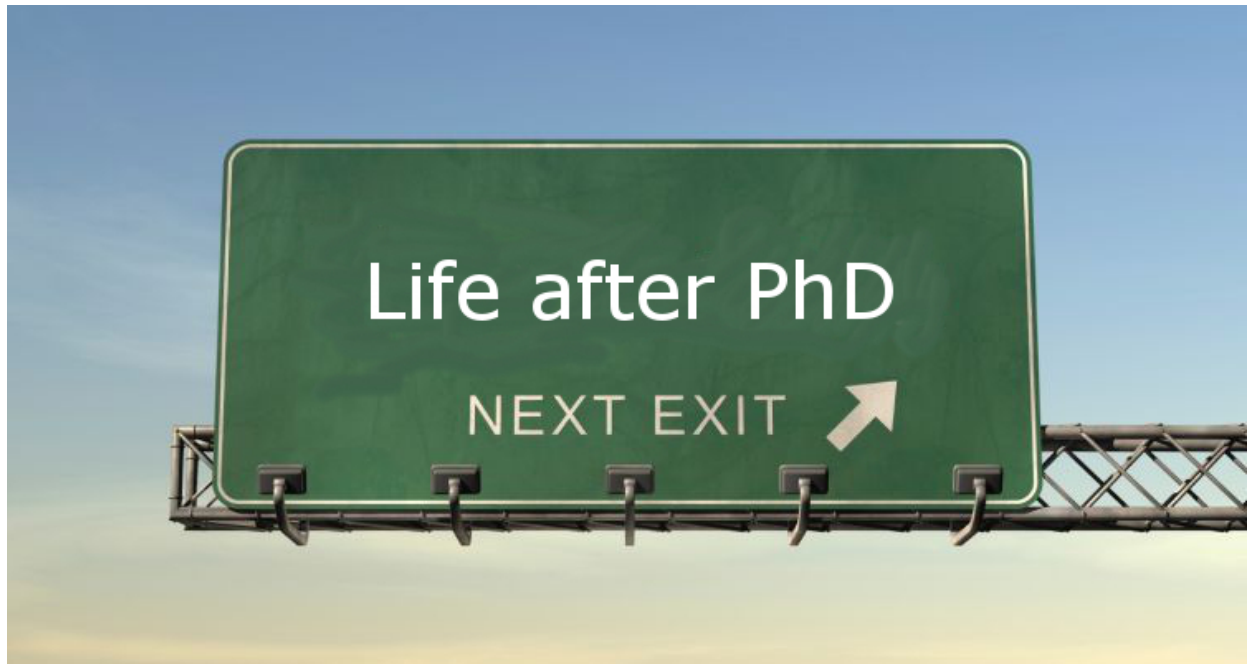


Program of the TRAIL PhD Congress 2018

Room Time	Unico van Wassenaer	Graaf van Leicester	Anna van Oostenrijk	Hertogen
09.30	Coffee/tea			
10.00 - 10.15		Opening		
10.20 - 12.00		Supply Chain Chair: René de Koster	Sharing & Pricing Chair: Jan Anne Annema	Acceptance Chair: Karst Geurs
12.00 - 13.00	Lunch in De Refter			
13.00 - 14.20		Automated Vehicles Chair: Marieke Martens	Activities-travel Chair: Rob van der Heijden	New Data Sources Chair: Eric van Berkum
14.20 - 15.20	Break & Supervisor of the Year			
15.20 - 16.40		Active Modes Chair: Henk Meurs	Network Models Chair: Soora Rasouli	Ports Chair: Iris Vis
16.45 - 18.00	Drinks & Q&A Life after PhD*			
18.00 - Appr. 20.00	Dinner			

* 'Q&A Life after PhD' chaired by Vincent Marchau and featuring Mariska van Essen (Consultant @ Goudappel Coffeng), Olga Huibregtse (Government @ KIM), Yashar Araghi (Consultant @ Significance) and Soora Rasouli (professor @ Eindhoven University of Technology).



‘Q&A: Life after PhD’

Do I want to stay in academia, or does a job in consultancy/government suits me better? How and when should I start thinking about my next career step? Can I develop certain skills during my PhD which help me to get my dream job?

Probably many of you are sometimes thinking about what to do after your PhD. That's why we invited 4 TRAIL-alumni to the congress to talk about their career. In an informal and plenary setting, we will give you the opportunity to ask them about their career choices (17:00-17:30).

The 4 alumni are:

Yashar Araghi – consultant at Significance

Mariska van Essen – consultant at Goudappel Coffeng

Olga Huibregtse – researcher at the KiM (Netherlands Institute for Transport Policy Analysis)

Soora Rasouli – professor at Eindhoven University of Technology

We hope to see all you during drinks this afternoon!

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Sessions

Below you will find a detailed overview of the sessions, presentations and abstracts.

Note that Session Chairs have been requested explicitly to pay attention to 'learning', for each PhD student.

Therefore, a Session Chair will fill in a form with Tops and Tips (presentation style and content) after each presentation. These forms will be discussed with the PhD student during or after the session, depending on the preferences of the Session Chair.

Session Supply Chain

Time : 10.20 – 12.00 hrs.

Room : Graaf van Leicester

Chairman : René de Koster

Program

10.20 - 10.40 hrs. Rie Larsen *

Towards Predictive Synchronicity using Model Predictive Control

10.40 - 11.00 hrs Qinqin Zeng **

Measuring company performance from an environmental perspective: a composite indicator for truck manufacturers

11.00 - 11.20 hrs Borut Zgonc **

Break-even distance estimation between combined and unimodal road freight transport

11.20 - 11.40 hrs Bahareh Zohoori *

Supply Chain Resilience in High-tech Industries

11.40 - 12.00 hrs Wenjing Guo **

Multi-commodity Multi-service Matching Design for Container 2 Transportation Systems

* starting research

** intermediate research

Towards Predictive Sychromodality using Model Predictive Control

Rie Larsen, Rudy Negenborn

Delays have a large impact on the efficiency of the transportation system. Both directly as lost connections and indirectly as cautiousness in the bookings. If a connection is lost, the shipper will have to reschedule, which may be difficult or costly as the transportation slots are already booked. In order to avoid arriving too late for a transfer the shipper may thus plan for longer waiting times at terminals than necessary and choose a route with fewer transfers between vehicles, leading to longer transportation time and more use of trucks. From the vehicle perspective, a lost connection results in an empty slot, unless an earlier delayed container can use the slot. Speculating in providing last minute slots for high prices may lead vehicle owners to spare their capacity in order to maximize their income which may cause inefficiencies in the surrounding transportation network. Inefficiencies in the transportation system does not only lead to slower and more expensive transportation, but also to a higher total energy consumption per transported container and thereby a larger negative ecological impact. When it is planned far into the future exactly what containers are to be transported by what vehicles, the risks imposed by delays are very large. On the other hand scheduling into the future ensures that if everything goes as planned, then the capacity is used the best possible. We propose to plan ahead, but re-plan frequently such that maximal information on the state of the transportation network is present when a decision becomes definitive. The flexible bookings, that are the core of sychromodal transportation, thus have the potential to increase transportation efficiency. To utilize this potential, suitable planning tools have to be developed. Sychromodal bookings allow for last-minute decisions on which freight is transported by which vehicle and can thus prevent inefficiencies if the planning tools operate close to real-time and with continuously updated information. Obtaining and processing information about the transportation network fast is becoming increasingly easier due to advances in information and communication technologies as well as computational power. This shifts the bottleneck in controlling the transportation network towards the planning tools. These tools should not only be capable of planning the transportation efficiently, but also to do so in a multi-company environment.

Such a planning tool is the aim of my work. In this presentation a real time planning tool that simultaneously route containers through a sychromodal hinterland network and plan vehicle (truck) movements in the same network is defined. The model considers multi-commodity flows between multiple origins/destinations and differentiate between different types of vehicles. The network furthermore has scheduled barge and train services. The method is based on model predictive control such that planned decisions that are not yet implemented can be changed online. Thus, since the network contains several intermediate terminals where transshipments can take place, the routes of the containers and trucks through the network are not known in advance. It is however assumed that when a truck departs from one location towards another location, it will arrive there after a deterministic travel time. The planning tool is used to challenge the common assumption in sychromodal planning that truck capacity is infinite and instantly available.

Acknowledgements : This research is supported by the project "Complexity Methods for Predictive Sychromodality" (project 439.16.120) of the Netherlands Organisation for Scientific Research (NWO).

Measuring company performance from an environmental perspective: a composite indicator for truck manufacturers

Qinqin Zeng

Only presentation

Break-even distance estimation between combined and unimodal road freight transport

Borut Zgonc, Metka Tekavčič, Marko Jakšič

The purpose of research is to examine the impact of distance on choosing between combined and conventional rail transport on one side, and unimodal road transport on the other side. In doing so, the break-even distances between the two modes are calculated. The calculation relies on a Monte Carlo simulation that takes account of a randomly generated shipper and receiver's locations in two separated market areas, independently of a certain transport corridor. The main hypothesis of research is that cost is one of the most important modal choice criteria in the freight-mode-choice process. The purpose of this research is to examine this hypothesis and develop a model to determine the mode choice on the basis of the break-even distances. Due to the fact that the break-even distance is difficult to generalize since it is influenced by several parameters, the main emphasis is given to determining the ranges in which break-even distances can occur. The limits of the ranges depend on the variability of drayage and long-haul distances, as well as on the technical and operational characteristics of transport modes, selected travel plans, and transport costs.

Methodically, the ideas and elements of the transport system analytical modelling found in the literature are used. The model consists of a submodule for calculating drayage distances in a circular market area and another submodule for calculating the distances between two separated market areas, taking different distance metrics into account.

The results confirm the importance of distance on the mode choice and show there is not only one but, in fact, many break-even distances between the two modes. They vary considerably depending on different travel plans, and shipper/receiver locations within market areas. Despite the inevitable assumptions made in such general analysis, the results reveal combined and some kinds of conventional rail transport that can provide a good alternative to unimodal road transport, even over relatively very short distances if the drayage costs are not too high. We believe the research helps understand competitiveness better in the freight transport sector and may also be useful for policy- and other decision-makers seeking to improve their evaluation of the opportunities and competitiveness in the freight transport market. Given that our research uses a generalized model to determine the mode choice, we believe that the findings presented in our paper will appeal to the experts who are particularly interested in a general examination of competitiveness of combined and conventional rail transport. Nevertheless, such research could lead to a more sustainable transport system.

Keywords:

Break-even distance; freight mode choice; combined transport; Monte Carlo simulation

Supply Chain Resilience in High-tech Industries

Bahareh Zohoori

Several supply chain disruption cases in the recent decades have shown the extent to which supply chains are vulnerable to variety of adverse events such as natural disasters, supplier bankruptcy, Labor dispute, war and terrorism, etc. According to the report published by Allianz Corporation on top business risks around the world in 2017, business interruption (incl. supply chain disruption) continues to be the top business risk for the fifth successive year (Figure 1). This implies the fact that in order to compete in today's risky business environments, companies need to strive for resilient supply chains by developing proactive and reactive disruption management policies toward disruptive risks. However, supply chain resilience is becoming very challenging due to the complexity of today's supply chains. The challenges are even more when it comes to the supply chain resilience in high-tech industries. High-tech supply chains have specific characteristics such as assemble to order (ATO) strategy, single supplier strategy, scarce capacity, demand and supply volatility, design volatility, etc. that together contribute in a high level of vulnerability in high-tech supply chains (Figure 2). Therefore, the main objective of this research is to provide decision makers in high-tech industries with an appropriate approach helping them to increase their resilience to disruption. Here we try to answer the following main research question:

What is an appropriate approach for designing strategies to enhance the resilience of high-tech supply chains, considering the unique characteristics of these supply chains?

There are three main research gaps in meeting the objective of this research. The first gap relates to unpredictability of disruptive events. Knowing the probability of occurrence and magnitude of risk underpin most of the methods for supply chain risk management. Although such approaches are suitable for operational (high frequent - low impact) risks, but they are not applicable to the disruptive (low frequent - high impact) risks. Here, there is a need for an approach to explore among many plausible consequences of disruptive events on the supply chain, no matter what would be the cause, in order to find areas of need for resilience practices. The second gap relates to the applicability of the state-of-the-art resilience strategies in high-tech supply chains. Although several researches has been done to develop reactive and proactive strategies for supply chain resilience, but evaluating the efficiency of such strategies in different types of supply chains, including high-tech's, need more research. The third research gap is associated with defining thresholds for activating reactive strategies. Candidate contingency plans would be inefficient unless they are activated at the right times. In a case of disruption in the supply chain, there is always a possibility of activating the reactive plans too early or too late. Therefore, it would be crucial to support the reactive resilience strategies with a monitoring system which is capable of detecting risk and defining threshold for activation of contingency plans. There isn't sufficient research in the literature in this regard.

The research will be conducted in three separate but interconnected phases. First the behavior of the high-tech supply chain as a complex socio-technical system will be modeled using agent- based and discrete event simulation. In the second phase the vulnerability of the supply chain and the efficiency of candidate resilience strategies will be assessed under many plausible future scenarios using exploratory modeling and analysis (EMA). EMA is a recent methodology developed by TU Delft to deal with decision making under deep uncertainty. Deep uncertainty refers to situations where decision makers and stakeholders do not know or cannot agree on a system description, the probability distributions of uncertainties or outcome of interest.

This research will apply EMA to deal with deep uncertainty related to future disruptive events that high-tech supply chain may encounter.

Finally in the third phase, a monitoring system will be designed by defining risk warning indicators and reactive plans activation thresholds in order to avoid potential losses due to an early or late activation of reactive plans.

