ITRL — INTEGRATED TRANSPORT RESEARCH LAB

KTH ROYAL INSTITUTE OF TECHNOLOGY

ITRL

Annual Report 2022

Content

Report designed by Malin Danielsson
Front cover image: Tobias Bolin
Icons: The Noun Project

Towards a transport system in a sustainable society

Transport is a central aspect of the way that we, as humans, live. However, whilst transport systems can contribute towards well-being and prosperity, they can also create negative impacts. For societies to prosper, it is imperative that our transport systems are flexible, smart, and clean, that we offer mobility solutions to all and that we limit the negative impacts of freight transport and the distribution of goods. This is the challenge that drives us.

We believe in an integrated approach. Therefore, to achieve our mission of building and conveying knowledge that contributes to the transition towards sustainable road transport, we integrate disciplines, system levels and stakeholders in our research.

We are currently in a transportation paradigm shift driven by the introduction of new technologies and the crucial need to transition to a sustainable transport system. However, along with the potential for great success in this field, comes a number of challenges.

Vision

Our vision is of a world in which future generations have access to socially just, environmentally clean and efficient transport systems.

Mission

Our mission is to build and convey knowledge that contributes to the transition towards sustainable road transport. We do this by integration disciplines, system levels and stakeholders in our research.

2022 in numbers

Most popular journals for ITRL

- Transportation Research Part A: Policy and Practice
- Travel Behaviour and Society

23
Core members of ITRL

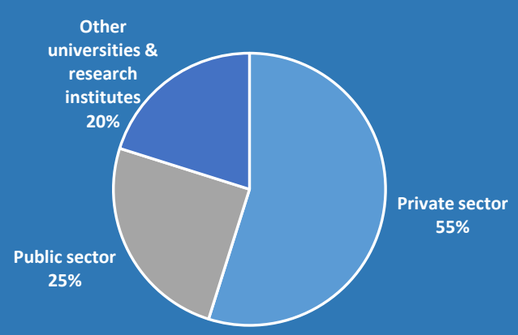
Staff

ITRL consists of a diverse group of people with various disciplines and backgrounds. The core team is at the end of 2022 approximately 23 people, among which there are 39% women (9) and 61% men (14). This contrasts with the year before which saw a more equal distribution.

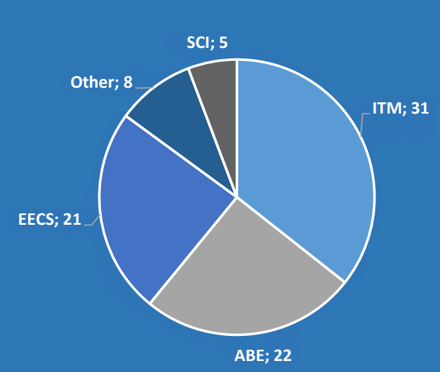
Mustafa Al-Janabi and Kaj Munhoz Arfvidsson became research assistants/engineers, primarily working with Smart Mobility Lab and the lab side of ITRL. During the year we also welcomed several master students from both KTH and other universities.

In 2022 ITRL had a PhD defence and Bhavana Vaddadi became the first person to start and complete their doctorate here. Erik Almlöf successfully defended his licentiate thesis during summer.

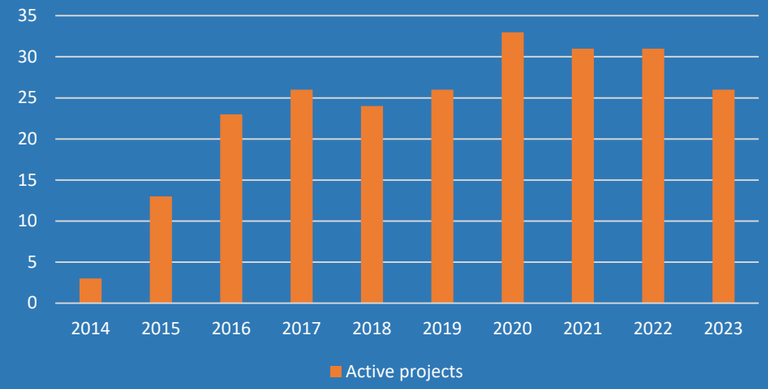
Collaboration partners



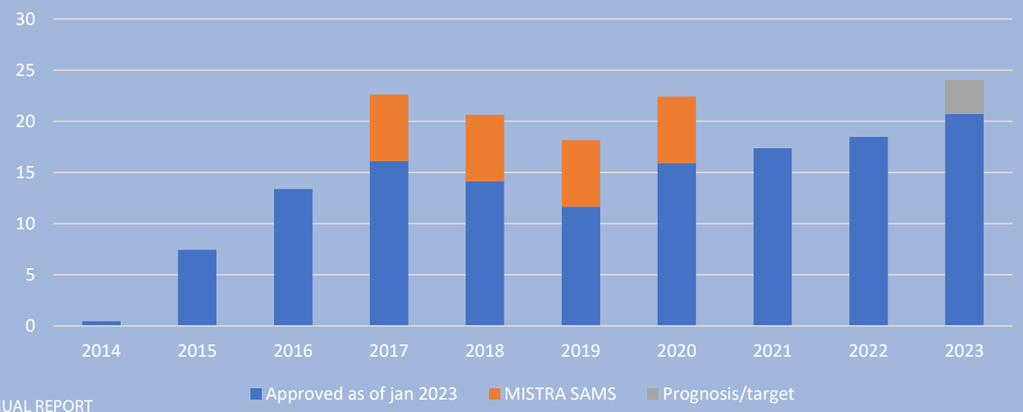
KTH School Involvement



Active projects



KTH Project budget (mkr)



