Towards a New and Inclusive Public Transport System

Research Agenda 2023-2027

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Towards a New and Inclusive Public Transport System

The world of public transport is changing rapidly. Developments such as electrification, automation, and shared mobility have had an impact on both demand and supply. Besides being smooth and safe, public transport must now also be green and inclusive. And then there is the still tangible impact of Covid-19. To make the right choices in this evolving landscape, we need new knowledge and new tools. Niels van Oort, associate professor at Delft University of Technology, drew up an updated Research Agenda for this.

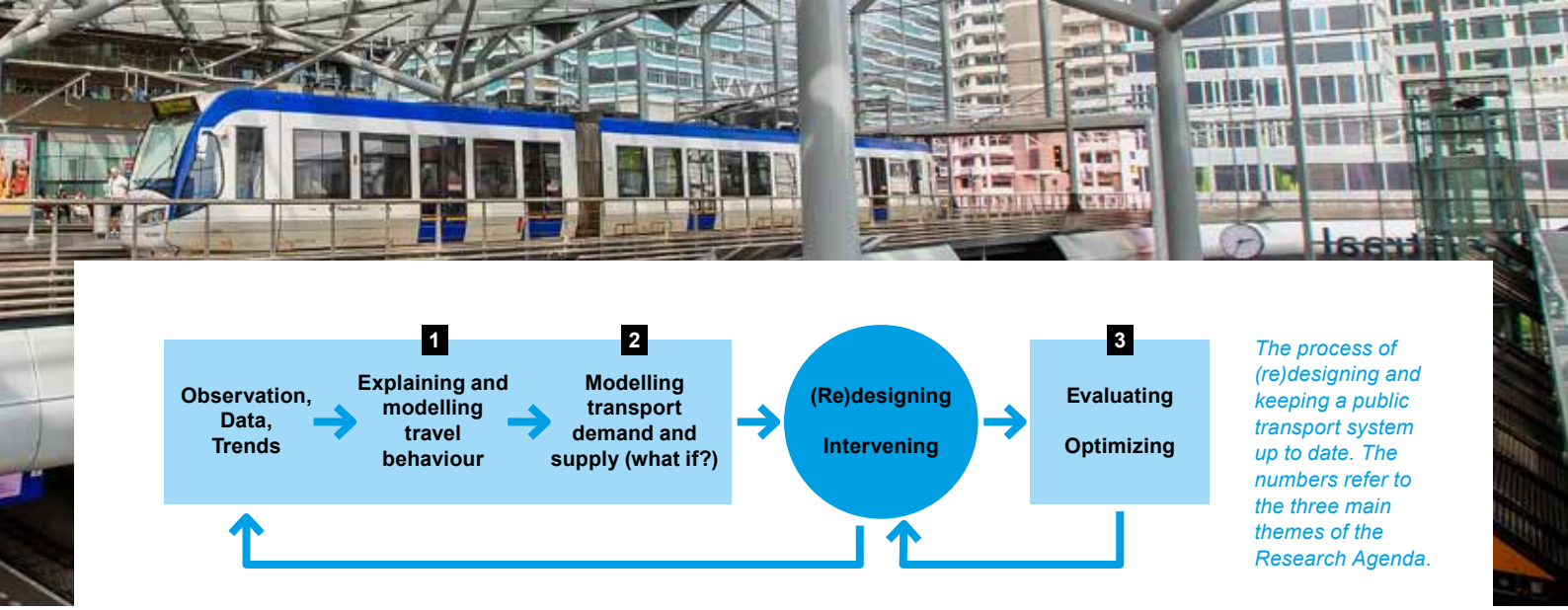
Trains, trams, buses, and metros have been ideal means of transporting large groups of passengers from A to B and back to A for decades. In terms of efficiency and space utilization, public transport is unbeatable, and these modes of transport should ideally remain so for many more decades.

Changing Landscape

However, this is not a done deal. To unlock the potential of public transport, the system must align optimally with the needs of passengers and society. This requires nearly perfect design and excellent operations. The challenge lies in the fact that the landscape of public transport is undergoing significant changes.

To begin with, developments like electrification, automation, and shared mobility have led to a range of new modes of transport, from electric shared bicycles to autonomous shuttles. These new modalities can serve as valuable additions to traditional public transport, as first-mile and last-mile solutions. But it is also possible that passengers will choose these new modes of transport as *alternatives* to public transport. How bad is that? What factors influence the passenger's choice of (new) transportation? And how can we achieve an optimal mix of transport modes?