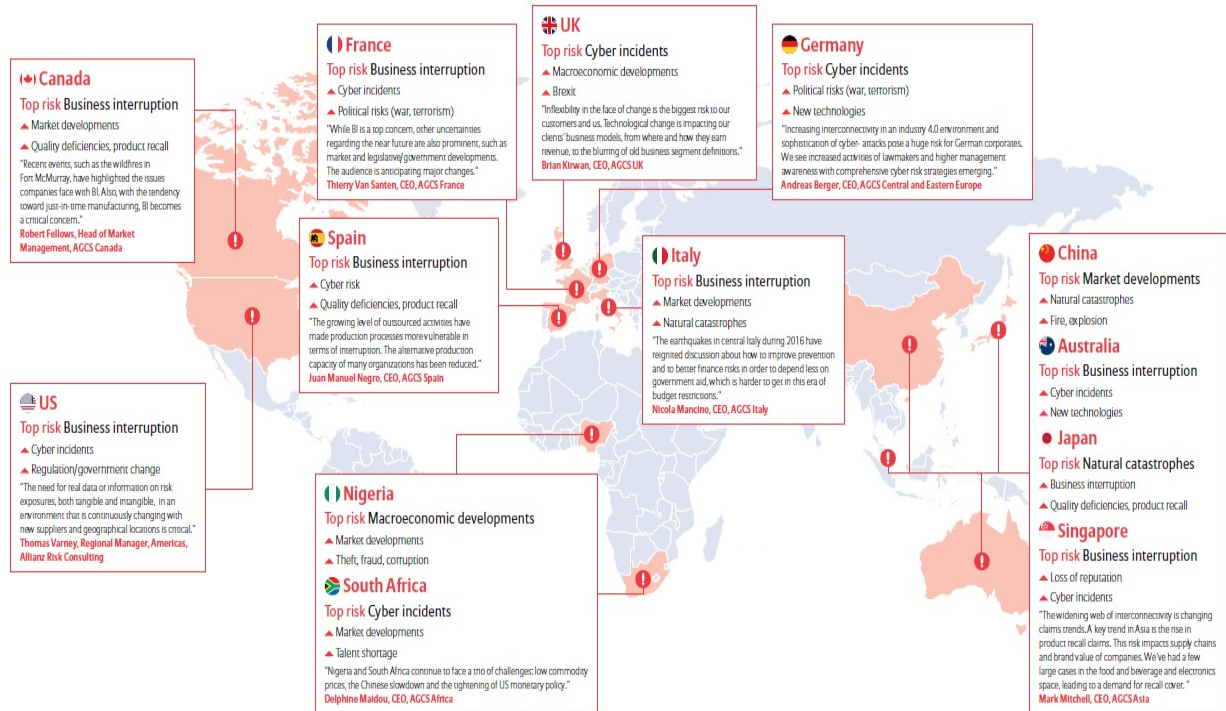


Figure 1: Allianz risk barometer report (2017): Top business risks around the world



Figure 2: Specific characteristics of high-tech supply chains leading to vulnerability

Multi-commodity Multi-service Matching Design for Container 2 Transportation Systems

Wenjing Guo

Synchromodal transportation comprises the promising idea of integrated planning and real time 2 switching while considering cost efficiency, time effectiveness and environmental impact. As the 3 foundation of real time switching, integrated planning has been researched at the operational level. 4 The intermodal routing choice problem is the major problem at the operational level. From an 5 integrated planning perspective, it is typically defined as a multi-commodity multimodal routing 6 choice problem. This paper proposes to consider the routing choice problem as a multi-commodity 7 multi-service matching problem with cost sharing characteristic of self-operated intermodal 8 services among commodities. The multi-commodity multi-service matching problem belongs to a 9 many-to-many matching problem in which a commodity can be matched with multiple services by 10 transferring at terminals, and multiple commodities can be matched with one service by 11 considering cost sharing and capacity limitations. The objective of the matching model is the 12 minimization of generalized cost combining transit cost, transfer cost, inventory cost and carbon 13 tax. Finally, this paper designs a numerical experiment to verify the feasibility of the proposed 14 model. In order to test the influence of the new aspects of the model, four different scenarios are 15 considered. The computational results indicate that the many-to-many matching model is suitable 16 for container transportation systems.

Keywords: Integrated planning , Multi-commodity, Multi-service, Many-to-many matching, 23 Self-operated intermodal service, Carbon tax

Session Sharing & Pricing

Time : 10.20 – 11.40 hrs.

Room : Anna van Oostenrijk

Chairman : Jan Anne Annema

Program

10.20 - 10.40 hrs **Teodora Szep ***

Comparison of incentives for cooperative driving

10.40 - 11.00 hrs **Konstanze Winter ****

Relocating and Parking Strategies for a Fleet of Shared Automated Vehicles

11.00 - 11.20 hrs **Ayu Andani ****

Effects of a toll road construction on the travel behavior of transport-disadvantaged group: a case study in Indonesia

11.20 - 11.40 hrs **Emiliano Heyns ***

Highway congestion

* starting research

** intermediate research

Comparison of incentives for cooperative driving

Teodora Szep

Rush hour traffic congestion is a major problem in urban areas and several attempts have been made to alleviate it. The goal of these attempts is to incentivize drivers to use an initially suboptimal alternative instead of driving during peak hour in the congestion for the sake of decreased overall travel time in the system.

Behavioural studies have extensively investigated incentives and it has been established that there are substantial differences between the two worlds: one where social norms prevail and one where market norms prevail (e.g. Heyman and Ariely, 2004). Moral incentives (such as asking for a favor or working voluntarily) signal that the situation is in the sphere of social norms, while monetary incentives (such as offering a payment) signal market norms. If moral incentives are used in the market sphere or monetary incentives in a social sphere, they can be ineffective, or in some cases even counterproductive. Literature suggests that in several cases extrinsic incentives undermine the intrinsic motivation (e.g., Pellerano et al., 2017). In other cases monetary incentives can increase the effectiveness of a moral scheme (e. g., in the case of recycling, Kinnaman, 2006). The vast majority of transport related literature studies market schemes (such as road taxes, congestion pricing or tradable credits [e.g. Levinson, 2010; Giuliano, 1992; Dogterom, 2017]) for congestion decrease. A few recent studies investigate social schemes as well, such as social routing (Van Essen et al., 2016; Ringhand and Vollrath, 2018). However, to date no studies have compared market and social schemes.

For data collection I use stated choice experiment assigning each respondent to one out of three contexts, each for one specific policy scheme. This is fixed for one respondent throughout the experiment. The core of each policy is that the users of a congested road have to use a mobile application that can send notifications to the drivers and display the alternatives and the recommendations or monetary incentives connected to them.

- The first context is the Social Routing (SR), where the policy is designed in the social sphere. That means I use words (e. g. social) and incentives (recommendation) that signal that the respondent is in the realm of social norms. This can be considered as an educational text, where I raise attention to that individual optimization leads to congestion, and with cooperation everyone can be better off.
- The second context is the Credit Trading (CT) scheme, where the policy is designed in the market sphere. The choice of words in the description (e.g. market, trading, pay) and the incentives (paying for using the individual optimum, and earning with other alternatives) signal that the respondent is in the realm of market norms.
- The third context is a mixture of the above two, a Voluntary Credit Trading (VCT) scheme. In this case I send mixed signals to the respondent by using the educational text with recommendation and monetary incentives too.

After the data collection I use discrete choice models (latent class model in particular) to analyse the results. I compare how specific attributes (such as effectiveness or behaviour of peers) weigh when respondents receive signals of only market norms, only social norms or both at the same time. Besides the behavioural insights, the results will allow to draw conclusion about the effectiveness of different incentives for cooperative driving.

Relocating and Parking Strategies for a Fleet of Shared Automated Vehicles

Konstanze Winter

Relocating and Parking Strategies for a Fleet of Shared Automated Vehicles

With the ongoing progress in the development of automated vehicle technology, questions about the potential impacts of self-driving vehicles on our current transport system become more urgent. In this paper, we focus on the impacts of a fleet of shared automated vehicles (SAV) operated in a demand-responsive, taxi-like fashion. We analyze three impacts: (1) congestion, (2) parking consumption, and (3) a potential transport mode shift. In particular, the focus is put on the management strategies for idle vehicles of a fleet of SAV. The automation of shared vehicles providing flexible public transport services in a cooperating fleet allows rethinking how idle vehicles are managed, as they are fully compliant, always ready for operation and do not compete with other fleet members. This research is part of an on-going project aiming at capturing the spatial needs of SAV and how parking policy can contribute to shaping the success of SAV services while mitigating undesirable externalities such as increased traffic volumes or an excessive occupation of parking facilities.

To analyse the impact of different approaches for managing idle vehicles in a fleet of SAV, five heuristic relocating strategies are tested, partly in combination with parking search strategies for on-street parking facilities. The strategies consist of (1) remaining: remaining idle at the last drop-off location, (2) cruising: cruising randomly through the network, (3) demand anticipation: relocating and parking in a demand-anticipatory manner, (4) supply anticipation: relocating and parking to achieve an even distribution of idle vehicle supply in the network on a zonal level, (5) demand-supply balancing: relocating and parking in order to balance demand and supply for the vehicles on a zonal level. The first two strategies allow benchmarking the three anticipatory relocation strategies in terms of additional driven mileage, congestion and location-specific parking space consumption.

The five relocation strategies are tested in an agent-based simulation model (MATSim), which simulates mode choice as a result of the performance of a mode vis-à-vis an agent's desired activity pattern. Each agent has a daily plan with scheduled activities and trips to reach these activities. After the simulation of a complete day, plans are scored based on its utility, and agents can partly alter their plans for the next run, including changing modes. Agents memorize a set of plans and the respective scores, which allows them to select the best plan with each run. The mode choice model based on which agents score and alter their daily plans is derived from established values for the Dutch population for the currently existing modes. For SAV it is based on values derived from a stated-preference experiment featuring these vehicles, which has been conducted previously in this research project.

Simulating SAV in a setting where agents make mode choices based on the performance of the modes allows investigating the impact the operational decisions concerning SAV on the success of SAV. A crucial aspect for SAV becoming a competitive mode are waiting times experienced by users. Short waiting times can only be achieved by operating a sufficiently large fleet of SAV. With the focus being put on relocating and parking idle vehicles of such a fleet, the spatial needs of idle SAV, in terms of quantity and location, can be analysed. This analysis can be used for developing parking management strategies for SAV that seek to provide comparable levels of service across space (in terms of waiting time) while minimizing undesired externalities of SAV such as overly occupying curbside parking space or induced congestion due to parking search or empty cruising of SAV.

To analyse what impact SAV can have on urban mobility and urban infrastructure use, all five strategies are tested for the case study of Amsterdam. For this case study, more than 180,000 agents are generated based on the Dutch activity-based model ALBATROSS.

These agents represent a fifth of the total travel demand of agents traveling within, towards or away from Amsterdam in the ALBATROSS model. The agents travel in a network consisting of more than 30,000 links with limited parking facilities (around 14,000 curbside parking lots are provided). The study area covers the entire built-up area of Amsterdam, which is divided into 82 zones. Simulated modes are private car, a fleet of SAV, public transport, biking and walking. Different scenarios are drawn in terms of the fleet size of the SAV service, starting at 500 vehicles and going up to a fleet size that could potentially serve the current travel demand for private motorized vehicles as boundary cases.

Effects of a toll road construction on the travel behavior of transport-disadvantaged group: a case study in Indonesia

Ayu Andani

The construction of major road infrastructure, such as a toll road, has been proved to improve the accessibility and stimulate the changes of land-use. The additional cost of travel and changes in accessibility that resulted from the interaction of land-use and transportation infrastructure could have an impact on the travel pattern and the preferences of travel (trip frequency or mode choice). This study explores to what extent the construction of a toll road, accessibility perception, and travel attitudes influence travel behavior of low-income people.

A joint revealed and stated preference survey was conducted in Summer-Autumn 2017 to collect data of 1,600 respondents living in the vicinity of the Cipularang toll road gates in Jakarta – Bandung region in Indonesia. The respondents are collected through a door-to-door survey using a computer-aided personal interview (CAPI) technology. The respondents were workers within the productive age (15-64). Thus, it is possible to analyze the trade-offs of travel cost and travel time on a regular basis. Lower-income people were also over-sampled since we expect that the effect of toll road costs to this population group will be higher than other groups.

A stated choice experiment designed in this study followed a fractional factorial design. The experiment only used a subset of all the possible alternatives, although still permits orthogonal estimation. In the survey, eight choice card sets were provided to the respondents. Each card consists of different values of monetary travel costs and time, which is pivoted from the real values of the respondent's recent trip via the toll road. The respondent is asked to choose between four alternatives, which are the combination of route and mode choice: (1) travel via the toll road and use the same mode, (2) travel via the toll road and use a different mode, (3) not travel via the toll road and use the same mode, or (4) not travel via the toll road and use a different mode. Opt-out choices, such as preferred another mode (e.g. motorcycle or train) and not to travel, were provided as well.

In the survey, we also collected data about socio-demographic, retrospective data of travel pattern, as well as accessibility perception of current neighborhood and attitude toward the toll road. From the survey, after the construction of the toll road, we found that the average commuting time has decreased slightly by 4.4%. Moreover, the usage of the car as a regular mode is increased by 60%.

Using the survey data, we develop a mixed logit model and a hybrid choice model which includes two latent variables. The results of mixed logit model estimation showed that the respondents negatively perceive the monetary travel cost and travel time. Other variables, such as income level, age, gender, travel type, and trip frequency were also found to be significant to influence route and mode choice. As expected, low-income people tend to choose opt-out options in which they can travel using the cheapest travel mode (motorcycle).

The model specification will be improved by incorporating latent factors, such as travel perception and attitude, to have a better understanding and prediction of the travel behavior of low-income people. Relevant results will be presented in the TRAIL Conference.