Social media statistics

LinkedIn followers

2022: 1312
2021: 961
2020: 574

Facebook followers

2022: 643
2021: 636
2020: 546

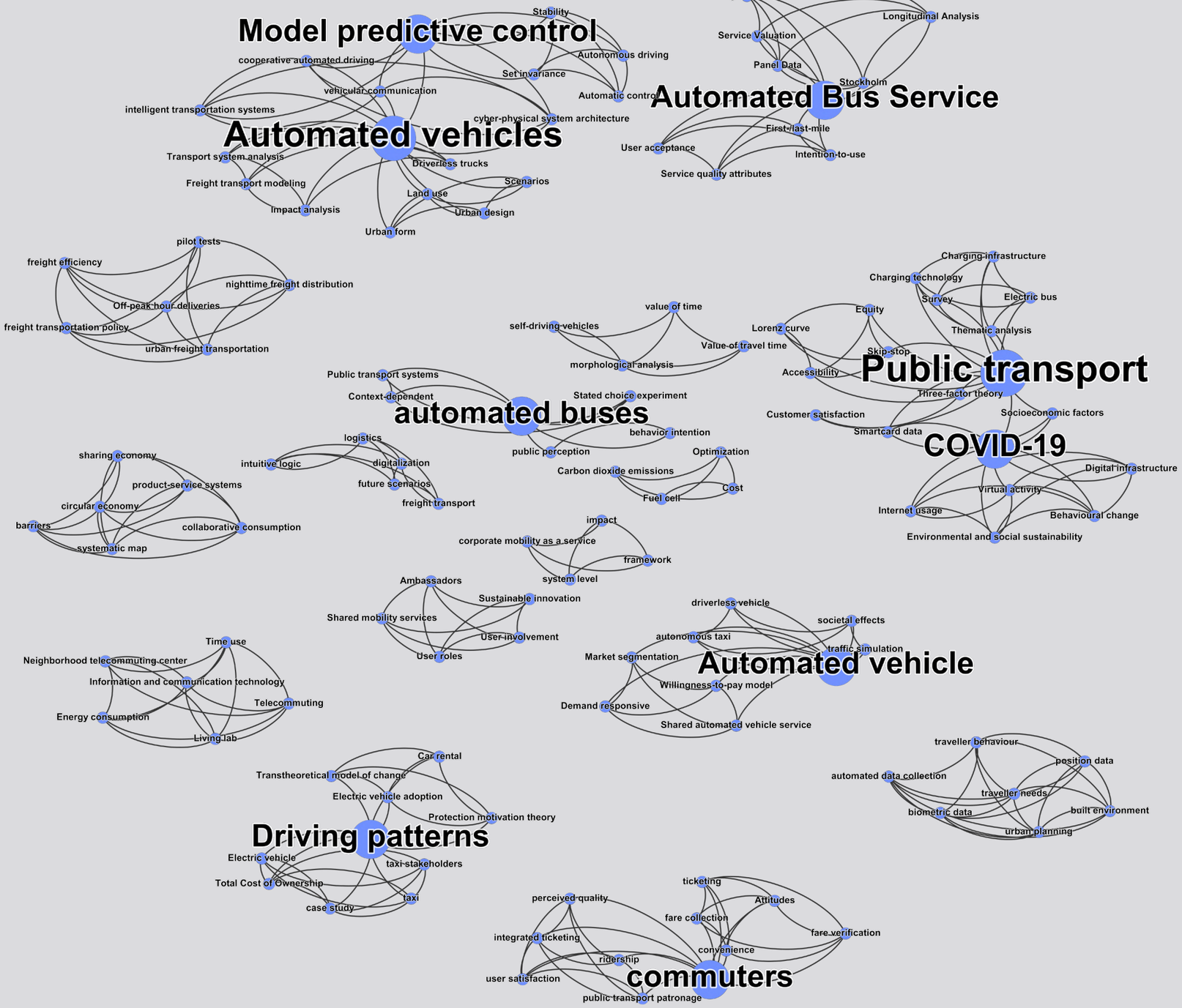
Newsletter subscribers

619

Most popular keywords

In ITRL publications

2016 - 2022



Projects

Projects started:

- EMobBM
- DATASETS
- STIFF
- HITS 2
- GEOMETRIC
- ELKOLL
- Urban Logistik Barkarby

Ongoing projects:

- 5G Ride
- Campus 2030
- DS BML - Drive Sweden Business Model Lab
- FOKA
- MERGEN - Multi-purpose biometric Evaluation Research tool Grounded in Emerging Network technologies
- SEAMLESS
- SocRob - Social robots accelerating the transition to sustainable transport
- IMPACT AED
- Stockholm Digital Parking
- Mistra SAMS 2
- PRESTO
- MUST - methods for Managing deep Uncertainty in planning for Sustainable Transport
- SLICE-T

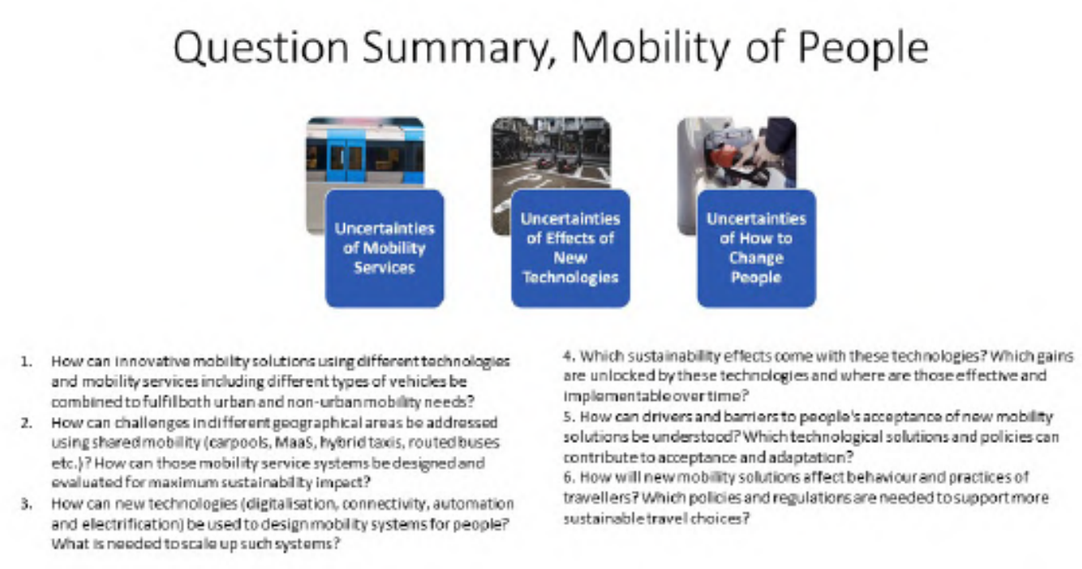
Finished projects:

- PSSST – Policies for sustainable, shared self-driving transportation
- E98ton
- SUSTEV
- TIFF
- InterCityLog2
- HITS2024
- LOLA
- ElSouth Stockholm
- ROSE
- CORD

Research

Mobility of People

The research program Mobility of People have during 2022 built further knowledge about the three challenge areas with different uncertainties of: mobility systems, effects of new technologies and how to change people's behaviours and practices in sustainable directions. The work is ongoing, and research activities and project results presented here are work-in-progress.