Meanwhile, public transport is also facing new goals and ambitions from society. Apart from being efficient, punctual, and reliable, transportation must now also be green and inclusive. With 'green' the public transport system is already well on its way, but what about 'inclusive'? What is required to avoid excluding groups and



The process of (re)designing and keeping a public transport system up to date. The numbers refer to the three main themes of the Research Agenda.

to ensure accessibility for, for example, people in rural areas? Shared mobility could be a solution, supported by hubs and Mobility as a Service, but how can we integrate it into the public transport system?

A final 'development' that has significantly impacted public transport is Covid-19. The lockdowns themselves of course did not do the transport providers any good, because transport virtually came to a standstill at times. But even now, *post-Covid*, the effects are noticeable: teleworking is more widely accepted, and some public transport users continue to avoid crowded places, resorting to private transportation. How long will these effects persist? And how can we make the public transport system more resilient, so it can adapt effectively to potential new crises and recover quickly?

New Insights and Tools Needed

The fact is that many of the questions mentioned above cannot be adequately answered at the moment, at least not in a scientifically substantiated manner. This is not surprising because a (partially) new landscape inherently requires (partially) new knowledge and tools. Given the importance of public transport and the societal goals that a robust public transport system can help achieve, it is crucial to promptly address these gaps.

At the *Smart Public Transport Lab*, we are eager to take the lead in this endeavour. When (re)designing a public transport system, you typically go through several phases – as depicted in the accompanying figure. We have assessed in each phase what knowledge, methodologies, and models are lacking to capture and calculate the new developments and requirements. We have then incorporated these 'blank spots' into this (updated) Research Agenda. Over the next five years, until 2027, we will focus on the three research lines of this Agenda.

As we explain on the next pages, we will conduct fundamental research but also develop and test new methodologies and models. In these efforts, we actively seek collaboration with governments and public transport companies to ensure that the insights and tools align effectively with the practical realities of public transport.

1 Research Line Travel Behaviour

→ Objective

To estimate how travellers respond to the availability of new modes of transport and disruptive events such as Covid-19, we need a better understanding of travellers' intentions, preferences, and behaviour.

→ Intended Results

We are working on new behavioural models to explain travel behaviour, including mode choice. With these models, we aim to *predict* such behaviour as well.

Explanation

With current insights and behavioural models, it is possible to predict the effects of, for example, an additional bus route here or an expansion of the railway there. It is even possible to estimate the prospects of a single new mode of transport. However, if we want to determine how all these new and emerging modalities – like flexible public transport, shared bicycles, and so forth – relate to each other and how they influence traditional trains, trams, buses, and metros, our current knowledge falls short.

Choice Behaviour

Understanding travellers' choice behaviour is particularly important, or in other words: what factors determine how a person chooses his or her mode of transport. So far, much research has been conducted on the influence of aspects such as waiting time, travel time, transfer time, and reliability. However, these are *dissatisfiers*: a traveller expects nothing less than a minimum waiting time, for example, and at such a point you can at most disappoint (if you fall short) and hardly seduce. To complete the picture, we need to investigate many more factors, such as weather, station accessibility, and *satisfiers* like convenience, shelter, and lighting. We also need to gain insight into the extent to which these factors differ per travel motive, per type of new mode of transport and (in the case of a multimodal trip) per type of connection.

In all of this, it is important not only to consider the (current) public transport passengers, but also travellers who do *not* use public transport. Why do they avoid public transport? Is it possible to tempt them to take the train, tram, bus, or metro? Can these new modes of transport help in this regard?

Another knowledge gap related to choice behaviour concerns the impacts of crises and disruptions. For example, has Covid-19 changed our attitudes and behaviour to such an extent that our mode preferences have also permanently changed? And what role does the possibility of working from home play in this context?

Tools

To acquire this knowledge, we need new methods. Asking travellers about their preferences, through methods like stated preference surveys, is valuable but not always sufficient: in addition to subjective *stated* preference, we also need objective *revealed* preference. We need to reconcile these two worlds, for example by combining surveys with GPS tracking. If entirely new scenarios are involved, then the use of virtual and augmented reality is an interesting option.

With this combination of subjective and objective data, we can develop, evaluate, and refine new behavioural models.

2 Research Line Demand and Supply

→ Objective

We aim to gain a better understanding of the interactions between the demand for (public) transport and its supply, considering the availability of new modes of transport and disruptions such as Covid-19.

→ Intended Results

We are developing comprehensive forecasting models that are able to incorporate new modes of transport, model multimodal journeys and could consider (sudden) behavioural changes, such as more frequent teleworking. In alignment with this, we will also update routing and timetabling models.

Explanation

In Research Line 1, we examine the impacts of new modes of transport and events like Covid-19 on traveller behaviour. In Research Line 2, we take this altered behaviour as a starting point and explore what it means for the traffic and transport system.