Highway congestion

Emiliano Heyns

Highway congestion is an increasingly pressing societal problem, both in terms of cost (many productive hours lost) and safety (highway congestion increases the risk of accidents). While there is a plethora of research on detecting and predicting traffic flow state from floating car data from data generators such as in-car navigation systems, little research has been done on how data already being generated by cars for the purpose of on-board control available on the vehicle CAN-bus (braking, steering, etc) could be put to use for those road and traffic management.

Preliminary research shows that data from vehicles is most often not clean, and that the same (kind of) information can differ greatly in its encoding, accuracy and resolution from one car manufacturer to another, and even between car types of one manufacturer. Thus, while the data volume that cars generate and could disclose is vast, due to the large variety of manufacturers and car companies the data is very diverse, both in terms of quality, quantity, and formatting. Therefore, it is still very difficult to extract data from cars and to interpret and use the data. Nevertheless, many companies and governments see great potential in this data, and various attempts are underway to extract the data from cars to aid in new forms of traffic management.

Although work has been done in the field on how to communicate the data from cars, there are no standards for what data is used and how the data should be used. There are proposals with respect to how a message will be communicated between vehicles and their surroundings, yet there are no proposals with respect to data quality needs under different circumstances. That means there are no complete requirements with respect to quality of the data, measured in accuracy, precision, resolution, reliability, plausibility, etc. This limits the usefulness of this data to a large extent within the field of traffic management.

The central research question is to find how can we assess the quality of data from cars, qualifying and/or quantifying the characteristics of this data into a data quality measure for the purposes of traffic management. To address this research question, several subprojects have been started, doing targeted research into cases where existing data sources such as floating car data and road side systems are insufficient; cases such detection of road wear and tear, potholes, early detection of incidents, slippery road detection where no roadside infrastructure exists, which would allow the road manager to better prioritise its resources, and possibilities for earlier detection of rising chance of congestion, which could allow dampening the length of the congestion.

Through these use-cases, we will will perform sensitivity analyses in order to find broader, more global measures for quantifying car sensor data quality across these cases. My current work focuses on quantification of the driver behavior under various traffic phases to be used as an early warning system for congestion.

Session Acceptance

Time : 10.20 – 12.00 hrs.

Room : Hertogen

Chairman : Karts Geurs

Program

10.20 - 10.40 hrs **Rick Wolbertus** **

Viewpoints on future electric vehicle charging infrastructure from industry experts and policy makers: An application of Q-methodology

10.40 - 11.00 hrs **Bo Zhang** **

From Passive to Active Drivers' Control Intervention: Exploring the Effects of Uncertainty Monitoring Request on Driver Attention, Take-over Performance and Acceptance

11.00 - 11.20 hrs **Bing Huang** **

Death by automation? Social acceptance of Automated Vehicles: Safety aspects

11.20 - 11.40 hrs **Timo Melman** *

Exploring the differences between comfort and sport mode in Renault's Multi-Sense

* starting research

** intermediate research

Viewpoints on future electric vehicle charging infrastructure from industry experts and policy makers: An application of Q-methodology

Rick Wolbertus

Charging infrastructure is seen as one of the major barriers to widespread adoption of electric vehicles. The lack of public charging infrastructure has often been regarded as a chicken-and-egg problem requiring additional investments from public stakeholders. These policy makers have to deal with a large array of stakeholders (Bakker, Maat, & van Wee, 2014) as the EV charging market is a combination of players in the auto, energy and parking market. These market players have different interests which can be in conflict. However for policy makers it not always clear how these viewpoints are (mis-)aligned, making it harder for them to make balanced trade-offs.

Stakeholder analysis has mostly been lacking when it comes to electric vehicle charging infrastructure planning. Several infrastructure planning studies do take a multi-actor approach when setting the criteria for an optimal charging infrastructure (Guo & Zhao, 2015; Sweda & Klabjan, 2015). However it often unclear how these criteria are balanced and why certain stakeholders were taken into account or left out. Stakeholder analysis was done by Bakker, Maat & van Wee (2014), Helmus & Van den Hoed (2016) and the dissertation of Wirges (2016). These studies highlight the different interests of the stakeholders and indicate which key performance indicators are relevant. However a systematic overview of how these stakeholders interests are aligned or are in conflict is missing.

This study uses Q-methodology (Exel & Graaf, 2005; Watts & Stenner, 2005) to analyse the different discourses that are present around developing charging infrastructure in the Netherlands. Following the steps of Q-methodology, the discourse around charging infrastructure is determined by collecting statements regarding charging infrastructure developments from relevant magazines such as Smart E-Mobility, Charged EVs and online fora on electric vehicles. A sample of 150+ statements was reduced to 44 (the Q-sample) which included all relevant viewpoints on charging infrastructure. The Q-sorting task was sent to 105 representatives that are currently working in the EV charging industry. Representatives were taken from the various fields related to the industry such, which included: Charging point operators, Mobility Service Providers, Utilities, Grid operators, Consultancy, Consumer interest, Car Manufacturing, Research and also policy makers both at the local and national level. In the sorting task participants are asked to rank (given a normal distribution) the statements according to the extent they agree with them. Given the fixed format of the distribution respondents are forced to make explicit considerations. The data was analysed using factor analysis (VARIMAX rotation), in which not the questions but the respondents are entered as variables. Scores on statements were compared across the different factors.

Preliminary (data collection still ongoing) results of the study are summarised as follows:

- The results indicate 3 to 4 different viewpoints on charging infrastructure.
- There is alignment in the following topics:
 - Interoperability across payments systems for charging points (positive)
 - Active role of local government (positive)
 - The use of fast charging stations (negative)
 - Pro-active role of local government in infrastructure roll-out (positive)
 - Feasibility of battery swap technology (negative)

- Significant misalignment can be found across the following topics:
 - The prominent role of the grid operators
 - The dominance of Battery electric vehicles in the zero-emission segment
 - The use of charging hubs instead of single charging stations
-

From Passive to Active Drivers' Control Intervention: Exploring the Effects of Uncertainty Monitoring Request on Driver Attention, Take-over Performance and Acceptance

Bo Zhang

Background

Manufacturers and scientists are now working towards a higher level of automation, where the system is capable of driving in certain conditions with the driver being periodically "out-of-the-loop". In case the system reaches its operational limits, the driver has to take over control in response to a take-over request (TOR), given sufficient time budget. However, in real on-road settings, a TOR with a long time budget cannot be always provided. If the automated driving system relies on radars or cameras to detect a collision with other road users, the achievable time budgets of the TOR are usually short. A concept to cope this issue is to issue an alert or monitoring request (MR) long before a critical location is approached relying on localization information or V2X communication, and could be applied when approaching a part of the road where TORs are likely to occur. The idea of a MR is that a driver is primed to take-over control but does not necessarily have to take over control. At present, the studies investigating the effect of the MR are still scarce.

Objective

The current study aims to investigate whether a MR works as intended by priming drivers to take-over control, and whether drivers would accept a concept that intermittently requests them to monitor the road.

Methods

A system was designed which intends to direct the driver's attention to the road by means of an MR, when the automation enters a location where a take-over is likely to occur. In the same time, the system can still issue a TOR in emergency situations (i.e., when a pedestrian is detected on the collision course). A baseline condition was implemented that only a TOR was presented in case of a critical event, but without MR. To examine whether the MR+TOR system gives rise to a cry-wolf effect, we included a final trial where an MR was presented, but no TOR followed. 42 participants took part in the driving simulator study, and each completed all three conditions in three separate sessions. The driver's monitoring state (i.e., whether the driver was attending to the road and had the hands on the steering wheel), driving performance (braking and steering take-over times in response to a TOR presented after the MR), as well as subjective experience measured and compared between the conditions.

Results

Results showed that the participants were responsive to the MR by looking at the road when requested. When being forewarned by the MR as compared to when receiving a TOR only, the participants had a shorter take-over response time, and fewer unneeded braking when no pedestrians cross the road. Significant lower mental workload, higher acceptance and trust were also rated for the MR + TOR system.

In the final trial where the TOR failed, the participants braked significantly later and harder than in the MR+TOR condition, and three participants collided with the pedestrians. Our results showed that the concept of MR combined with TOR is promising, but at a risk of developing over-reliance on TOR signals among the drivers.

Death by automation? Social acceptance of Automated Vehicles: Safety aspects

Bing Huang

Automated vehicles (AVs) have received much attention recently, particularly when the first pedestrian death involving an automated taxi happened in March 2018 in Tempe, U.S.. The accident puts the spotlight on AVs and raises questions and debates among policy makers, car manufacturers, trend forecasters, and even the general public about safety issues. While in the literature, safety aspects towards AVs have been also discussed and studied by many researchers (Milakis et al. 2017; Kyriakidis et al. 2015; Schoettle and Sivak, 2014; etc.). One stream has focused on the discussion that automating the responsibility of drivers would make the travelling much safer or even generate the opposite effect, such as many studies mention the potential of AVs to improve traffic safety, while Bainbridge (1983) states that there will be more fatalities and damages unless the vehicles are fully automated; Vissers et al. (2016) discuss the Interaction of partially automated vehicles with other traffic. The other stream has centred on the issues related to social acceptance and ethical acceptability (Taebi, 2017). The concern about AVs' safety aspects has been mentioned many time in the literature (Becker and W. Axhausen, 2017; Zmud et al., 2016; Kyriakidis et al., 2015; SWOV, 2017), factors like software or hardware failures, software hacking, or insufficient protection of privacy are all expected to influence the social acceptance. And many questions about ethical acceptability (Santoni de Sio, 2016), such as "when an AV has to decide in a split-second between injuring its driver in a crash, or a pedestrian, how should it decide?" (Bonneton et al., 2016), are unsurprisingly asked mainly by ethics scholars, and are based on carefully designed thought experiments, conceptual analyses and normative reasoning. Needless to say, both lines of research should be considered of crucial importance: understanding both ethical acceptability and social acceptance, especially when related to safety aspects, holds the key to a smooth transition to an AV-era.

This paper contributes to the empirical literature on social acceptance of AVs, with a particular focus on safety aspects, by reporting the results of discrete choice experiments which measured public support levels for future 'worlds' where the introduction of AVs would be associated with significant changes in traffic safety levels. We distinguished between three types of traffic safety related variables: Fatalities caused by conventional cars, fatalities caused by technical failure of the AV (e.g. a software bug), fatalities caused by deliberate misuse of the AV by an external party (e.g. software hack). The first experiment was conducted during the spring of 2017. 510 Dutch adults were asked to state whether he or she supports, or objects against, a scenario where AVs would be driving on Dutch roads alongside conventional vehicles. A standard MNL model is estimated, and the results show that, on average, a fatality caused by the AV is weighted as much as 5 fatalities caused by conventional cars. Such substantial difference in weights suggests that there is a big difference of social acceptance between AV fatalities and conventional car fatalities. This paradoxical but intuitive result arouses our curiosity and interest to delve into the reason. Do people indeed hate being killed by the machine more than by human performance errors?

Or the high evaluation of AV fatalities is due to the perception bias, like reference effects and loss aversion, as the respondents are very likely to make choices by comparing scenarios with current situation where no AVs are existing. Therefore, we conducted a second experiment in May 2018 which we were expected to influence people's reference points, by randomly assigning various reference points to respondents, either a current scenario with no AVs running on roads, or a "future" scenario of a mixture of AVs and non-AVs. Eventually, 412 Dutch adults were investigated. The MNL model estimation results show that when we replicate the first experiment where people's reference point is the current situation, the difference in social acceptance between AVs' and conventional car fatalities can be still found in the dataset, but becomes smaller – a fatality caused by the deliberate misuse of the AV weights as much as 2 fatalities caused by human failure in a non-AV, and a fatality due to technical failures weights 1.5 times larger than a fatality caused by human failure. However, for the respondents who were presented with "future" scenarios, we find a slight difference between non-AV fatalities and AV deliberate misuse fatalities, and even no difference between non-AV fatalities and AV technical failure fatalities. the results show that the reference effect do matter people's evaluation. The first AV accident is highly mentioned and attracts much attention, but as time goes on, it will fade away eventually, just as we did with the conventional vehicles.

By doing this study, we aim to understand and measure social acceptance towards fatalities caused by AVs and non-AVs, and to help pave the way for a smooth and safe transition towards a transport system including AVs. We believe that our results hold important implications for policy-makers, industry leaders and scholars.

Exploring the differences between comfort and sport mode in Renault's Multi-Sense

Timo Melman

Car manufacturers are developing new systems that not only make driving safer but also more comfortable and fun. The latter is becoming more and more important since people spend a large amount of time traveling by car. On average, an adult in the US spends 76 minutes a day driving a vehicle and takes approximately once a week a trip over 80 km (Department for Transport, 2013). One system that is intended to improve the driving experience is Renault's Multi-Sense®, a system that allows the driver to select a driving mode (e.g., sport, comfort, eco, neutral). The Multi-Sense mode affects parameters of the four-wheel steering system, drivetrain, adaptive dampers, and cockpit ambiance (Renault, 2015).

Although the Multi-sense was introduced on the market in 2015, it is presently unclear what the main differences in vehicle state are, that can be measured online from the CAN signals, between different modes. In this exploratory study we investigated which vehicle-related variables discriminate online between the sport and comfort mode.

One test driver drove with a Renault Talisman on a rural road of 9.1 km long containing single-lane and two-lane sections (Fig. 1). The test driver (first author) drove this track 4 times in sport mode and 4 times in comfort mode in alternating order (starting with sport). In this within-subject design, the driver was instructed to drive as he normally would, and with similar mean speed, for both conditions. During the experiment, 887 CAN signals were recorded at a frequency between 10 Hz and 100 Hz, together with the GPS location of the vehicle (sampled at 0.5 Hz).