Uncertainties of mobility systems

During 2022, within our research projects, we explored the impacts of new mobility systems at micro, meso, and macro levels and the system level (integration of micro, meso and macro). Understanding the uncertainties of developing, implementing, operating, and governing mobility systems remains a challenge area in this research program. Besides individually assessing the micro, meso and macro levels of innovations in mobility systems, we also worked towards developing an assessment framework to analyse the system-level impacts of these mobility systems.

Framework-based assessments

In the research project KOMPIS, an assessment framework was developed for understanding the potential impacts of Mobility as a Service (a relatively recent innovation in new mobility systems). With the help of key performance indicators and both qualitative and quantitative data collection methods (surveys and interviews), this framework enables evaluations that assess individual level (users), organisational level (organisations that develop and operate MaaS, as well as organisations that adopt MaaS), and societal level (city, municipality, region) of different types of MaaS services to suggest development and governance of sustainable mobility service systems. Using this framework in the SEAMLESS project, the aim is to collect and assess data from various types of MaaS pilots to explore how and to what extent MaaS would impact factors such as travel behaviour, accessibility, emissions, and business opportunities, to name a few. Since the fall of 2020, the SEAMLESS project has successfully conducted two stakeholder seminars to introduce the SEAMLESS and KOMPIS assessment method and recruited MaaS pilots for data collaboration. However, due to COVID-19 and factors related to constraints in data sharing, there has been a lack of data provided through the MaaS pilots. While this presented a great challenge, with the help of interviews and surveys with experts within the MaaS field of study (which includes MaaS operators, researchers, and municipalities), SEAMLESS is in the process of designing data collection and analysis methods at the individual and organisational levels as well as designing future scenarios for MaaS development and operation for the year 2035 at the macro level. Three research papers were presented at the ICoMaaS conference in 2022 in Tampere, Finland.

Uncertainties about the effects of new technologies

During 2022 we have researched the effects of autonomous vehicles and remote driving on drivers from different perspectives and levels in several projects. Furthermore, we have studied the impact of autonomous buses and artificial intelligence on an individual passenger level. Moreover, we have researched the impact of autonomous, electrified and shared transport systems on a policy level. We have also examined methods for measuring the psychological effects of micro-mobility, focusing on the hardware and software solutions needed for large-scale testing.

Autonomous vehicles and remote driving

When moving to automated road transport systems, there will be an increased need to manage fleets and their operations and solve problems that the autonomous vehicle might have, e.g. decision problems due to changing environments needing remote assistance. These could be solved by giving the vehicle permission to proceed, giving it a new safe path, or even taking control and remotely driving it. In the MERGEN research project, we study the methods of measuring the cognitive load of travellers. One focus group is remote operators and how remote driving affects them differently than actual driving. It also assesses challenging scenarios for remote operators in traffic control towers to acquire knowledge of the requirements of the remote operation of autonomous vehicles. So far, we have conducted several tests and learned that our test methods work well to measure cognitive load.

The REDO research project focuses on the feedback to the remote driver and supporting control strategies to support the remote driver for better precision and safety. Here we have found that the steering feedback needed during remote driving is different than what is required during actual driving, so feedback cues for remote driving need to be explicitly designed for that case. Both projects have initiated collaborations with the start-up company InnoBrain to include their measurement equipment of brain activity (EEG) in future experiments. Results from both MERGEN and REDO can be used for scale-up studies in AVTCT2 and future projects to understand the feasibility and impacts of transport systems' transitions towards autonomous vehicles and remote driving. MERGEN has also collaborated with BOKU (University of Natural Resources and Life Sciences, Vienna) on more in-depth methods for understanding how action cues are perceived differently in simulator studies, which should be applicable in remote operations of vehicles in the future.

Autonomous buses and artificial intelligence

Artificial intelligence is booming and offers opportunities in self-driving public transport. Since self-driving vehicle technologies are becoming increasingly ready for broad implementation, it becomes more important to tailor them to users' needs. In the research project Social Robots, we investigate whether social robots can be

strong contenders to human operators and if they can fulfil the users' needs in future driverless buses and push the idea of shared mobility in this unique format. Structuring the unstructured, i.e., to provide real-time travel data has been identified as the main potential of social robots, according to the public transport industry and academic professionals. We are exploring this increased level of convenience and assessing how the introduction of social robots in driverless buses can impact passengers' comfort levels and safety. By applying both qualitative and quantitative data collection methods, we are also exploring how this unique combination of innovations can drive people towards adopting shared mobility solutions in their daily lives. Currently, pilot experimentations with two situations (one with the robot and one with a virtual assistant) are being conducted with users to streamline and strengthen the full-scale experiment conducted in spring 2023.

Autonomous, electric and shared transport systems

In the research project PSSST – Policies for sustainable, shared, and self-driving transportation – we investigated the potential for different policy tools given shared self-driving vehicles. The project was funded by Region Stockholm in collaboration between ITRL and the Division of Transport Planning at KTH and ran from 2021 to 2022. In the project, we have used past research results on the effects of self-driving technology to elicit possible policy interventions to target sustainability given a world with abundant self-driving vehicles. Furthermore, an analytical model has been developed to evaluate the effects of these policy instruments, and the entire evaluation will complete in 2023.

FOKA is an ongoing research project from 2022-2023. ITRL and Nobina Technology, Region Stockholm, Järfälla municipality, ObserveIT and Telia will design, implement, and test autonomous buses without operators onboard but with remote driving support from the control tower. In the project, we explore barriers (technical, legal, data sharing, passenger attitudes and needs and up-scaling of business models) to extended use of autonomous and connected vehicles and how such transport can support public transport to be attractive and sustainable to encourage travel with shared resources.
In 2022 ITRL initiated the project ELKOLL, a project funded by Voi Technology AB and Västtrafik, the public transport operator in the Greater Gothenburg area. In the project, we will investigate the relationship between e-scooters and public transport to address whether e-scooters are competing or complementing. The project will finish by mid-2023 and is mainly carried out by master students.

