning under uncertainty, raise awareness about some of the trade-offs in anticipatory planning, and familiarize them with decision support and automated planning. The game is designed to provide the player with insight into (i) a typical intermodal planning problem, (ii) the benefits and challenges in anticipatory planning, (iii) the benefits of decision support and automated planning rules, (iv) the complexity of the planning problem, and (v) the formalization of automated planning rules. On the other hand, the game also provides the game master with insights related to the behaviour of the participants, their awareness about the trade-offs in anticipatory planning, their learning process, and the way they respond to various forms of decision support, automated planning rules and optimization algorithms.

Trucks & Barges from the App Store



Game Management System

Trucks & Barges Game Management System

The game master needs to be able to create his/her own game scenarios and invite participants to join a certain game. For this purpose, we created a game management system. A game scenario describes all problem settings, such as the modalities that are available, costs, container arrival probabilities, destination probabilities, etc. Using these settings, the game master can represent different logistics challenges. As such, human performance can be evaluated from various perspectives. Next, the game master defines the rounds to be played. Each round consists of a pre-defined number of weeks where a player is in the same mode. There five modes to be used in the different rounds: practice (with a built-in tutorial), normal, support (where players receive decision support from various algorithms), planning (where players create their own algorithm), and automated (where the player can see one of the built-in algorithms into action).

EXPERIENCE

The project has been finished within 1 year and every deliverable has been successfully finished as originally planned. However, the project took more effort than initially anticipated, resulting in higher costs, which eventually has been financed by the consortium partners themselves (especially by the software developers Pineapple Studios and the University of Twente).

Within this relatively small project, most of the effort came from Pineapple Studios and the University of Twente. The University of Twente was primarily responsible for the design of the game mechanics, logic of the game, algorithm design, game scenarios, gaming sessions, testing, valorisation, and project management. Pineapple Studios was responsible for the software implementation of the game itself. Our partner eXomodal also heavily contributed to the algorithm design. The other consortium partners primarily contributed by identification and formulation of the requirements (what are realistic game scenarios, what are desirable planning situations to simulated within the game, what are nice algorithms to include within the game) and were active within the valorisation process.

The role of our logistics partners was primarily to participate within various gaming sessions, e.g., with the purpose of training their employees, to educate their customers, or arouse the interest of future personnel. We did organize several of these sessions. For example, Rotra B.V. used the game at the “Dag van de Logistiek” on October 31, 2019 (where many students interested in logistics played the game). Furthermore, we organized a workshop “AI in de Logistiek” at Rotra, where we played the game with all employees of the IT department on November 11, 2019. Furthermore, we used the game in two full day workshops given by us at the “Week van de Logistiek” on Vliegveld Twenthe, March 11+12, 2020. Here, a large number of logistics professionals as well as job seekers within the logistics sector joined our stand to play the game. However, the original plan was to organize these workshops with all of our consortium members. Sadly, this was not possible, as by the time we finished the game, the COVID-19 situation did not allow to organize these workshops before the end of our project on June 1, 2020.

UNIVERSITY OF TWENTE.

Serious gaming at the University of Twente

The game Trucks & Barges has been used within various courses at the University of Twente, but also at several other national and international universities. At the University of Twente, we used the game within an introductory course for the master program Industrial Engineering & Management, to provide students insight into (i) a typical intermodal planning problem, (ii) the benefits and challenges in anticipatory scheduling, (iii) the benefits of decision support and automated planning rules, (iv) the complexity of the planning problem, and (v) the formalization of automated planning rules. More specifically, the students did not only had to create their own algorithm with the built-in algorithm creator, but also had to program their own algorithm in a standalone tool using the same simulated game scenarios as also present in the game. This way, we could compare the performance of their programmed algorithm with their manual performance as well as with their automated planning rules as defined with the algorithm creator within the game.

Serious gaming at Rotra B.V.

rotra

We organized a workshop “AI in de Logistiek” at Rotra for all employees of the IT department. In this workshop, we first provided an introduction into mathematical optimization, algorithms, decision-support, planning rules, Artificial Intelligence (AI) and Machine Learning (ML). Next, we presented a large overview of possible applications of AI in logistics. To provide a hands-on experience with these topics, we played the game in various rounds: a practice round to get familiar with the game, a normal round to see how well the logistics professionals at this company can plan manually, a decision-support round to see how these logistics professionals respond to decision-support, and finally a round where they have to create their own algorithms. The workshop was organized on November 11, 2019.

FUTURE

The development of a serious game as considered in this project is not a goal in itself. Instead, the game is only a means to educate the logistics planners of the future, and to stimulate a “mental switch” towards decision-support and automated planning within the transport sector. The game Trucks & Barges offers an ideal opportunity to educate the planner of the future on the challenges involved in transportation planning, the benefits of decision support and automated planning rules, and the way automated planning rules can be designed. To achieve this, we now have to actively market the game and extend it with educational packages that allow for an easy adoption of this game under the following target audience:

- Secondary education (Voortgezet Onderwijs, VO): to enthuse students and attract attention to the area of logistics.
- Middle-level applied education (MBO), universities of applied sciences (HBO), and research universities (WO): the game can be used at various educational levels to educate on logistics planning, the challenges involved in logistics planning, to use of decision support, and the design of algorithms for automated planning.
- Employees active in the area of logistics: our game and educational material can be used within training\workshop sessions as well as by individuals.

Follow-up

- First, we need to make sure that everyone can have proper access to the game, which also included proper documentation, manuals, and educational material.
- Second, we need to make sure the game remains available, as the game needs maintenance with new iOS and Android releases. Also proper hosting needs to be arranged in accordance with increasing demands with increasing number of players.
- Third, we need to market the game and corresponding educational material more actively, e.g., at logistics fairs but also by offering workshops at logistics companies.

“this game could stimulate a mental switch towards decision-support and automated planning within the transport sector”

PROJECT PARTNERS

UNIVERSITY OF TWENTE

The University of Twente is the ultimate people-first university of technology, empowering society through sustainable solutions. Role in this project: coordination, algorithm design, supervising the software implementation, and facilitating the interaction between project partners.

PINEAPPLE STUDIOS BV

Pineapple Studios is a software development team that loves fast and beautiful apps. Role in this project: software design and implementation, graphic design, user-interface and animation, and testing.

ROTRA BV

Rotra is a digital freight forwarder. Role in this project: identification and formulation of requirements, co-creator of the algorithms, and active in the valorisation process.

DELTAGO

Deltago brings knowledge to people and organizations helping them to transfer ideas into action and improve their ability to 'act'. Role in this project: identification and formulation of requirements, co-creator of the algorithms, and active in the valorisation process.

EMONS GROUP

Emons Group is a privately owned group of logistics companies. Role in this project: identification and formulation of requirements, co-creator of the algorithms, and active in the valorisation process.

COMBI TERMINAL TWENTE BV

Combi Terminal Twente B.V. (CTT) has a State-of-the-art inland terminal in the Netherlands. Role in this project: identification and formulation of requirements, co-creator of the algorithms, and active in the valorisation process.

EXOMODAL

Exomodal designs software solutions for the logistics sector. Role in this project: identification and formulation of requirements, co-creator of the algorithms, and active in the valorisation process.

DUTCH INSTITUTE FOR ADVANCED LOGISTICS

TKI Dinalog is het technologisch top instituut van de topsector logistiek ter bevordering van innovatie in de logistieke sector.

Publicatiedatum: augustus ’20

www.tki-dinalog.nl