For each of the 8 drives, we calculated the mean value of each of the signals, the standard deviation of each signal (a measure of variation), and the mean absolute successive difference of each signal (a measure of the amount of sample-to-sample fluctuations in the signal). Next, Cohen's d was computed as a measure of effect size between the 4 values for the sport mode and the 4 values for the comfort mode.

The effect sizes for the 30 most-discriminating measures are shown in Figure 3. The main differences occurred in Engine RPM and engine-torque related values (presumably because the car drove at a lower gear in sport mode, resulting in higher available torque), high-frequency variation in axle height (presumably because of changes in damping; see also Fig. 2), and rear-wheel speed (possibly because of the increased rear-wheel steering in sport mode compared to the comfort mode).

The results show no clear changes in terms of mean speed (Sport: 41.38 km/h, SD = 0.58, n = 4; Comfort 40.81 km/h, SD = 1.02, n = 4), suggesting the same driving style (as instructed) for all 8 trails.

In conclusion, in this exploratory study, we provide first evidence that the Multi-Sense sport mode is manifested by effects in engine torque, body height variation, rear-wheel speed, and rear-wheel angles (Fig. 4). In future research, we will replicate these findings, and aim to contribute to developing driver-adaptive modes towards a better driving experience.

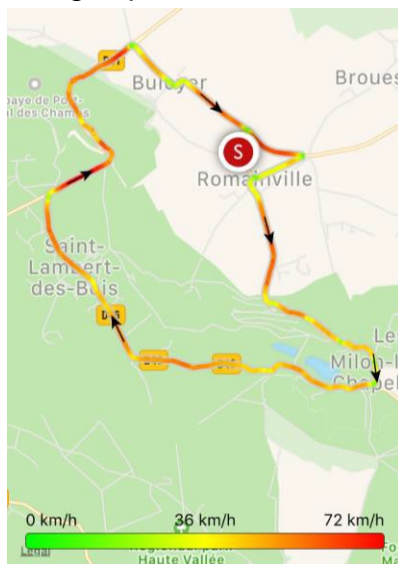


Figure 1. The driven trajectory for all trails. The start/end is visualized with the red S-sign and the driven direction with an arrow.

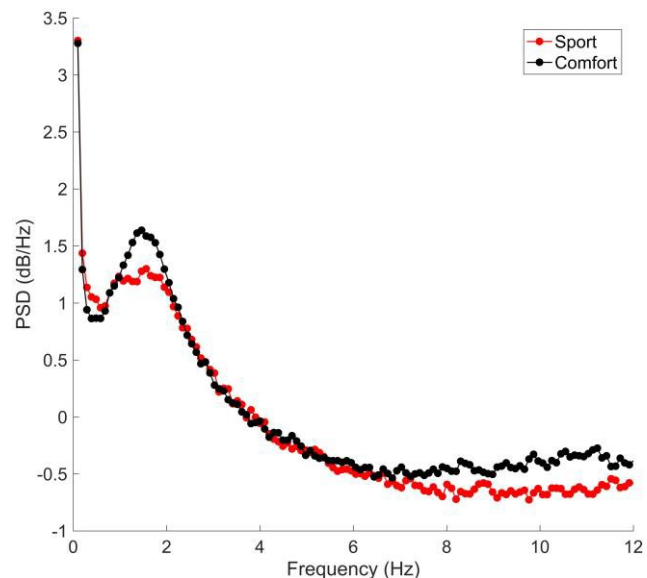


Figure 2. Power spectral density plot of the distance between the rear axle and body for the total driven time for both comfort (black) and sport (red). As can be seen, the comfort mode exhibits more power than the sport mode at the higher frequencies and between 1 and 2 Hz.

Session Automated Vehicles

Time : 13.00 – 14.20 hrs.

Room : Graaf van Leicester

Chairman : Marieke Martens

Program

13.00 - 13.20 hrs **Johan Los** **

Autonomous Vehicle Routing: Optimizing Individual Pickups and Deliveries in a Multi-Agent System with Auctions

13.20 - 13.40 hrs **Anika Boelhouwer** **

Review of HMI transition designs in highly automated vehicles: an embodied interaction perspective.

13.40 - 14.00 hrs **Andreia Martins Martinho** *

Novel perspectives on ethics and Autonomous Vehicles

14.00 - 14.20 hrs **Francesco Walker** *

Gaze Behaviour and Galvanic Skin Response as Indicators of Driver Trust in Automated Vehicles

* starting research

** intermediate research

Autonomous Vehicle Routing: Optimizing Individual Pickups and Deliveries in a Multi-Agent System with Auctions

Johan Los

The trends of autonomous transportation and mobility on demand with increasing numbers of dynamic requests require individual or agent-based vehicle routing optimization that is rarely considered in current decision support approaches.

Autonomous transportation services may no longer depend on (human-controlled) centralized routing, but may autonomously optimize routes on the level of a single vehicle and may therefore even act as independent vehicular entrepreneurs. When vehicles act as independent intelligent agents, their coordination and cooperation becomes increasingly significant, particularly for co-operative routing and traffic management. While many cooperative transportation models assume a centralized planning approach with full information sharing, this is not always possible due to competition or missing information. Embedding agent-based routing models in Multi-Agent Systems (MASs) is one way to explicitly model decentralized optimization with limited information sharing. However, current multi-agent approaches are restricted to simplified routing and transportation problems or heuristic implementations.

We develop a MAS that finds solutions for a realistic Generalized Pickup and Delivery Problem with Time Windows and Preferences, in which multiple pickup and delivery locations can be available per order. Agents responsible for the individual transport orders act as auctioneers, i.e., they try to find an assignment of the order to a vehicle by announcing their requirements, waiting for bids from vehicles, and selecting one of the bids that is most profitable. Autonomous vehicle agents iteratively solve individual decentralized subproblems based on the transport requests they receive.

A novel aspect in our approach, in line with recent developments of metaheuristics, is the computation of exact solutions for vehicles' local subproblems within the decentralized framework, where other auction approaches use elementary insertion heuristics. Solving local subproblems exactly has added value in cases where heuristics fail to find a solution, and global solution quality increases when its constituents have better solutions.

Another important aspect is that order agents interact with only a well-selected promising subset of the vehicles to limit the communicational and computational load. Although we might lack some good bids from other vehicles, we expect a better result due to a gain in time.

We compare the developed MAS approach against a Single-Agent System (SAS), i.e., a centralized planning model assuming full information availability. Although the SAS produces better results on smaller instances of 500 orders, the MAS outperforms the SAS on instances of 1000 and 2000 orders, given limited computation time and using a limited vehicle interaction percentage. We show that the MAS in particular performs well when computation time is limited and the problem size is large. This makes the MAS a suitable approach for large-scale and dynamic routing problems.

Review of HMI transition designs in highly automated vehicles: an embodied interaction perspective.

Anika Boelhouwer

Review of HMI transition designs in highly automated vehicles: an embodied interaction perspective.

Anika Boelhouwer, PhD University of Twente. [566 words]

Highly automated systems can bring multiple benefits for both the driver and society as a whole such as; fuel and accompanying costs reductions, co2 emission reductions, and improved driver comfort. One of the main driver benefits is that he or she can engage in non-driving tasks while traveling as the driver is no longer required to continuously monitor the driving situation. Studies like that of Merat, Jamson, Lai, & Carsten, (2012) have already shown that drivers engage in tasks ranging from reading to playing games on a tablet. and leisure in automated vehicles.

The emersion of drivers in non-driving tasks can create large difficulties when they have to take-back control of the vehicle. Firstly, drivers have to disengage both physically and mentally from the non-driving tasks. Mentally disengaging can be difficult, especially in cognitive and emotionally demanding activities such as reading a book or watching an engaging movie. Physically disengaging may also take some additional effort, for example when the driver has reclined his chair and put of his glasses to relax. Secondly, studies have shown severely lowered situational awareness in drivers that had been engaged in other tasks for long periods of time. When a driver is requested to take-back control, the driver first needs to be able to regain his situational awareness to a level on which he is capable of safely taking back control (Endsley, 2012). If the driver does not take back control on time and in a safe manner; safety, efficiency and comfort benefits of automated driving are lost.

Until now, the development and research on transitioning a driver from a non-driving task back to full control has been mainly addressed from a traditional cognitive psychology (in combination with human centred design) perspective. In this traditional perspective, cognition is considered to be “the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses”.

This study proposes to look at the mode transition case from a different perspective: embodied interaction. This perspective may provide new insights on the transition process and create new design spaces. Embodied interaction proposes that all knowledge and sense-making of the world emerges from a continuous and simultaneous interaction with the world (van Dijk, van der Lugt, & Hummels, 2014). In this perspective, cognition is not strictly designated as sequential processes of the brain. Rather, cognition is the entire system of interaction between mind, body and world. As M. Anderson (2003) stated “cognition is a highly embodied or situated activity [...] thinking beings ought be considered first and foremost as acting beings”. In this embodied perspective, the emphasis of gaining knowledge is focused on the physical acting of a person in a specific situation. By discarding the idea that cognition and knowledge is only mental, new design spaces may be discovered. More emphasis can be put on the combination of mind and body having cognition in interaction with a situated world.

This study will review current mode transition solutions in industry and research based on embodied interaction characteristics.

Concluding, this study investigates two main research questions: (1) To what extent do current commercial and conceptual transition designs in highly automated vehicles take embodied cognition into consideration. (2) Can we find a unused design space for designing mode transitions in highly automated cars (and if so, what is this space?). During the Trail PhD congress the review set-up and preliminary results will be discussed.

Novel perspectives on ethics and Autonomous Vehicles

Andreia Martins Martinho

Great expectations are placed in autonomous vehicles (A.V.s) for reducing road crash fatalities and saving lives. Although the date on which they will hit the market is still uncertain – some authors believe the technology will be ready by 2020 while others suggest two or three more decades will be needed for it to be suitable for widespread use (Sparrow and Howard 2017) - the main point of contention regarding A.V.s concerns ethics rather than technology. Given that societal expectations regarding compliance with traffic rules and prevention of accidents have their foundation in core moral issues found in philosophy and ethics (Thornton, Pan et al. 2017), the actions of A.V.s are likely to be interpreted by society through an ethical lens (Gerdes and Thornton 2016). Therefore, the scientific community has been debating extensively whether A.Vs can be designed a priori to embody ethical principles and which ethical principles should be adopted (Gerdes and Thornton 2016). This debate is particularly rich not only for the amount and diversity of views put forward in the literature, such as Utilitarianism (Bonneton 2015, Bonneton, Shariff et al. 2016, Faulhaber, Dittmer et al. 2018), Rawlsianism (Leben 2017), or Deontology (Thornton, Pan et al. 2017) but also for engaging authors from different quadrants of science. Recently, however, concerns have been raised about an overstatement of this ‘social dilemma’ which could cause a delay in the fruition of the social benefits of A.V.s. (Bonneton, Shariff et al. 2016, Zhao 2016). This work aims at reviewing and exploring novel perspectives on the issue of A.V. ethics. A somewhat straightforward and easy solution would be only to allow systems that enable shared and cooperative guidance and control of vehicles by human operators (Flemisch, Canpolat et al. 2017). Adopting this solution would however exclude full automation vehicles (SAE International level 5) and the social benefits of such A.Vs. A more sophisticated approach is to equip A.Vs. with human social norms and emotions. This means that under extreme situations the A.V. would eventually react as a human being. A recent study introduced the concept of an artificial society of AV.s equipped with different personalities and social norms coded into their auto-pilot. The authors used Netlogo to simulate the artificial society of A.V.s and reported lower average number of accidents when compared to a non-social norms artificial society (Riaz, Jabbar et al. 2018). Although promising, this approach raises important questions related to whether it is ethical to use A.V.s that are not safer than humans (Shladover 2016), the type of situations in which A.V.s should be equipped with human social norms and emotions, and how to capture such norms and emotions.

Gaze Behaviour and Galvanic Skin Response as Indicators of Driver Trust in Automated Vehicles

Francesco Walker *

Extensive evidence shows that drivers' intention to use self-driving technology is strongly modulated by trust, and that the benefits promised by automated vehicles will not be achieved if users do not trust them. It follows that vehicles should be designed to achieve optimal trust. However, there is no consensus as to how this should be assessed. To understand how trust impacts the use of Highly Automated Vehicles we need effective trust metrics. Up till now, most studies have relied on self-reports. However, questionnaires are not a continuous measure. This means they cannot capture real-time changes in user trust, and are hard to use outside an experimental context. Analysis of drivers' gaze behaviour, coupled with galvanic skin response (GSR), could potentially provide a continuous and objective measure of trust.

In previous work we have found preliminary evidence that gaze behaviour can provide an effective measure of trust during Highly Automated Driving (HAD). Furthermore, it is already known that GSR can provide a reliable measure of cognitive load and stress. In this study, we will see whether combining these measures can provide a better indication of trust than either measure individually. Videos will be used to simulate HAD. In the videos, the simulated vehicle will perform longitudinal and lateral vehicle control, and apply the brakes when cyclists or pedestrians are crossing the road. Participants will be asked to pay attention to the road and perform a secondary task, but only if they trust the way the system is handling the driving. We will compare two groups of participants, in the University of Twente driving simulator. One group will view videos of a car handling the driving task perfectly; a second group will view videos of a car struggling with the driving task (i.e. it tends to drift towards the centre of the road and brakes abruptly when approaching crossing pedestrians or cyclists).