Uncertainties about how to change people

In 2022, we continued to carry out research projects to understand how to shift people's behaviours and practices in sustainable directions. During 2022, we concluded the research on how a co-work hub located in Tullinge, south of Stockholm, influenced and changed transport behaviour and commuting trips.

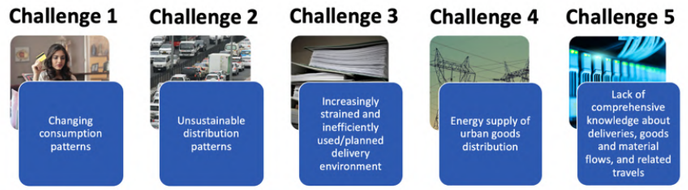
Changes when a co-work hub was introduced

As a part of Mistra SAMS Living Lab, we developed a co-working space in Tullinge, south of Stockholm. With help from our partners, such as Ericsson, we recruited more than 60 participants who lived in and around Tullinge but worked elsewhere in the Stockholm region. The co-work hub offered a professional workspace with facilities encouraging efficient and sustainable work and travel practices. Using this real-life experiment, we aimed to understand possible changes that a decentralised co-work hub could have on the participants' travel and work behaviour. Many participants expressed the need for the hub. As a follow-up to previous research at the hub, from October 2021 to January 2022, we designed and conducted another round of interviews with about ten (including the quitters and the regulars). A summary report based on the results collected through these interviews was produced.

Research

Urban Goods Distribution

The Urban Goods Distribution (UGD) research program has the scope of distribution of goods (and collection of waste and recycling) within the urban environment and aim at Sustainable urban goods distribution through collaboration. The UGD program road map, established in 2020, identified the following five challenges and five groups of research questions that were coupled to possible technological trends and solutions that can potentially address the challenges.



Connected goods: How, and by how much, can information from connected goods improve the efficiency and sustainability of urban distributions (C2), promote a more sustainable consumption of products and transport services (C1), and improve the horizontal collaboration and data sharing in urban goods distribution (C5)?

Dynamic redistribution of transport supply / resources and demand: How can new vehicle designs, delivery concepts, and new technologies even out the peaks and valleys in- and reduce the negative impact of urban distributions (C3) and improve the resource efficiency of urban distributions (C2)?

Electrification of urban goods distributions: What combination of vehicle configurations, charging infrastructure, placement and dimensioning, can facilitate the electrification of urban goods distribution?

Urban consolidation and delivery hubs: How can the placement, dimensioning, and sharing of urban distribution hubs and smart boxes, as well as the use of connected goods, be utilised to reduce fragmented deliveries and pickups?

System-wide resource efficiency through transport data sharing: Which data about transport operations needs to be shared, which technical solutions and business models are needed to facilitate this sharing, and how can a knowledge market be created that enable horizontal collaboration, system-wide resource efficient goods distribution?

HITS 2024 (Sustainable and Integrated Urban Transport System)

This project is the light-house project of the UGD program where with the lead of Scania and the coordination of CLOSER, KTH researchers alongside 16 other academic and industrial partners conduct research with the aim to accelerate the development of an efficient and sustainable urban freight transport system towards the vision of increased system efficiency in terms of increased use of vehicles and infrastructure. Researchers in HITS 2024 have carried out research in six topics that aim to address some aspects of all the five challenges of the UGD program. The following is a summary of the research from the first part of the project (until 2021/22) and the ongoing and planed future research activities for the second parts of the project (from 2022/23).

Collaborative Innovation and Design
With a focus on Challenge 2 and 3, in this research topic, our KTH researchers (Erik Stenemo, Mia Hesselgren, Mats Magnusson, and Fitim Selimi) study tests and pilots that are carried out within the HITS 2024 project, to gain more knowledge about collaborative innovation processes. Thereby, they are building knowledge on conditions for sustainability transitions of transport systems and understand how these are affected by and affect different innovation ecosystems, different lock-ins (technological, organizational and social) and at different levels (micro, meso and macro). As collaborative innovation cannot be understood from a single perspective. Thus, they use a multi-disciplinary theoretical lens and design methods which include field observations and interviews. Specifically, they investigate possibilities of re-configuring and re-organising sociotechnical systems through studying trials of off-peak deliveries and urban consolidation centers in Stockholm. Findings so far indicate that the efficient use of resources was considered the main business and societal value of implementing off-peak deliveries and urban consolidation centers and that the barriers to overcome included uncertainties regarding costs, lack of regulations and trust which requires collaboration, re-organisation and re-configuration.

Environmental assessment of city distribution
With a focus on Challenge 2 and 3, in this research topic, our colleagues from IVL and SSPA (Sebastian Bäckström and Sönke Behrends), with the help of stakeholder workshops and interviews, freight trip generation models and simulations, official statistical data, and on-site observations, investigate 1) what the external costs of

delivery traffic that enters Södermalm today are and 2) how large the reduction potential by freight consolidation systems and 'off peak'-solutions is. They have found that the current external costs are approximately 20 000 € per day of which 80% is due to congestion and that the consolidation scenarios studied can reduce the costs by 75% and that a combination of suburban- and urban consolidation centers can lead to the largest reductions. Our colleagues have also evaluated the potential of urban consolidated delivery solutions that use fixed and mobile parcel lockers as destinations for the "last-mile" delivery and have found that mobile lockers have higher external costs, but still result in significant reductions compared to today's operations. Much of the work on 2022 was focused on discussing how to adapt and apply the models developed in the first part of HITS on the new case study area around the MOOD gallery and how to collect better data to increase the models' validity.