Challenges

An example. Depending on our use of new modes of transport, these modalities will sometimes *replace* but often *complement* conventional modes of transport. In the latter case, journeys become multimodal, where a traveller, for example, takes an electric shared bicycle to the station, from there travels by train and covers the last part by shared taxi. The concept of 'coexistence' and 'multimodal' is only marginally included in the current forecast and transport demand models. More research is needed to capture the dynamics between demand and the increasingly diverse supply.

New behaviour resulting from, for example, Covid-19 also require us to reconsider planning, especially for train services. Many public transport companies still operate with fixed hourly patterns throughout the day and week. But if we continue to work from home more, it may be useful to make the timetables flexible, with a busy Tuesday

or Thursday having a different arrangement than a quiet Friday. We could even go a step further by also varying the *routes*: different start or end points and/or different stops, depending on the time of day or week. This way, passengers always get a train service that is tailored to their needs, while the transport provider can offer that service at the same or perhaps even lower costs. Variable planning is currently a bridge too far for routing and timetabling models: they need a major update.

Tools

To (further) develop the aforementioned models, we need new techniques. In the case of forecasting models, the challenge lies in accurately simulating real-time dynamics and interactions within the expanding transport system. Agent-based simulation methods can effectively model passenger preferences. To predict the interaction between demand and supply, machine learning and deep learning techniques appear to be the appropriate methods.

For the update of routing and timetabling models, we intend to apply advanced clustering techniques to analyse demand patterns throughout the day and week. Subsequently, we can design a flexible timetable using mixed-integer programming models and genetic algorithms.

3 Research Line Design and Evaluation

→ Objective

To better evaluate public transport projects on their merits, we need more insight into so-called broader benefits, such as inclusivity and sustainability. What is the 'value' of public transport and shared mobility when considering these benefits, and how can we steer the design accordingly?

→ Intended Results

We will introduce a new method for designing and assessing a multimodal public transport and shared mobility system. This new methodology should be multi-objective and focused on (also) achieving societal goals.

Explanation

With the knowledge from Research Lines 1 and 2, we have a solid foundation for designing a public transport system, including flexible schedules. However, what do we aim for with that system? Traditionally, we measure the success of a public transport system based on speed, punctuality, and passenger numbers. But there is now a growing awareness that the value of public transport – especially compared to private transportation – encompasses more. For this purpose, we previously developed the so-called *5E model*, which identifies five themes contributing to success: Effective mobility, Efficient city, Economy, Equity, and Environment. This model provides guidelines for quantifying these different values, but the last two require further exploration.

Inclusivity

We have a fairly clear understanding of what is involved in the theme of equity or inclusivity: it ranges from physical exclusion to geographical exclusion and the 'digital divide.' However, the question is how to make these aspects concrete, with sharp definitions, for instance, and how to measure them. In the initial stages, our research will focus on this aspect. Once clarity is achieved, we can shift the focus to developing and testing 'inclusivity interventions' and methodologies to implement those measures in a well-founded manner.

For this part of the Research Agenda, we will use various quantitative and qualitative methods, including GIS analyses (identifying where specific problems occur), interviews, focus groups, and serious gaming.

Sustainability

Then the topic of environment. The transport sector is responsible for a quarter of total greenhouse gas emissions in the EU. Solutions like electric (shared) mobility are believed to help reduce this environmental damage. However, how sustainable are these new modes of transport and services, really? And how does this compare to public transport? Reducing the use of fossil fuels is always beneficial. But electric vehicles also have an environmental impact: that energy must first be generated. The problem of fine particles due to braking and tire wear may even increase because electric cars are often heavier. To have a complete environmental picture of transportation, we must also consider the indirect costs, such as the infrastructure and vehicle production, including any electric batteries.

To make the right considerations in terms of sustainability, we intend to conduct life cycle analyses of all different modes of transport and services. This way, we can steer the design and evaluation of (public) transport systems based on the direct and indirect environmental impacts of a solution.

Do You Want to Contribute to Our Agenda?

We seldom conduct research in the Smart Public Transport Lab alone: our professors, lecturers, postdocs, and PhD students work closely with transport companies, government agencies, and consulting firms. This ensures that our research aligns optimally with the field.

We are always open to new collaborations, including on the topics outlined in this Research Agenda. So, do you recognize yourself in the challenges outlined and the planned research? Do you have useful data? Do you see opportunities for setting up case studies and field lab experiments? Do you have other ideas, or do you just want to know more about our Agenda? Then call or email Niels van Oort: **+31 6 15 90 86 44** / **n.vanoort@tudelft.nl**

→ About Niels van Oort

Dr. Niels van Oort is associate professor of Public Transport and Shared Mobility at Delft University of Technology and co-director of the Smart Public Transport Lab. His research primarily focuses on designing and evaluating public transport systems. He consistently finds a balance between the sometimes conflicting interests of governments, transport companies, and passengers. His goal is to make a societal impact and contribute to a society that is accessible, inclusive, and sustainable.