In line with Walker et al. (2018), Korber et al. (2018), and Hergeth et al.'s (2016) results, we expect to find a negative relationship between trust, as measured via self-reports, and monitoring frequency and GSR values. We hypothesize that a weighted normalized sum of monitoring frequency and GSR will provide a better measure of trust than either of these indicators alone. If our proposed measure proves to be reliable, it could provide an objective and easily implementable method for continuous measurement of driver trust during HAD

Session Activities Travel

Time : 13.00 – 14.00 hrs

Room : Anna van Oostenrijk

Chairman : Rob van der Heijden

Program

13.00 - 13.20 hrs **Maria Alonso Gonzalez ****

Which is the disutility of sharing a ride? - Willingness to share in ride-sourcing services

13.20 - 13.40 hrs **Baiba Pudane ****

Activity-travel Behaviour in the Automated Vehicle—era: A Time-use Model and Its Estimation

13.40 - 14.00 hrs **Florian Schneider ****

Deriving and assessing activity hierarchies from travel distances

* starting research

** intermediate research

Which is the disutility of sharing a ride? - Willingness to share in ride-sourcing services

Maria Alonso Gonzalez

Mobility as a Service (MaaS) refers to the complete integration of all services related to mobility: including information integration, payment integration and the integrated usage of all available modes of transport. MaaS aims at reducing car ownership and is expected to improve urban mobility, reducing congestion and vehicle miles travelled. However, whether these outcomes take place depends on which modal shifts happen as a result of MaaS and the importance of collective transportation in it.

In the paradigm of MaaS, traditional collective transportation (mass transit) could be complemented with collective flexible on-demand services, such as microtransit. Microtransit can therefore provide a more tailored trip alternative while keeping vehicle occupancy higher than the average private car trips. But the question is, who are the individuals interested in MaaS and in microtransit? Are they the same? And what are their current mobility patterns? Are they current car addicts or traditional public transit users that would eventually adopt these services? These are the questions this piece of research tackles.

MaaS and microtransit do not operate in the Netherlands in an integrated setting as of yet. Therefore, behaviour towards these novel mobility concepts cannot be observed in order to cluster respondents. That is why initial attitudes towards these services are measured and analysed. We perform an attitudinal questionnaire among urban individuals in the Netherlands. Respondents are presented with a series of attitudinal Likert-scale statements related to MaaS and microtransit. This study has a sample size of 1000 respondents. All targeted respondents are eighteen years old or older and live in urban areas in the Netherlands and are part of the Netherlands Mobility Panel (MPN).

The methodology includes a dimensionality reduction followed by a clustering approach. Firstly, a factor analysis is performed to extract a series of latent variables from the attitudinal indicators. The scores on these latent variables are then used to cluster respondents using latent class cluster analysis (LCCA). LCCA differs from traditional clustering methods such as K-means in several aspects. We want to highlight three of them: first, it uses a probability-based classification; second, it uses statistical indicators to identify the number of clusters, and last, it can directly classify the nature of the subgroups simultaneously to the clustering (by including covariates) (Magidson & Vermunt, 2002). On these grounds, we use LCCA for our analysis. The analysis is performed using the LatentGOLD software tool.

The model will be enriched with covariates to explain class membership. The covariates used analyse individual mobility-related attributes and socioeconomic characteristics. This scheme, with the covariates to be included in the model, are depicted in Figure 1.

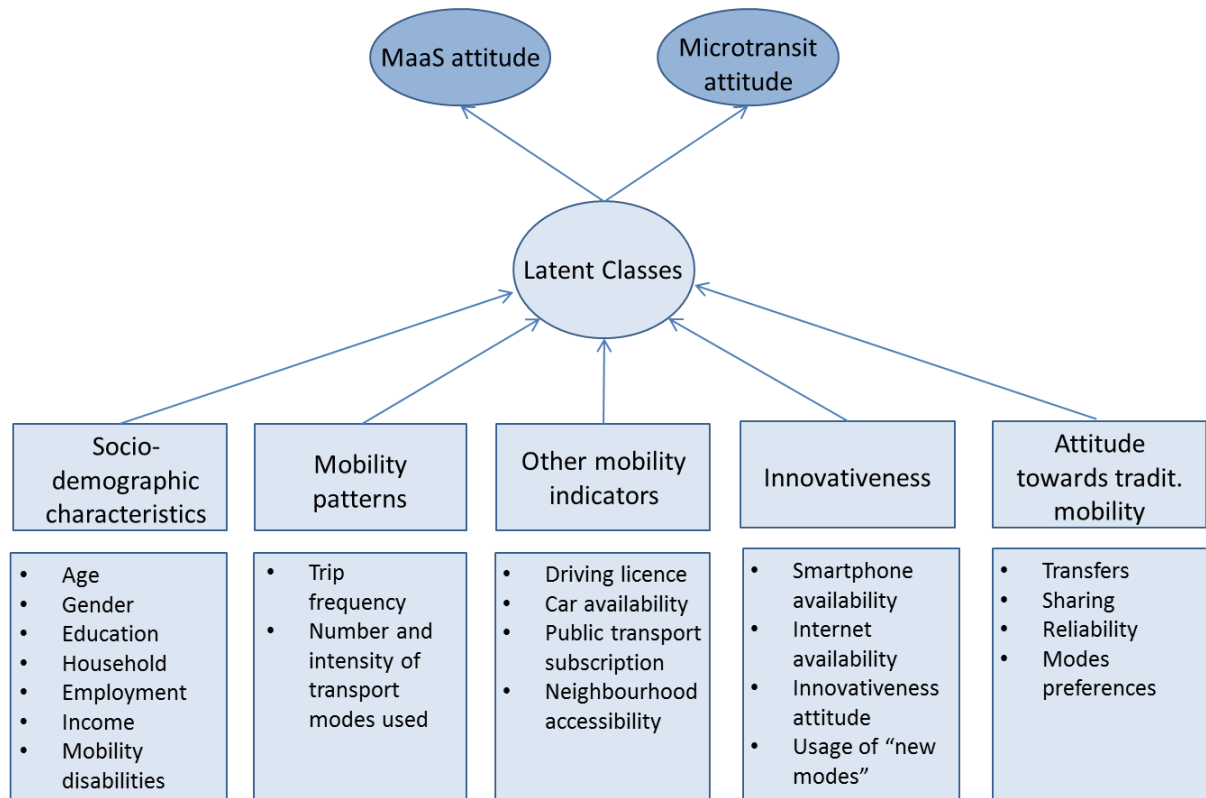


Figure 1: Model scheme

The results of this study will help examining which segments have a positive attitude towards MaaS and microtransit. Consequences of possible modal shifts from these segments towards these new mobility aspects are also discussed. Better understanding the attitudes of different segments can also support customizing MaaS and microtransit to fit the needs and desires of different individuals.

Activity-travel Behaviour in the Automated Vehicle–era: A Time-use Model and Its Estimation

Baiba Pudane

Fully Automated Vehicles (AVs) are expected to change activity-travel behaviour of travellers, because, compared to the present modes, they will allow their users to perform a much broader range of non-driving activities while travelling. Activities that require privacy, absence of distractions and even specialised equipment may be possible in future AVs. Furthermore, on-board environment may be designed to resemble currently stationary locations, such as office, bedroom or kitchen. In such circumstances, it can be expected that introduction of AVs will drastically change travellers' daily activity schedules. Travellers may transfer some of their daily activities to the travel time, which would not only decrease the burden of travelling, but also would free time at other parts of the day. The redeemed time can be used for more activities or longer travel. The latter is a concern of policy makers, since an often-asked question is 'will the productivity and well-being gains of meaningful travel time-use induce more travel?' (Wadud et al., 2016)

Therefore, it is necessary to model the potential change of activity-travel behaviour in the AV-era. The most common approach in the travel behaviour literature is to reduce the penalty associated with travel time (typically, the value of time) to reflect improved travel conditions (e.g., Childress et al. 2015). This approach however cannot capture, for example, the redeemed-time effect mentioned before. We address this problem by formalising activity-travel behaviour in a time-use model, where constraints ensure that activity-transfer and redeemed time effects are captured. Specifically, we assume that individuals are utility-maximisers and optimise the selection of their activities and activity locations (stationary or on board). The model captures an interplay among stationary activities, on-board activities and travel: stationary activities (yielding utility) generate a need for travel (yielding disutility); travel enables on-board activities (yielding utility); on-board activities may (fully or partially) replace stationary activities. Our model is an extension of the classical microeconomic time-use models (Becker, 1965).

Next, we transform the time-use model in order to enable the estimation of its parameters – the utility associated with different activities (performed stationary and on board AV), disutility of travel, as well as the penalty for potential activity fragmentation (splitting any activity among several stationary and/or on-board locations). This transformation yields a constrained MNL model (Martínez et al., 2009), which can be estimated using discrete choice techniques. The necessary data can be obtained from a new type of survey, which may be called 'stated activity-travel diary': participants would re-arrange given daily activity plans with consideration that some activities may be performed during travel. Such survey is currently in planning. In our presentation, we will show our time-use model in the original and constrained MNL form, as well as estimation results – using either synthetic data or first data from the survey.

Activity scheduling is the widely recognised process that underlies our observable travel patterns. In this process, activity participation and related activity attributes such as location or duration are planned in an ongoing process of scheduling and rescheduling. While there is general agreement that the (re)scheduling process is organised around a skeleton of priority activities, the definition of a realistic and practicable priority scheme is still challenging.

Findings in literature suggest that particularly the degree of temporal, spatial and interpersonal flexibility as well as routines shape an activity's priority in the scheduling process. Since this kind of data is normally not available in ordinary travel diaries, activity type (such as work or shopping) is mostly used in practice as a proxy. However, there is some evidence that activity type alone does not sufficiently predict the flexibility and routine degrees of an activity. For this reason, more research is necessary to describe for which combinations of activity types a priority can reliably be derived from this functional activity attribute and for which additional attributes, such as company, are indispensable.

In this study, we propose a new method to derive and assess hierarchies between different activity types from travel diary data. This type of data generally reports the revealed travel behaviour in form of consecutive trips, including in particular information on origin and destination, travel distance, timing (departure and arrival time), used travel mode and on the activity that purposed the trip. There are some signals in literature that travel distance displays the importance of an activity: activities for which people travel further, are more important and thus have a higher priority. Using the scope of home-based tours that include two different out-of-home activity types, we conduct pairwise comparisons regarding the distance-wise arrangements of both activities. More precisely, we calculate relative distance positions by relating the total travel distance to every activity location within the tour to the total distance of the tour. The underlying reasoning is that the more an activity is situated close to the mid-way of the tour (in distance), the more it is dominating it. Consequently, a comparison between the dispersions of both activity types around the half distance of the tour reveals the prevailing hierarchy. In addition, the magnitude of the difference between both measures of dispersion is an indicator of the strength and consistency of the hierarchy. This is the case since large differences can only appear when one activity type is predominantly situated close to the mid-way while the other is mainly close to the home location. Small differences, however, indicate that both activity types are evenly distant from the mid-way or that the distance-wise hierarchy is often inversed between observations.

In order to put our approach into perspective, we use activity durations as a benchmark for the resulting activity priority. Findings in literature report that longer activities are also planned earlier, and thus have a higher priority. A comparative analysis between distance-wise positions and activity durations will allow to validate the method.

Preliminary results indicate that priorities between pairs of activity types could successfully be derived using distance positions. Both the hierarchies as well as their strengths are in line with intuitive expectations. For instance, 'grocery shopping' was clearly dominated by 'work' but much less by 'picking up or dropping off a person'. Moreover, most priorities were confirmed by the outcomes of the activity duration analysis or, conversely, raised interesting questions that deserve further attention.

Session New Data Sources

Time : 13.00 – 14.20 hrs

Room : Hertogen

Chairman : Eric van Berkum

Program

13.00 - 13.20 hrs **Oskar Eikenbroek ***

Pattern Recognition in Urban Traffic Flows

13.20 - 13.40 hrs **Vincent Gong ***

Crowd Characterization using Social Media Data in City-Scale Events for Crowd Management

13.40 - 14.00 hrs **Ahmad Alwosheel ***

Graying the 'black-box': Interpretable Artificial Neural Networks to Understand Travel Choice Behavior

14.00 - 14.20 hrs **Yang Zhou ****

Quantitative analysis of the impacts of wind and current on ship behavior in ports based on AIS data

* starting research

** intermediate research

Pattern Recognition in Urban Traffic Flows

Oskar Eikenbroek

A better understanding of variability in traffic volume, including the corresponding source, allow authorities to optimize local and network-wide traffic management systems. Albeit a general increase of available data sources, still very little is known about the dynamics of urban traffic networks in comparison to freeways [3]. The variation in traffic flows is unambiguously the result of variable travel demand and supply. The impact assessment of policy measures on both a local and network level, however, is often based on the resulting traffic flows. Hence, an extensive analysis with respect to the urban traffic flow time series is required.

Regularity and randomness characterize traffic flow time series [4, 5]. The regularity describes the repeating patterns in the observed flows, which is a fundamental property for prediction schemes. These spatio-temporal regularities are either long- or short-term in nature. Most literature (see Crawford et al. [1], Li et al. [2]) focuses on long-term recurrent variations, i.e., the regularity in traffic flows on a daily level, and the impact of predictable explanatory variables (e.g., day of the week) with respect to the variation. However, traffic flows also show short-term variations, due to, e.g., dynamic traffic signal settings and incidents.

In this paper, we argue that both long- and short-term fluctuations in traffic flow are predictable due to the repeated behavior in time and space. The discovery of spatio-temporal patterns is nonetheless a difficult task. Aggregated measurements in traffic counts do not directly reveal patterns due to random variations (noise and local, short-term, fluctuations in supply and demand) and the aggregation level.

We propose a novel machine learning method that decomposes a multivariate traffic time series into multiple interpretable profiles and analyze the periodicity with respect to the activation of these profiles. The underlying profiles are unknown beforehand, and therefore we use a convolutional autoencoder that finds (1) the long- and short-term profiles in the presence of noise, (2) the activation of each profile, and (3) the linear combination among them to construct a ‘denoised’ reproduction of the original time series. This approach uses the power of the neural network to learn a compressed representation of the input, but we also have the merit of directly interpretable results.