Sustainable vehicle design
With a focus on Challenge 2 and 3, in this research topic, our industrial PhD student (Raphael Andreolli) from Scania supervised by KTH researcher (Mikael Nybacka) investigate how autonomous modular vehicles (AMV) should be configured, designed and operated to give the most benefit with respect to sustainability and performance, taking both vehicle and system level perspectives. AMVs are flexible vehicles that can transport people, goods and waste during daily and nightly operations without human drivers. In 2021, we have developed a second-by-second backward facing longitudinal vehicle dynamics model based on driving cycles that can be used to compute vehicle: energy consumption, range, battery pack, battery discharging, payload capacity and vehicle performance measures (startability, gradeability, accelerationability, and maximum speed). With this model in mind, in 2022 we have conducted a systematic literature review on the topic of "real vehicle usage modelling of AMVs within vehicle routing problems". In 2023 we will develop a vehicle routing problem formulation tailored for HITS relevant use-cases of AMVs in city logistics that incorporates the vehicle specific properties captured by our model.

Impacts of modular multi-purpose vehicles
With a focus on Challenge 2 and 3, in this research topics, our PhD student (Jonas Hatzenbühler) supervised by KTH researchers (Erik Jenelius, Oded Cats, and Gyözö Gidofalvi) investigate how to solve the pickup and delivery problem with AMV fleets. We have solved a series of use case scenarios using an exact optimization algorithm and an adaptive large neighborhood search algorithm and found that AMV fleet based UGD can lead to 1) cost savings of up to 15%, 2) additional savings due to collaboration, 3) higher utilization of vehicle capacity, 4) reduction of empty kilometers, 5) similar unserved demand, 6) reduction of fleet size of up to 34%, 7) reduction of passenger waiting times of up to 4%, and 8) reduction of trip duration of up to 32%. Our proposed models can be used by companies and policy makers to identify required fleet sizes, optimal vehicle routes and cost savings due to different types of operation and vehicle technologies. In 2022, we have extended the scope and formulated research questions for the simulations depot placement and dimensioning and charging of vehicles. We have also initiated the recruitment of a postdoc to perform the research.

System level effects of urban logistics concepts
With a focus on Challenge 2 and 3, in this research topic, our PhD student (Claudia Andruetto) supervised by KTH researcher (Anna Pernestål) investigate how to model and design an urban freight transport system using system dynamics modelling such that the transport-related externalities that negatively affect the liveability of the urban environment and the health of citizens can be minimized. We identified a set of indicators from the Sustainable Development Goals, defined from the perspective of society and of the Logistics Service Providers (LSPs). Using the set of indicators, we evaluated the sustainability of electrification, consolidation, cargo bikes and automation. The results (see Figure 1) show that the indicators regarding the environment (i.e., air pollution, congestion) are emphasised; however, sustainability is more than just the environment, therefore indicators such as land use, noise and working conditions should be explored further.

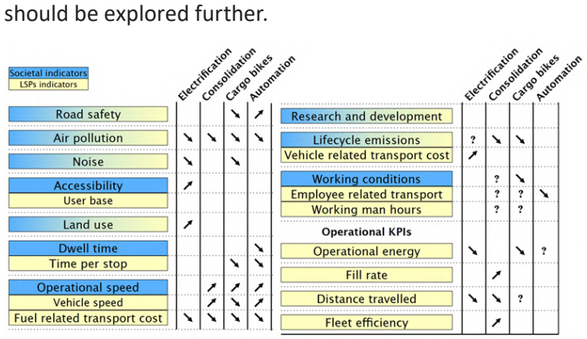


Figure 1: Indicators of sustainability of electrification, consolidation, cargo bikes and automation from societal and LSP perspectives.

We have used system dynamics to implement a model of a city hub system to improve consolidation in the last mile. Such system dynamic models can be used to understand the dynamics of system, the feedback mechanisms and the time delays. Specifically, we will use our model for scenario analysis to understand the impacts of the modelled urban logistics practices. Currently, the model is a graphical qualitative model. Next, we will make the model quantitative and perform sensitivity testing and scenario analysis.

Data sharing
With a focus on Challenge 5, in this research topic, our visiting researcher (Annette Hultåker) from Scania investigates what is needed to succeed with data sharing and explores value adding services, especially with sustainability effects. We have found that successfully data sharing requires 8 factors: data, business value, regulatory foundation, trust, infrastructure, security, meta data, and skills. We have also found that data sharing between transport actors can enable analytical services with societal benefits, sustainability benefits, and internal and external business benefits. One key takeaway from the study is that hubs often seem to be excluded from the data sharing, which makes mainly their planning difficult.

Policy, legislation, and regulation
With a focus on Challenge 5 and 3, in this research topic, our colleagues from Uppsala University (Kristina Andresson) primarily investigate the current and expected legal obstacles or enablers of data sharing and off-peak deliveries. We have found that lots of legislation regarding data sharing will change during 2022-23 and a several new EU Acts will come in place. First comes the "Sales of Goods Act" and then comes "Law on Domestic Road Transport." A key takeaway is that one needs to pay close attention because legislation will affect business models.

InterCityLog2 - Minimize transport work with cross-border collaboration

With a focus on Challenge 2 and 3, in this research project, together with partners, our PhD student (Ehsan Saqib) supervised by KTH researcher (Gyözö Gidofalvi) investigate how to assess the energy efficiency potential in solutions identified as unutilized potential for collaborative and consolidated low emission transport solutions in cities. In practice, this means that we study and collect data about the current operations of ÄlskadeStad in Stockholm and devise methods that assess the energy, business, and environmental costs of the current shared city hub based consolidated package delivery and recycling material pickup logistics operations of partners Bring and Ragn-Sells. For this purpose, we performed transport work, energy use, and delivery and handling time measurements of the current operations and compared it to traditional non-collaborative delivery and pickup operations as well as optimized operations that are found by a heuristic optimization model that determines the optimal fleet size and routes for consolidated delivery and pickup operations.

After extensive, modelling, data collections, and evaluations, in 2022 we have successfully completed the InterCityLog2 project and reported the main findings as follows. Energy consumption of a smaller electric vehicle is significantly lower per kilo than Business as Usual (BAU), i.e., distribution and collection of goods and recycling materials without an urban consolidation using traditional HVO / diesel distribution / recycling truck. Generally, the economy of the operations has been described as reasonable by the logistics companies. The pre-sorting at the terminal for consolidated delivery from city terminal can save four person-hours daily but needs complex and tight system and process integration. The accurate tacking of operations for BAU was difficult with simple GPS in urban delivery environment with garages and underground passages. It is difficult to estimate handling times for a model. A simulation and optimization model has been built and has been used to analyze the efficiency of the operations and discover opportunities for improvements and new material flows. Extensive experiments based on measurements of real operations have revealed the following. First, fleet optimization favors larger vehicles for the costs model that is dominated by handling time and driver costs. Second, route optimization alone can save 27% (13%) and 7% (4%) of vehicle-km (time) for pickup and deliveries separately, and 23% (11%) combined. Finally, the savings for route optimization and flow consolidation (i.e., the combined delivery and pickup on the same route) combined is 24% (12%) of vehicle-km and (time) with 2%, 2% and 12% in energy, emissions, and OPEX savings. Only a minor part of the savings is from the flow consolidation, which is limited by the need to return of empty recycling bins.