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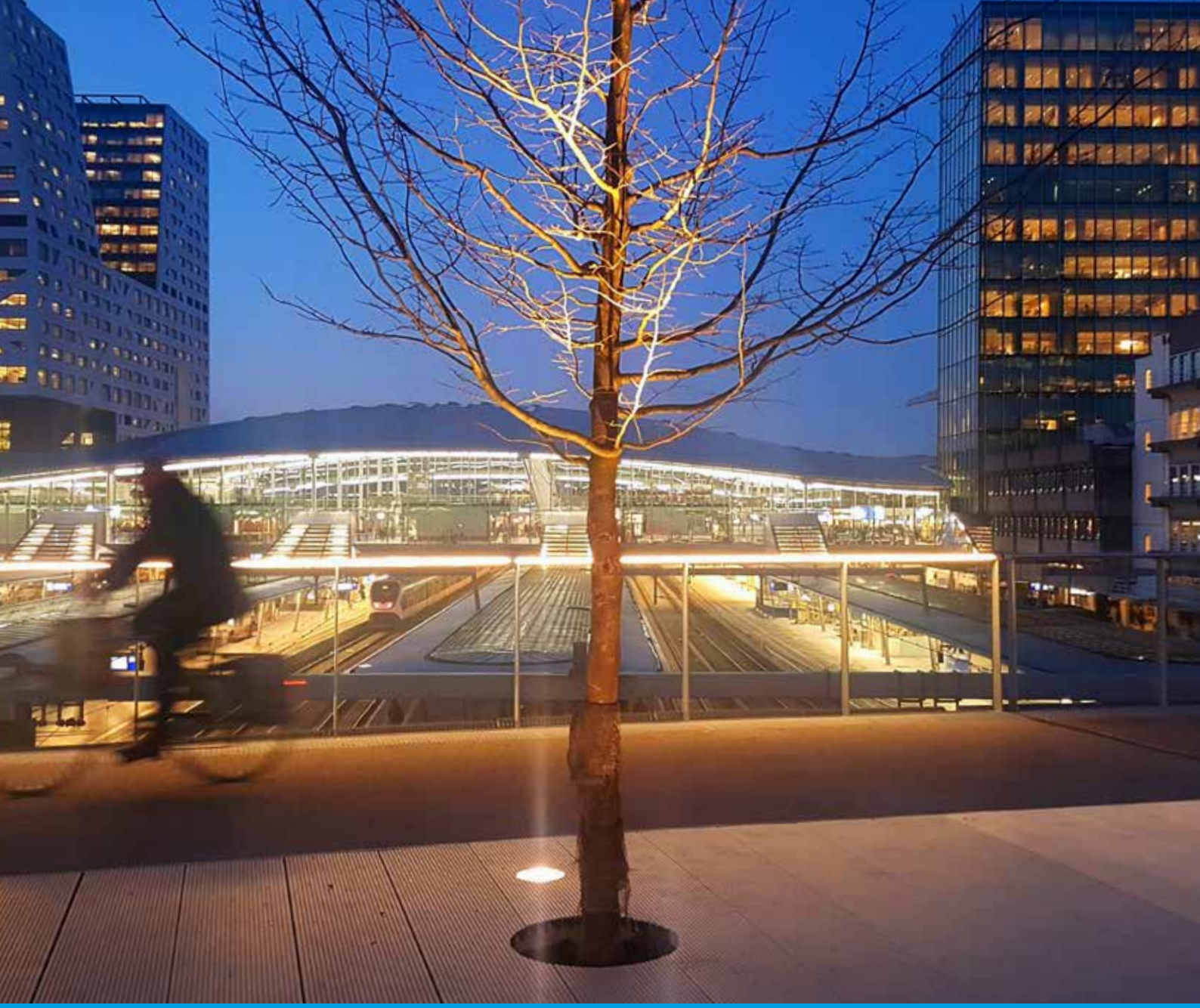
→ About the Smart Public Transport Lab

The Smart Public Transport Lab at Delft University of Technology develops novel solutions and methods for planning, operating, and managing public transport. The lab involves nine (associate) professors and more than twenty PhD students, postdocs, and researchers. Every year, around twenty students graduate from the lab. Together, they guarantee high-quality scientific research with practical relevance. The Smart Public Transport Lab collaborates closely with government agencies, transport companies, consulting firms, and other knowledge institutions.

smartptlab.tudelft.nl



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