We apply our approach to analyze variation in traffic volumes in the city of Enschede, the Netherlands. Data were collected at loop detectors near signalized intersections from January 2016 to September 2017. We show that the long-term profiles can be used to study traffic demand over time. Short-term profiles can be attributed to local events, such as accidents.

The results show that our approach is able to denoise the original input, and that seemingly different daily traffic flows at a single location consist of the same ‘base’ long-term profile. Moreover, holidays highly impact the magnitude of the peak flow, but its impact is limited with respect to the base profile. Furthermore, we particularly analyze the activations of short-term profiles before and after football matches.

Crowd Characterization using Social Media Data in City-Scale Events for Crowd Management

Vincent Gong

As cities compete for global importance and influence, city-scale public events are becoming an important ingredient to foster tourism and economic growth. Sports events, thematic exhibitions, and national celebrations are examples of city-scale events that take place in vast urban areas, and attract large amounts of participants within short time spans. The scale and intensity of these happenings demand technological solutions supporting stakeholders (e.g. event organizers, public and safety authorities, attendees) to manage the crowd.

Public authorities manage the crowd at a given event, to minimize the risk of incidents due to issues caused by external and internal threats. Crowd managers usually apply predefined measures according to qualitative interpretation of the crowd by policemen, stewards, or event organization employees.

As the efficiency and effectiveness of crowd management measures depend on pedestrian behaviour (1, 2), it is valuable for stakeholders to have information about pedestrian behaviour of the crowd. Pedestrian behaviour is influenced by factors such as age, gender, and ethnicity (3). Insights into these factors in an event's population can help estimating and predicting crowd behaviour, and as such is beneficial to crowd management.

However, information about crowds is difficult to capture, e.g. by manually sampled by stewards or staff members (4) or ICT solutions (e.g. GPS, custom mobile apps). The advent of

Web-based technologies provides new sources of social data that could be used to analyze and understand behaviour. Several platforms such as Twitter, Instagram and Foursquare are widely used. Social media content (e.g. text messages, images) is time-stamped and often geo-tagged, and it inherently contains rich semantic information that could be used for characterizing the crowd. The rich semantic information makes social media a promising data source to provide information for crowd characterization in the city-scale events.

Previous work investigated social media as data source to analyze human behaviour in cities. While showing the utility of social media data in urban application domains, no previous work aimed at characterizing the crowd of city-scale events using factors relevant to crowd management. What is lacking is an in-depth understanding of which factors could be extracted from social media data, and which automatic user modelling techniques can provide accurate and reliable estimation of such factors.

In this work, we first identify a set of factors that are relevant for pedestrian behaviour analysis, and explore methods for extracting information about these factors from social media data. To showcase the application of these methods in real world contexts, we performed two case studies having different properties, the Sail 2015 and Kingsday 2016. In each case, we collect social media data from multiple platforms, extract several properties of their attendees, including demographics, city-role, social media posts coordinate, Point of Interest (PoI) preferences, and word use using SocialGlass1, an integrated system for processing social media data..

We observed that the age distribution in Kingsday is more evenly distributed than in Sail. There is less percentage of local tourists join the Kingsday event than in Sail. Moreover, more social media usage and PoI visits are observed in IJhaven area in Sail than Kingsday event, The word use of the people across events from social media successfully captured the words about event topic and people emotion.

We show that it is possible to characterize crowds in city-scale events using social media data, thus paving the way for new real-time applications on crowd monitoring and management for city-scale events.

Graying the ‘black-box’: Interpretable Artificial Neural Networks to Understand Travel Choice Behavior

Ahmad Alwosheel

Artificial Neural Networks (ANNs) are receiving an increasing interest from the choice modeling community to analyze travel choice behavior (e.g., Hensher & Ton, 2000; Mohammadian & Miller, 2002; Van Cranenburgh & Alwosheel, 2017). This sharp increase in the popularity of ANNs as a tool for travel behavior analysis has resulted from a range of improvements in ANNs’ capabilities, a rapid increases in computational power, and the increasing volumes and diversity of data. However, ever since the introduction of ANNs, but especially in recent years (e.g., Castelvechi, 2016), ANNs have been criticized for its ‘black-box’ nature. That is, unlike the conventional choice models whose estimation results can be directly interpreted in terms of attribute weights, elasticities and the like, the interpretability of estimated ANN’s parameters is very limited. This has led to use the estimated ANNs for forecasting purposes, with less to offer in terms of learning about behavioral processes.

This research aims to investigate this limitation by opening the ANNs’ ‘black box’. More specifically, this research attempts to understand the inner working mechanism of ANNs by identifying which features or patterns each of their input neurons have learned to detect. To do so, we consider a recently developed method in the field of machine learning called activation maximization (AM) (Erthan et al., 2009). Basically, AM methodology uses a ‘reverse-engineering’ approach to synthesize an input (e.g., travel mode attributes) that highly activates a neuron. By doing so, we are able to extract what the estimated ANNs has learned and identify the main patterns of a particular output.

To see to what extent AM can provide interpretable ANNs estimations, we conducted a study on one of empirical data typically encountered in the field of choice analysis. Preliminary results show that AM is able to deliver an interpretation of what the ANN has learned. This finding encourages to further explore the interpretation possibilities of ANNs for better understanding of the travel behavior.

Quantitative analysis of the impacts of wind and current on ship behavior in ports based on AIS data

Yang Zhou

Due to the increasing ship traffic flows in ports, maritime traffic safety has attracted much attention. In addition to traffic flow, ship safety is also influenced by external navigational factors. As revealed by AIS (Automatic Identification System) data in the port of Rotterdam, ships behave differently in different external conditions. In this research, ship behavior is deemed as the resulting dynamic movement affected by three aspects, including the ship maneuverability, the control behavior decided by the bridge team, and the external conditions. Instead of using the detailed ship motion in six degrees of freedom to calculate the forces on ships or test the ship maneuverability, the ship behavior can be observed by the other ships or recorded by AIS in real-life situations. Based on a preliminary analysis of ship behavior in the port of Rotterdam by Zhou, Daamen, Vellinga, and Hoogendoorn (2017), the impacts of wind and current on ship behavior in a straight waterway have been qualitatively revealed. However, to further simulate or predict ship behavior in real-life situations, such impacts on ship behavior need to be quantified.

AIS data have been proven to be a valuable source to investigate actual ship behavior. In this contribution, the AIS data set of the whole year 2014 at the entrance to the port of Rotterdam is collected to describe the ship behavior by four attributes, including heading, COG (Course over Ground), SOG (Speed over Ground), and position. To investigate the impacts of wind and current, only ship behavior under good visibility is selected, in which all ships should follow the same rules of conduct according to the COLREGs (International Regulations for Preventing Collisions at Sea). The navigational conditions under good visibility, weak wind, and weak current is defined as the unhindered scenario. The ships are clustered into classes with similar behavior in the unhindered scenario. The ships in these classes are expected to behave similarly in the hindered situation, where the behavior of the classes in the unhindered scenario is deemed as the reference. To analyze the impact of wind, the ship behavior under different wind speeds with different directions is compared to the reference behavior. Based on the locally measured wind data and the heading of each ship, four wind directions are defined, being with the wind, against the wind, wind from the port side and wind from the starboard side. The impact of current on ship behavior is similarly analyzed as well. The vertical current velocity data are collected from the port authority, which is calculated by the SIMONA model (Vollebregt, Roest, & Lander, 2003) with an input of the measured water level from eight stations around the port. Considering only the surface velocity and the depth-averaged velocity are known in a real-life situation, the surface current is defined as the indicator to represent the current condition. The result reveals how wind and current affect the ship behavior attributes. However, from the viewpoint of ship maneuverability, the ship behavior is affected by the resultant force of both wind and current. Thus, to quantify such impacts on ship behavior, the conditions of both wind and current will be considered together to analyze each trajectory as in the real-life situation. This way, the results will reveal the quantitative changes in values and distribution of ship behavior due to the impacts of wind and current. The analysis results can be used in the development of a new nautical traffic model to simulate ship behavior while considering external factors.

Session Active Modes

Time : 15.20 – 16.40 hrs.
Room : Graaf van Leicester
Chairman : Henk Meurs

Program

- 15.20 - 15.40 hrs **Marie-Jette Wierbos** **
Estimating the Capacity of Bicycle Paths and Capacity Drop in Bicycle Flow
- 15.40 - 16.00 hrs **Alexandra Gavriilidou** **
Modelling cyclist queue formation at urban intersections using a two-layer discrete choice framework
- 16.00 - 16.20 hrs **Giulia Reggiani** *
Managing bicycle flows in urban areas
- 16.20 - 16.40 hrs **Alphonse Vial** *
Unravelling Active Mode Mobility in Cities with a Vehicular Sensing Network

* starting research

** intermediate research

Estimating the Capacity of Bicycle Paths and Capacity Drop in Bicycle Flow

Marie-Jette Wierbos

Capacity and traffic demand determine the traffic flow on roads, which is the number of travellers per unit of time. Demand is the desired flow (how many people want to travel per unit of time) and capacity is the maximum flow (how many people can travel per unit of time). Free flow occurs when the demand is beneath capacity while congestion occurs in the opposite situation when demand exceeds the capacity. The maximum flow is reached just before the onset of congestion and drops right after congestion has occurred. This phenomenon is known as the capacity drop and has so far been observed in motorized traffic and pedestrian flow, but not yet in bicycle flow. This research aims to estimate the capacity of bicycle paths of different widths, before and after the onset of congestion.

An experiment has been set-up to estimate the maximum flow rate on a bicycle path. The cyclists were instructed to cycle on a 2m wide path of 60m length. An obstacle was placed halfway through the track, which created a bottleneck by narrowing the path. The width of this bottleneck varied between scenarios in steps of 25cm. Six different scenarios were tested and repeated 3 times each. A sketch of the experimental layout is shown in Figure 1. The demand exceeded capacity in all runs, leading to congestion at the upstream side of the bottleneck. A camera captured all bicycle movements from a top-down angle for the path between 10m before and 2m after the start of the bottleneck. A total of 34 cyclists participated in the experiment, consisting mainly of students who use the bike on a daily basis.

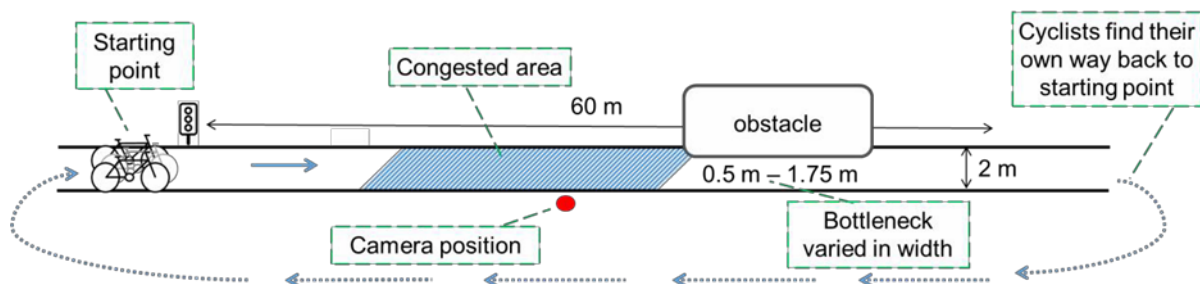


Figure 1 Sketch of the experimental design

The presentation at the conference will describe the experimental setup and the analysis of the camera data. Initial results of the analysis show that the capacity of the bottleneck is linearly related to the cycle path width. The bicycle flow through the narrow section peaked just before congestion occurred and stabilized towards a lower value during congestion. This shows that the capacity drop, which is a phenomenon originally known from motorized traffic, also occurs in bicycle traffic.

Modelling cyclist queue formation at urban intersections using a two-layer discrete choice framework

Alexandra Gavriilidou

Even though the interest in cycling in cities increases, research into bicycle traffic behaviour is still in its infancy. Insights into this behavior, understanding how cyclists interact with each other and make use of cycling infrastructure is crucial if the cities are to be designed to accommodate large amounts of cyclists and ensure their safety. Since models can be used to evaluate different designs under varying traffic situations, this need for insights is linked with the need to create reliable and accurate models that can, for example, assess the capacity of intersections or predict the number of encounters on bi-directional cycle paths as a surrogate safety measure.

This work describes a novel microscopic modeling approach to estimate the bicycle queue formation process at signalised intersections. This process is followed by every cyclist who approaches an intersection during the red phase and queues waiting for a green light. The proposed modelling framework applies discrete choice theory in two layers. The top layer represents the decision making regarding where to stop in a queue. The output of this layer (intended queuing position) is input for the bottom layer, which decides upon the controls (pedalling and steering) to reach this position. Each layer has its own discrete choice model and the result of this interaction and decisions over time is the cyclist trajectory to reach the intended queuing position.

The top layer is illustrated in Fig. 1(a). The cycle lane is discretised in diamond-shaped cells, since they represent better the space a bicycle occupies, and each cell is assigned a utility based on cell attributes. Using discrete choice theory, a model can be estimated from empirical trajectory data, which reveal the significant attributes and their relative contribution to the overall cell utility. This model is, then, used to determine the intended queuing position of each upcoming cyclist, given availability conditions determined by the positions of other cyclists in the queue.

This intended queuing position is fed as input to the discrete choice model of the bottom layer, whereby the cyclist chooses the steering and pedalling intensity with the highest utility. These intensity alternatives are visualised by the fan-shaped grid in Fig. 1(b), inspired by the discrete choice model for pedestrian walking behaviour developed by [1]. The arched zones represent possible speeds that can be reached through pedalling or braking, while the angular sections capture the radial directions accessible with the appropriate steering. A sequence of decisions within this layer leads the cyclist to the final position.