Modelling framework for off-peak / silent / zero emission deliveries

Building on our off-peak delivery experiences in the Off-peak Pilot, ECCENTRIC, ZEUS, and HITS 2024 projects, in 2022, within the scope of the complementary, recently started projects "DATASETS: exploring DynAmic environmental TAxation for a Sustainable, Efficient urban Transport System" and "GEOMETRIC: GEO-based Multi-layer Environmental Modelling of Urban TRaffIC", KTH researchers (Romain Rumpler, Gyözö Gidofalvi, and Jonas Mårtensson) and PhD students (Siddharth Venkataraman and Sacha Baclet) continued to improve building blocks that enable real-time noise exposure assessment. Specifically, we have been developing a modelling chain that simulates micro-level traffic whose output is streamed into a noise emission and propagation modelling tool with high resolution / fast evaluation in focus. In the Hornsgatan-testbed of the GEOMETRIC project we have deployed 12 noise monitoring stations in order to feeding the necessary data into the modelling chain for micro-level representation of the traffic, and to provide validation checkpoints for the complete modelling chain. With these models and tools in mind, KTH researchers (Michele Simoni and Gyözö Gidofalvi) have supervised visiting PhD student (Wenqi Lu and Ziwei Yi) to design reinforcement learning based methods that dynamically set traffic rules for smart urban zones to minimize a selected negative impact (congestion, noise exposure, emission, etc.) of urban good deliveries.

Research

End-to-End Freight Transport

The vision of the End-to-end freight transport program (E2E) is a fossil-free, just and efficient transport system. The main challenges addressed by the program are 1) fossil fuel dependence, 2) low transport efficiency and sub-optimal flows, 3) unsound market structures and 4) changing transport demand.

Focus questions End-to-end Freight Transport

1. How can an up-scaled and optimal combination of biofuels and electrification be achieved for long distance freight?
2. What is the right size of vehicles, or the right combination of a vehicle fleet, in order to improve transport efficiency and modal shifts?
3. Can logistics flows be reshaped to make them sustainable by, for example, enabling horizontal optimization utilizing digitalization, connectivity, data sharing, and automation?
4. How can digital technologies be utilized to go beyond reducing CO2 emissions; having an impact on such issues as enabling fair trade, gender equality etc. in logistics?
5. What are the requirements for the large-scale adoption of driverless vehicles that also meet changing transportation demands?
6. What are the system level impacts of circular economy principles and global logistics on long distance freight transport?

Selected projects in End-to-end Freight Transport

Fossil fuel dependence in transport is one of the major contributors to the CO2 emissions. Electrification is receiving increasing attention. Battery-electric heavy vehicles were considered infeasible just some five years ago but now there are massive investments in this technology. The E-CHARGE project is a large Vinnova-funded project with the aim to accelerate the deployment of electric heavy vehicles. ITRL has recently joined the project with a Scania-employed industrial PhD student, Vivek Venkatesh Shenoy, who will study what fleet operators/owners need to consider when going electric based on total operating economy (TOE), available charging infrastructure, and logistical constraints. The project will be run in close relation to Scania's customers, and it will consider optimization of TOE with respect to multiple parameters.

The MUST project kicked off in December 2021. During 2022, the project progressed at a limited pace due to parental leave. Nonetheless, the year constituted a productive first period for the project and progress was made in the following aspects. The aim of the project is to conceptualize and analyze uncertainties in future technological and societal development and the challenges it brings for long-term transport planning and policy development. A literature review was performed to examine decision-making under deep uncertainty in sociotechnical systems within the transportation domain. For transport forecasting and policy analysis, a key challenge is so called scenario uncertainty, i.e., large uncertainty in the broader societal and technological development of the world. Many of the fundamental forecast assumptions and input data are highly uncertain and the current forecasting practice does not fully acknowledge nor account for that. The project has also explored how Exploratory Modeling and Analysis (EMA) can be used to leverage transport policy analyses. A simplified transport model tool for analyzing climate target policy packages is coupled with an external software tool for performing EMA. The robustness of previously proposed policies can be analyzed with respect to uncertainty in how the economy and emerging transport technologies will develop. EMA is expected to generate better insights about the robustness and trade-offs of various policy alternatives compared to conventional analysis practices.

The IMPACT-AED project aims to facilitate a systematic discussion on the impact of Automation, Electrification, and Digitalization (AED) on the freight supply chain. The general problem of how freight transportation systems respond to new technologies is described using the three-layered Wandel model (Wandel et al., 1992) in the freight supply chain, which includes material flow, transport flow, and infrastructure. The transition of the freight transport system due to the electromobility paradigm is studies by system dynamic modeling.

The main question is the barriers and motivations for electrifying the freight transportation system. Charging infrastructure availability is one of the most important barriers in the transition of freight transport systems. The question is how the availability of charging infrastructure will affect e-truck sales and market uptake, and how both the public and private sectors can or should invest to ensure a sustainable future. A mathematical system dynamics model is developed to explore the dynamics of the problem. Future steps in this research will focus on the co-transition of the transportation and energy systems; a collaborative transition to a more sustainable future. In particular, the focus will be 1) morphological analysis to structure the future development of AED (Automation, Electrification, and Digitalization), 2) System Dynamics conceptual modeling to understand the effect of electrification on the freight transport system, 3) System Dynamics mathematical modeling to explore how the availability of charging infrastructure will affect e-truck sales and market uptake, and how both the public and private sectors can or should invest to ensure a sustainable future, and 4) System Dynamics Mathematical modelling to explore co-transition of the transportation and electricity energy systems.

The TIFF project has ended and the sequel STIFF started. The projects studiy the service market system for trucks (maintenance, repair, and vehicle monitoring services) when introducing driverless vehicles (SDVs). Lina Rylander, industrial PhD student at Scania (on parental leave from summer 2022), has proposed a new design of the service market system for SDVs. The questions that have been explored are how the system is affected by removing the driver and which considerations are needed when redesigning the system. The study showed that the driver has a significant role in the service market system considering five theme aspects 1) Fault detection, 2) Decision-making, 3) Information exchange, 4) Information retrieval, and 5) Tacit knowledge and experience. These five theme aspects can exist singly, but they often exist jointly. The information exchange and information retrieval are essential for decision making; however, experience is often needed when interpreting information. This interpretation of the theme aspects can be illustrated by a sensemaking process, where the system actors use experience and knowledge to, for example, decide upon suitable actions.

In the same projects, PhD student Xin Tao studied the situation when vehicles are detected with certain types of faults and get into alarm situations. Human drivers play a vital role in deciding what strategies and actions to take, but when driverless vehicles are introduced, human driver's decision-making will no longer exist, which urges new solutions on both technological and managerial levels. Xin's PhD thesis (to be presented during spring 2023) depicts the current human decision-making process by analyzing field study data in the truck industry, which contributes to gaining domain knowledge and identifying research gaps. An integrated vehicle health management scheme is applied to automate this decision-making process by integrating vehicle health state estimation and prediction, resource utilization, and self-adaptive management. To implement this scheme, fault diagnosis and decision-making methods are proposed, and a decision support system is designed. A risk-based automated decision-making method is presented, which imitates the human decision-making process. On this basis, a collaborative decision-making method is proposed by considering traffic congestion, which is a currently neglected public concern. Simulation results show that the proposed methods could effectively reduce the economic risk and the risk of traffic congestion.

Research

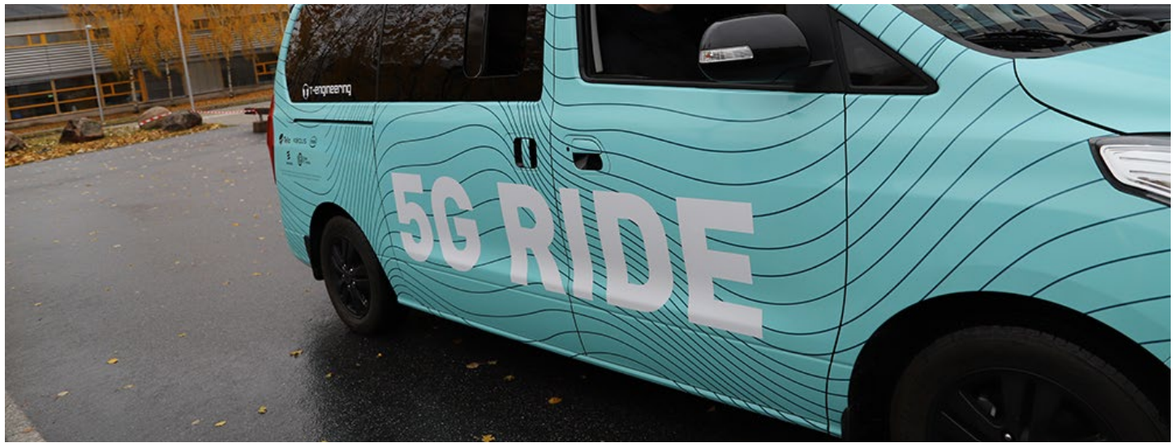
Connected Transport

Mobile connectivity and the access to transport and vehicle data will be a critical factor in the road transport system infrastructure. It is estimated that there will be half a billion connected vehicles in 2025. Vehicles will be connected to the internet and cloud services to gain access to online services such as traffic and route information. Vehicles will also be connected to each other to handle complex situations and coordinate decisions. These systems will bring new demands on reliability, latency, and efficiency.

ITRL is running project SLICE-T together with Ericsson, Scania, Telia and Trafikverket, where system-level technical, societal, and environmental impacts of providing mobile connectivity to transport systems and services is studied. Various classes of connected transport services will be analyzed to quantify their relevance over time for transport system sustainability (defined in a broad sense, comprising environmental impact, safety, efficiency, and business models). The connectivity requirements of the most relevant service types will be analyzed and used to assess the required network performance along different types of roads, and how those networks can be deployed. Costs of deploying and operating the network and the added value provided for the transport operator and end users – including individuals, public transport and cargo service providers -- will be investigated. Based on the technical and economic analysis, the project will identify hurdles and possibilities for deployment, adoption, and usage. The project will identify technical and business solutions for mobile network operators, transport service providers and road infrastructure operators that contribute to a sustainable transport evolution. In preliminary work, PhD student Elisa Bin has studied a budgeted 5G cell selection problem in order to maximize the number of served connected vehicles under individual rate requirements.

The 5G Ride projects implements and demonstrates control towers for automated vehicles, connected to the Ericsson Innovation cloud. The new phase of this project will focus on connected infrastructure sensors from Viscando that would improve the situational awareness for operating automated vehicles. The aim is to analyse and experimentally validate the use of 5G connectivity for this safety-critical high-demand use-case of connected vehicles and sensors. The work is done both with Scania, connected to WASP industrial PhD student Vandana Narri's project on connected shared situation awareness, and together with Ericsson in the newly established Kista Innovation Park. PhD student Frank Jiang and research engineers Mustafa Al-Janabi and Kaj Munhoz Arfvidsson have worked intensely to integrate the SVEA miniature vehicle platform into the project.

ITRL has also established a new collaboration with Stockholms Stad and Kista Science City, in a project GEOMETRIC, funded by Digital Futures and ITRL, utilizing a testbed at Hornsgatan. The goal is to study the effect on noise and emissions from urban traffic in a this multi-sensor testbed. The sensor setup has been installed during the fall 2022 and measurements and modelling will continue during 2023. The vision of the proposed project is to establish a framework enabling dynamically optimized traffic control with a view to reduce the negative impact associated with the transport system in dense urban areas, e.g., including congestion or pollutant and noise emissions.



Research

Electrification

Electrification is one of the megatrends that has the potential to decarbonize transportation and is currently disrupting the transport industry. It has been one of the cross-cutting focus areas of ITRL since its inception.