The models for both layers have been estimated based on microscopic trajectory data from cyclist queues that were derived from video camera footage at a signalised intersection in Amsterdam [2]. The estimation approach and resulting models will be presented in the conference.

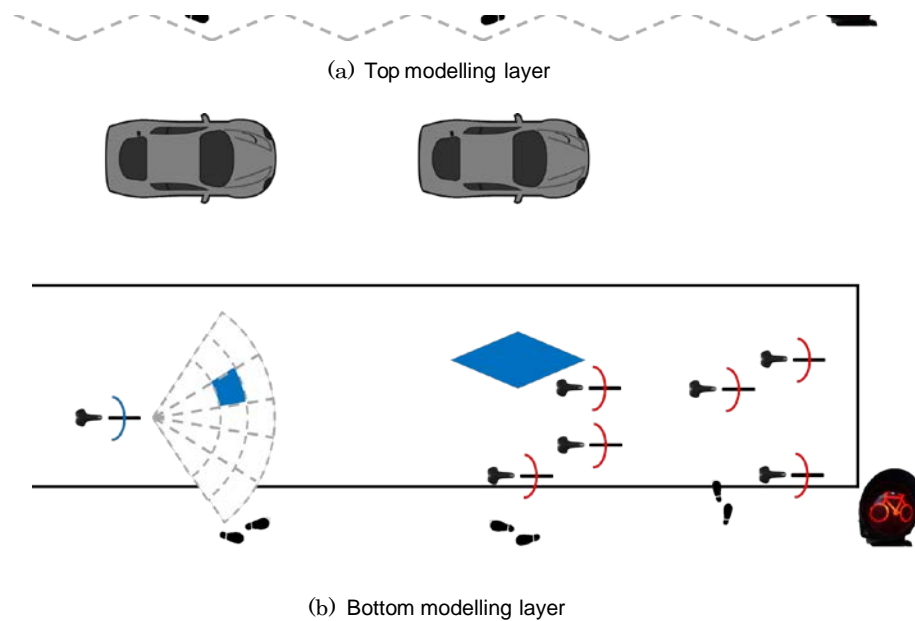


Figure 1: The blue cyclist approaching the traffic light decides in the top layer the intended queuing position (shaded blue cell) based on availability conditions and utility maximisation. Given this, the speed and steering control can be divided in discrete alternatives, whose choice sequence in the bottom layer leads the cyclist to this position.

Managing bicycle flows in urban areas

Giulia Reggiani

Why bike traffic estimation

The increase of trips made by bicycle in the last decade in Europe [6] has brought new challenges for municipalities and road users. Longer waiting times at intersections for cyclists, higher risk of bike-car accidents and decreased road accessibility for pedestrians are just some of the new issues bike-friendly cities are starting to tackle. It is clear that there is a need to manage the existing cycling infrastructure in a safer and more efficient way. In order to develop bicycle traffic management solutions, a state estimation phase is required beforehand, to infer the current on-road bicycle traffic condition from sensors signals.

This research aims to develop real time state estimation models of bicycle traffic in proximity to signalised intersections, in urban areas with high bicycle volumes. The possible applications of this research are: 1) use the estimates as input for traffic control at intersections 2) use the estimates as weights on a graph to define route guidance based on optimal route identification.

Overview of traffic estimation and research gap

Traffic state estimation infers traffic state variables using partially observed and noisy data. The conventional macroscopic traffic states used in car domain are density, average speed and flow [7]. Other traffic states are, for example, queue lengths, waiting time, travel time, number of bicycles in a queue, aggregated volumes. Literature on bicycles shows plenty of studies related to volume estimation (bike counts) and a minority on travel time and speed. To the best of the author's knowledge no research has focused on bicycle waiting time estimation at intersections, with the exception of [2].

By knowing which intersections have longer waiting times, users can take better decisions in their route choice. Waiting time can also be used to improve level of service of intersections by optimizing traffic signal timing. This research started exploring on waiting time because it is functional for the end applications we defined previously. However, we do not exclude to explore other states as well. Most studies use bike data aggregated at the daily level, for example [3] [4] [5]. Only a few use shorter time intervals such as 2-hours and hourly estimates [1] [8]. However, it is of great utility to increase temporal resolution (smaller temporal scale) in order to capture the dynamics of bicycle traffic. Our re- search tries to close the gap, by estimating waiting time with a high temporal resolution.

Research steps and first model

All traffic states can be analysed at one specific location or across a whole network of roads and intersections. The plan is to explore both location and network estimates through the following core research steps:

1. Development of estimation model for bike traffic in one location
2. Red light violation prediction model
3. Development of estimation models on a Network Level.

Our research starts [step 1] by estimating at specific location (one intersection) and then expands [step 3] the model to a road network level (multiple adjacent intersections). The second phase is needed to improve the first-step model. As a fact, having an insight on which factors influence red light violations will make estimates of traffic in proximity to intersections more accurate.

The first part of this study has developed a Neural Network (NN) model to estimate individual delayed travel times (DTT) in proximity to an intersection. Where DTT is defined as the sum of cycling and waiting time. From DTT waiting time can be easily derived subtracting the average unimpeded cycling time. Neural Networks were tested as a methodological approach, given that previous regression and ARIMA models in the work of [2] did not bring accurate estimations. The proposed model uses loop sensor data, traffic light information and queue information of cyclists. Real data signals retrieved from loop sensors were available, however, they were not used due to the incorporated noise. Instead, in order to test the proposed NN model, data was simulated based on camera observations. These NN models revealed to be suitable for this specific estimation task, particularly if the arrival-departure process of cyclists does not include too much stochasticity.

Unravelling Active Mode Mobility in Cities with a Vehicular Sensing Network

Alphonse Vial

While urbanization is defying public spaces, it is important to understand the mobility of people for the design and management of urban infrastructures, as well as public and private transportation. Technologies emerging over the past decades are now entering physical space, creating a new digital layer around our living environment. This new digital dimension can help observe and manage phenomena in cities, aiming to make them more sustainable, while radically changing the way we interact with infrastructure and our environment. This digital layer, which includes sensors and pervasive mobile systems, enables the gathering of large amounts of spatiotemporal data, generated by different types of entities. Observations about individuals (in time and space) can be collected by spatially distributed sensing

platforms, and shared among each other. This way, a number of sensors observe a process which is not observable as a whole for each sensor, however is, for the collection of sensors. In this sensing paradigm, pedestrians and cyclists, both interacting in the urban environment, are temporarily perceived by individual observers (sensing-platforms), and continuously monitored in an observer network (sensing network).

In the past, a number of studies have used vehicles to monitor the urban environment, i.e. traffic, pollution, or road conditions. As the number of sensors in a vehicle has increased by the thrive to so-called intelligent vehicles, it evolved from a purely mechanical to a veritable cyber-physical system that generates large amounts of real-time data. These data are essential to the proper working of a vehicle/s components and functionalities, but at the same time, make them amenable to a multitude of other uses. In the context of this research, the sensing platform, can thus be understood as a vehicle with a variety of sensors, which captures pedestrians/ and cyclists/ mobility features from a number of distinct signals it generates when perceiving its environment. In the foreseeable future, large groups of connected intelligent vehicles are expected to be deployed and coordinate their actions through ad-hoc communication networks. The promising nature of these connected sensing-platforms enables to carry out functions, proven to be difficult when performed by a single vehicle agent. In this dynamic, multi-sensor environment, active mode distributions, velocities and directions can be measured by combining information provided by a fleet of mobile observers (e.g. intelligent vehicles). This offers a number of advantages over more traditional approaches using stationary sensors or more recently available data from mobile or wearable devices.

This research introduces a mobile ad-hoc sensing network that uses intelligent vehicles as sensing platforms. This research attempts to organize ideas and bridge elements from different fields of research, combined in a robust research framework to measure active mode mobility in cities. The elements presented at this year/s TRAIL conference, as part of a global work plan, set forth the groundwork of the future PhD research. Addressing this vehicular sensing paradigm, identified attributes and requirements to such a wireless sensor network will be presented and discussed. Then, information, categorized in sensor types, and applied methods, for detecting and tracking pedestrian and cyclist movements, both derived from prominent literature and building the technological foundation of this research, will be explained. Ultimately, spatiotemporal coordination and control for the mobile sensor platforms will be discussed, and suitable approaches for state estimation in sensing networks that describe the large-scale environment are introduced. Overall, the presented research considers the state of the art, discusses important research challenges, while assessing the technological potential, paving the way to this new sensing paradigm.

Session Network Models

Time : 15.20 – 16.40 hrs

Room : Anna van Oostenrijk

Chairman : Soora Rasouli

Program

15.20 - 15.40 hrs **Yongqiu Zhu** **

Integrated timetable rescheduling and passenger routing using dynamic event-activity networks

15.40 - 16.00 hrs **Breno Beirigo** ***

Dual-mode vehicle routing in mixed autonomous and non-autonomous zone networks

16.00 - 16.20 hrs **Ding Luo** **

Complex network representations of public transport service supply

16.20 - 16.40 hrs **Gert-Jaap Polinder** **

Evaluating a line plan

** intermediate research

*** advanced research

Integrated timetable rescheduling and passenger routing using dynamic event-activity networks

Yongqiu Zhu

Depending on the severities of interruptions, Cacchiani et al. (2014) classify railway timetable rescheduling models into two types. One deals with disturbances that refer to small perturbations like extended running/dwelling times of trains. Another one deals with disruptions that are relatively major events leading to dropped infrastructure capacities (e.g. station closures or track blockages on open track sections). In railway systems, disruptions take place on a daily basis, and usually last for a long time. For example, an average of 7 disruptions occurred per day in the Dutch railways, and each of them lasted for 2 hours, 43 minutes averagely, considering the period from January 1, 2011 to February 28, 2018 (data source: www.rijdendetreinen.nl). In practice, the current way of handling disruptions is based on various contingency plans that are designed beforehand. When a disruption occurred, a suitable plan is selected, and possibly modified further according to the disruption specifications. Both the design and modification process is completed by experienced dispatchers, during which passengers are rarely considered. As a result, the disruption timetable is not passenger-friendly. Therefore, this paper establishes a Mixed Integer Linear Programming (MILP) model that automatically produces an optimal disruption timetable by taking passengers into account.

The first challenge of this problem is adapting the time-distance train paths to the dropped infrastructure capacities, in order to prevent any conflicts between trains. Most literature about disruption timetable generation focuses on this challenge. For example, Ghaemi et al. (2018); Louwerse and Huisman (2014); Veelenturf et al. (2015); Zhan et al. (2015). The second challenge of this problem is considering passenger reactions towards the timetable during the rescheduling process. The literature on passenger-oriented timetable rescheduling for disturbance is actually solving this challenge, whereas the first challenge (i.e. IBTI) doesn't need to be considered. For example, Corman et al. (2016); Dollevoet et al. (2012); Sato et al. (2013).

The literature focusing on both challenges is quite few, but receives increasing attention in recent years. For example, Veelenturf et al. (2017) prepare a series of timetable adaptations first, and then decide which adaptations should be applied depending on whether the resulting passenger convenience is reduced. The decision process is embedded in an iterative framework where one adaptation is decided in each iteration. Such adaptations are limited to adding extra stops to trains. Cadarso et al. (2013) reschedule the timetable and rolling stock simultaneously by completely cancelling trains or inserting emergency trains. Passenger demand is obtained by a frequency-based assignment model first, and then the rescheduling model aims to accommodate these passenger demand as much as possible. Binder et al. (2017) include passenger assignment during the rescheduling based on a pre-constructed graph. By discretizing the time horizon, the possible adaptations to train services due to different dispatching measures are transformed to train-relevant arcs including delay arcs, re-routing arcs

and conflict arcs. Passenger-relevant arcs (e.g. transfer arcs, waiting arcs, etc.) are also constructed to ensure passenger assignment. Then, only binary variables are needed in the rescheduling model to decide which arcs should be chosen by trains or passengers, in order to generate a passenger-friendly disruption timetable without any operation conflicts.

In this paper, we deal with both challenges. A Mixed Integer Linear Programming (MILP) model is established, in which timetable rescheduling and passenger routing are integrated. Five dispatching measures are adopted, which are delaying, reordering, cancelling, flexible stopping, and flexible short-turning trains. Flexible stopping means that for each train, the original scheduled stops could be skipped, and extra stops could be added to the stations which it originally passes through. Flexible short-turning means that a train can flexibly choose the station to be short-turned. For each train, among the stations that it originally serves or passes through, the ones of which the layouts permit short-turning are all chosen as the short-turn station candidates. By introducing flexibilities regarding stopping patterns and short-turn stations, more alternative path choices can be explored for passengers, thus improving the possibility of producing a passenger-friendly disruption timetable. To describe passenger behaviour dynamically during rescheduling, we propose a dynamic event-activity network. This network is dynamically formulated during the rescheduling process according to the applied dispatching measures, based on which passengers can be assigned to the appropriate trains considering their preferences on waiting times for the first trains, the in-vehicle times, the number of transfers, and the waiting times at transfer stations.

The proposed model has been tested to part of the Dutch railway network with 17 stations and 6 train lines operating half-hourly in each direction. Long computation time is found as an issue of this model when using the mathematical programming solver GUROBI. In future, an efficient algorithm will be designed to solve this model.

Dual-mode vehicle routing in mixed autonomous and non-autonomous zone networks

Breno Beirigo

Abstract— Autonomous vehicles (AVs) are expected to widely re-define mobility in the future, transforming many solutions into autonomous services. Nonetheless, this development requires an expected transition phase of several decades in which some regions will provide sufficient infrastructure for AV movements, while others will not support AVs yet. In this work, we propose an operational planning model for mobility services operating in regions with AV-ready and not AV-ready zones. To this end, we model detailed automated driving areas and consider a heterogeneous fleet comprised of three vehicle types: autonomous, conventional, and dual-mode. While autonomous and conventional vehicles can only operate in their designated areas, dual-mode vehicles service zone-crossing demands in which both human and autonomous driving are required. For such a hybrid network, we introduce a new mathematical planning model based on a site-dependent variant of the heterogeneous dial-a-ride problem (HDARP). With a numerical study for the city of Delft, The Netherlands, we provide insights into how operational costs, service levels, and fleet utilization develop under 405 scenarios of multiple infrastructural settings and technology costs.

Index Terms— Autonomous Vehicles, Ride Sharing, Mobility Services, Autonomous Zones, Dual-Mode Vehicles

Complex network representations of public transport service supply

Ding Luo

Complex network science has been adopted as an appealing tool to study public transport networks in the past decade, but critical challenges hindering the further development of this field still remain. This study aims to address some of these challenges by making a threefold contribution. First, we propose a multiscale representation of the public transport network which is consequential for constructing the input network graphs that are needed for the complex network science approach. Second, we enrich several topological representations of the public transport network by adding weights derived from the scheduled service to links. An application of these enriched representations to node importance analysis based on centrality measures is presented. Third, we offer an open source tool for the implementation which takes the General Transit Feed Specification (GTFS) data as the input. The Amsterdam tram network is used as a case study to demonstrate the proposed methodology. The multiscale representation of this network is first presented, and the subsequent analysis shows that the centrality measures computed based on the enriched graphs better reflect the service supply of the network. This study paves the way to a series of applications which allow the transportation community to further benefit from complex network theories and methods.

Evaluating a line plan

Gert-Jaap Polinder

1 Introduction

In railway planning processes, the traditional approach is to consecutively find a line plan, a timetable, a rolling stock schedule and crew schedules. For each of these individual problems, models and methods are available to find good solutions, if a solution exists. The solution to one of the problems, serves as input for the next problem. This consecutive approach is a natural approach, but has the drawback that it does not necessarily lead to a globally optimal solution, i.e., a model that integrates everything can in theory lead to better solutions. Next to this, it is not necessarily true that a solution to one of the problems provides feasible input to a problem that is solved later. For example, suppose we find a good line plan and use that to find a timetable. It is very well possible that no timetable exists corresponding to this line plan. Reasons for this can be that there are too many trains on the network or that certain required connections can never be realised. A method to overcome this, is to integrate several of these planning steps into one model. An overview and some models to achieve this can be found in Schöbel (2017).

Although this integration might lead to better results, it means that several computationally challenging models are integrated into even more difficult models. In our research, we try to bridge the gap between line planning and timetabling in a different way. We want to analyse a line plan with respect to operational feasibility and want to take into account what such a line plan would mean for passengers.

2 Our approach

In our approach to analyse a line plan, we start by integrating timetabling and passenger routing. This leads to a highly complicated model. First of all, the timetabling model is already hard to solve, it is shown to be NP-complete by Serafini and Ukovich (1989), and solving it by a Mixed Integer Programming solver generally does not lead to optimal solutions. Next to this, when integrating the passenger routing, many routes are possible. First of all, this is due to the fact that a timetable is not yet known, and hence the connections between trains are not known. Secondly, there are many possible geographical routes.

Since no timetable is known yet, we assume passengers arrive at their origin station according to a uniform distribution. As soon as they arrive, they are assigned to a path that minimizes their total (weighted) travel time. This travel time is composed of waiting at the origin station, an in-train time, a possible transfer time and possible transfer penalty.

We relax the integrated model, by leaving out the safety constraint and by only considering 'reasonable' (geographical) passenger routes. Furthermore, we can leave out a number of OD- pairs that are very small and have only short journeys, and hence they do not really influence the timetable. This leads to a model that can actually be solved on reasonable sized instances. This model provides a timetable, together with passenger routes, but it is not a feasible timetable from an operational perspective, as safety constraints are left out. However, it does give an idea what the ideal timetable would look like, from a passengers point of view and it can give a good estimate what passenger travel times approximately are. Furthermore, we can compare this to the current situation and see where we improve and for who the timetable becomes worse.

In order to deal with the fact that no safety constraints are taken into account, we use a method by Cacchiani et al. (2015), and slightly adapt it to our needs. This method required an input timetable (which is computed by our integrated model), and tries to schedule all trains in a feasible way, while trying to schedule them as close as possible to the time they are planned in the input timetable.

3 Results

We tested our methodology on instances of Netherlands Railways. We show we can solve our integrated model on reasonably sized instances and obtain good results. Furthermore, we show that by the algorithm of Cacchiani et al. (2015), we can achieve a feasible timetable that increases the passenger travel times by only a small percentage with respect to that of the input timetable.

Session Ports

Time : 15.20 – 16.40 hrs.

Room : Hertogen

Chairman : Iris Vis

Program

15.20 - 15.40 hrs **Camill Harter** *

The European hinterland transport network as a complex network – How is robustness affected by the multi-mode and multi-operator structure?

15.40 - 16.00 hrs **Bob Castelein** **

What makes a reefer hub? Cold chain policies for container ports.

16.00 - 16.20 hrs **Hobbs White** **

Planning with heterogeneous elements of transportation capacity in synchromodal networks

16.20 - 16.40 hrs **Mingying Xu** **

The evolution of the shipping sulphur cap: multi-level governance in rhetoric or reality?

* starting research

** intermediate research

The European hinterland transport network as a complex network – How is robustness affected by the multi-mode and multi-operator structure?

Camill Harter

Robustness of transport networks has widely been studied for unimodal networks. Hinter- land container transport, however, comprises multiple interlinked networks formed by different transport modes, which impacts robustness. On the one hand, alternative transport modes provide backup capacities, on the other hand, disruption can cascade easier across interlinked networks. We show that robustness against random and targeted failure differs substantially between multimodal networks and their unimodal counterparts and assess how this general- izes to other multimodal networks. We use a unique dataset containing all intermodal services scheduled in the European hinterland from 2016-2018.

Keywords: hinterland transport, complex networks, robustness

What makes a reefer hub? Cold chain policies for container ports.

Bob Castelein

Reefer containers – temperature controlled containers used in the ‘cold’ supply chains of temperature- sensitive products – are a fast-growing segment in the container shipping market. The intermodal compatibility, reliability (in terms of delivery and quality control), flexibility, and traceability that these containers and associated technology provide make it an attractive means of transportation for temperature-sensitive cargoes. Facilitated by these technological developments in the reefer market, the growing global demand for temperature-sensitive products, such as imported food products, flowers, specialty chemicals and pharmaceutical products drives the further expansion of reefer trades. The past decade, the reefer market has been the only segment showing consistent year-on-year growth in a generally depressed container shipping market.

Accordingly, port authorities and port users aim to attract these fast-growing, high-value cargo flows. Reefer containers however, place more stringent demands on port infrastructure, energy supply, and handling processes than standard containers, prompting the question what measures port authorities can take to help better facilitate the transportation of reefer containers and hence improve their competitive position in this market. While the scientific literature on port competitiveness has addressed the question how (container) ports can become more attractive to port users, so far containers have been considered ‘black boxes’ – a homogenous commodity without regard for differentiation in their contents. As ports compete not only for volume, but for value as well, a more disaggregated perspective on container flows – and how ports can better attract and facilitate these – is desirable, taking into account developments in niche markets such as reefer containers.

This paper addresses this gap by focusing on port policies specifically tailored to respond to challenges and opportunities in one segment of the container market, namely the reefer market. The study surveys policy measures implemented by the 50 largest container ports in the world, in order to identify the spectrum of measures applied. Drawing on this database of measures, the study arrives at a typology of measures categorized conceptually by type, goal, and scope.

A hierarchy is observed in these types of measures, in that port authorities implementing the most advanced types of measures typically have the broadest

spectrum of measures overall, including measures that directly target the physical handling, storage and transportation of refrigerated cargoes. The goals of the policies – as far as articulated by port authorities – are diverse beyond the attraction of valuable cargo

and activities only, and include food quality improvements, modal split targets, and stimulation of the domestic agrifood sector.

Cold chain policies can be implemented within the port area, directed towards the ports foreland or hinterland, or impact on the overall cold chain. Most commonly, ports (co)-invest in or aim for cluster formation around cold stores within the port.

There is little evidence that port authorities pursue policies in line with an overarching strategy, taking into account the logistics, marketing, technology, and sustainability dimensions of cold chain facilitation. Based on this policy classification, we outline the general tenets such a strategy should contain as a consideration for port policymakers.

Planning with heterogeneous elements of transportation capacity in synchromodal networks

Hobbs White

Synchromodality is an outgrowth of the intermodal planning field and builds on previous investigations into extended gate networks and responsive routing. As a dynamic system, it is intended to encourage advantageous modal utilization and operational flexibility, and centers on a model of open-mode bookings whereby a client shipper relinquishes route and mode choice to the synchromodal network operator. The operator can then leverage its situational visibility and discretion over routing and modal decisions to support system-wide efficiencies. The operator is enabled to aggregate freight flows across its network, and to defer certain assignment decisions until late in the planning horizon. This decouples the specific allocation of freight flows from the sourcing of transportation capacity in the network planning process, presenting the operator with an opportunity to tailor their motive network structure to meet the particular needs of their client base or similar strategic goals. To this end, the operator may curate a portfolio of varied transportation capacity to serve prospective demand. We note that capacity planning should therefore be considered as a longer-term planning exercise. However, there is limited parity in the focus on system design problems within intermodal research, and we argue that intermodal networks, and synchromodal networks in particular, would benefit from further inquiry into the strategic planning of transport supply. Thus, faced with uncertain demand, an intermodal network operator must source transportation capacity from an assortment of carriers and service providers, heterogeneous in characteristics such as mode, cost, and availability. The network operator seeks to hedge against the risks of inefficient asset utilization and costly recourse to subcontracted carriage by selecting optimally from a set of potential agreement classes with capacity suppliers, each subject to varied ranges of duration, lead-time, and commitment thresholds for purchase. We address this planning problem by presenting an optimal capacity investment policy under stochastic demand. We do so using a multidimensional cost minimizing newsvendor program with sequentially revealed demand, with which we are able to comment on (i) the appropriate level of transportation capacity to install in a given network, and (ii) the selection of the particular capacity elements from a heterogeneous supply pool to ensure this optimal

level is met. This analytically tractable methodology supports an intuitive solution approach for the synchromodal capacity investment problem. It further can provide easy to digest scenario-dependent rules for optimal investment policies. We will illustrate this model in a stylized synchromodal system on a constructed intermodal network, with particular attention paid toward strategic capacity sourcing.

The evolution of the shipping sulphur cap: multi-level governance in rhetoric or reality?

Mingying Xu

- *Objective*

To reduce ship-generated sulphur emissions, the International Maritime Organization (IMO) has set global sulphur limit in MARPOL Annex VI and designated Emission Control Areas (ECAs) where stricter sulfur cap is imposed. However, pending implementation issues, the absence of standard for enforcement, and a strong cost-saving incentive to non-compliance, have triggered mounting concerns over possible patchy enforcement and distortion of a global level playing field for the shipping industry. The objective of this presentation is to further our understanding of how the ECA sulphur regulation is implemented through the perspective of multi-level governance, and derive implications for global sulphur cap implementation. Hence the research question is: what are the dynamics in multi-level governance that shape the implementation of ECA sulphur regulation?

- *Data/Methodology*

A qualitative approach is adopted in this presentation, based on document analysis, interviews and field observation. Documents of relevance include academic studies, practical research reports, policy papers, press releases, etc. Interviews are conducted with a variety of stakeholders of the issue, ranging from regulating authorities and agencies, shipping companies and trade associations, port authorities, refineries, bunker suppliers, fuel testers, research institutes to environmental NGOs. Coding is conducted for interview data analysis. Empirical findings also come from observation of IMO meetings and access to its archives. Based on insights from the multi-level governance theory and policy implementation literature, a conceptual model is devised to further analyze the above-mentioned data.

A comparative case study is in design to gain empirical findings. Three countries in existing ECAs are chosen as cases, namely, the Netherlands, the US and China. The first two are located within IMO- designated ECAs, whereas the one in China is promulgated by its domestic legislation.

- *Results/Findings*

In this ongoing research, the development of ECA sulphur regulations in the three cases is first traced, and key elements such as actors, their resources and their level of action are mapped out. Such retrieval is necessary because stakeholders' interests, positions and their interactions in policymaking may form dynamics that influence policy implementation. Implementation of ECA sulphur regulations is then compared and unraveled by revisiting these dynamics, as well as the context and institutions that constitute the overall setting.

Some of the preliminary findings include:

- Though IMO member states are the decision maker at the IMO and solely responsible for implementing the sulphur regulation, shipping and oil industry have gained considerable weight on the sulphur issue, with their activities noticeable on various levels in various arenas, and from policymaking to enforcement;
- A member state's explicit environmental orientation and strong influence in legislative discussions does not necessarily translate into stringent enforcement of subsequent regulation;
- Institutional complexity, which triggers coordination and contention, can provide opportunities for stakeholder involvement and network formation in policy activities.

- *Implications for Research/Policy*

First, in terms of theoretical implications, this research shows that the concept of multi-level governance can be a helpful descriptive tool to study public policies in multi-level regimes, but contextual and institutional factors deserve the attention of researchers when applying multi-level governance in their policy analysis.

Second, by adopting a governance perspective in analysis, this presentation investigates a relatively less probed side of the sulphur cap issue by delving into its governance arrangements and dynamics.

Third, as work in progress, this project may contribute to further understanding of maritime environmental policy implementation on the global level, and provide insights for implementing the forthcoming 0.5% global sulphur cap effective since 2020.

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NOTES