Electrification is one of the megatrends that has the potential to decarbonize transportation and is currently disrupting the transport industry. It has been one of the cross-cutting focus areas of ITRL since its inception. Earlier electrification projects focused on the use and demonstration of electrified transport solutions (e.g., EVs / electric trucks, stationary and dynamic charging). More recent projects focused on planning and optimizing large-scale transport electrification via simulations. The challenges of the electrification research program have not yet been explicitly defined in a roadmap, but given the multiple stakeholders (OEMs for vehicles, battery, and chargers; logistics / mobility service providers and users; grid operators, charging network operators, governments and state), their multiple objectives and constraints, the multiple transport electrification solutions and applications, and their interactions, it is clear that the integrated approach of ITRL to researching the topic is needed. The aims and results of current electrification project below give a good indication of the problem complexities and the approaches needed.

Electrified Transport in South Stockholm

In this Trafikverket / TripleF funded pre-study, KTH researchers (Rami Darwish, Adam Uhrdin, and Mats Engwall) and partners aimed to identify the key actors enabling electrified transports tied to a typical logistics hub and how these actors are affected by this technology transition. The analysis focused on the implication on these actors' business models given a set of plausible future scenarios. To do so we engaged in a qualitative case study focused on the emerging logistics hub Stockholm South located in Södertälje and Nykvarn at the strategic intersection between the motorways E4 and E20, the railway Svealandsbanan and Södertälje Port with close access to the Baltic Sea. We reviewed reports and conducted interviews and a workshop with a wide set of actors that are affected and may contribute to electrification of transports. The study resulted in a map of the emerging business ecosystem for electrified transportation and the identification of key bottlenecks that hold back the development of this ecosystem and thus also the transition to electrified transportation. The study highlighted business model related bottlenecks, which are playing an increasingly significant role as technical bottlenecks are being resolved.

TRACER

In this Trafikverket / TripleF funded PhD project, KTH researchers (Gyözö Gidofalvi, György Dán, and Ehsan Saqib) in collaboration with new project partners Ellevio, PostNord and Tarfikverket, investigate how to accelerate the electrification of the heavy freight transport industry and the realization of the positive effects thereof by deriving transport electrification scenarios that maximize the benefit and minimize the cost of electrification for all stakeholders. After Nikita Tagner's initial investigations about the key actors (fleet operators, charging point operators, grid operators, and vehicle manufacturers), truck operation statistics (mileage, mass utilization, emissions, etc.), challenges and costs of high-power charging of battery electric trucks, and the Total Cost of Ownership (TCO) for truck owners, in 2022, the project has been renewed to focus on charging infrastructure planning and electrified logistics operations from the charging point operator and the fleet operators perspective.

We are still in the early phases of the project and are currently discovering the transport electrification challenges of these actors. For example, how to plan the transport electrification transition (including charging infrastructure rollout and vehicle purchase plans) of a large logistics company that subcontracts many of its transport routes to small transport companies that also serve many other customers and routes? The renewed project will also more focus on the resilience of the charging infrastructure and the operations on them.

What we can see from the RoSE simulations is that the uncoordinated transport and charging schedules even on an optimally placed and dimensioned charging infrastructure will at some stations and times lead to queue meanwhile the chargers of the same station may be bellow acceptable utilization rates at other times. How to eliminate the queues and even out the charger utilizations and related loads in the grid in space and time will be an important focus of the renewed project.

Tool that allows the map-based exploration of the results of EV routing and charging simulations. The timeseries show the variability of charging queue and charger utilization in space and time through two charging stations as examples.

LOLA - Cost-benefit Optimized Charging Infrastructure

KTH In this SEC funded pre-study, KTH researchers (Gyözö Gidofalvi, Can Yan, and Ehsan Saqib) are extending the route-based charging infrastructure planning model of the prior RENO project and are investigating how to incorporate charging stations as an electrification option and how to effectively model and consider the charging infrastructures costs, including the cost of grid connections that is required to supply the charging demand, in the cost-benefit optimization of charging infrastructure plans. In 2022, we have finalized the extensions of the route-based charging infrastructure plan evaluations and optimizations based on the observation that charging at stations will take a relatively long time hence will be most attractive at locations where the driver can use the time during charging for other activities. These locations will most likely be at the start and end of the route and around five hours into the route when loading, unloading and mandatory rest stops usually take place. Thus, as with electric roads, the charging needs and the charging utilities along the routes should primarily depend on the routes and not the traffic counts. This route-based model is then used to optimize charging infrastructure plans that maximize these charging utilities and corresponding revenues per unit charging infrastructures costs.

Preliminary results indicate that for most full-scale electrification scenarios—which are primarily defined by vehicle battery sizes, and charging power capacities, equipment costs, and behaviors—if charging equipment is proportionally dimensioned to the charging demands, then the ROI for stations tend to be higher than for electric roads. This would justify current policies and market developments that prefer stationary charging. However, these analyses neglect the differences in required grid development / enforcements costs, TCO and environmental footprints of manufacturing due to battery size requirements, and the cost of wasteful charging stops in autonomous transport futures for the two charging types. Future work can include the incorporation of these externalities into the scenario evaluation and charging infrastructure optimization framework.

We have also learned that while one can reasonably estimate the connection costs to plausible grid components (e.g., medium voltage substations) considering the land cover and terrain, these connection costs are negligible compared to the charging equipment and installation costs and that the presence of- or connection cost to these components are not relevant for the cost and feasibility of providing the required power capacity at a given location. In particular, a true grid capacity cost map can only be provided by the distribution system operators (DSOs), which requires access to classified grid information, solving complex power flow equations on the classified data, and insights into what other grid developments are in the pipeline of the local DSO. This realization reinforces the need for a new charging infrastructure planning paradigm which instead of deriving different “optimal” charging infrastructure (master) plans for a range of transport electrification scenarios, allows the planner to interactively plan and maximize the transport electrification performance (revenues, charger utilizations, transport route electrification, etc.) of the planned charging network as cost-effective options for establishing charging infrastructure (including access to land, relevant facilities, and last but not least grid capacity) present themselves at different locations.

RoSE - Learning in Routing Games for Sustainable Electromobility

In this C3.ai Digital Transformation Institute funded project within the framework of Digital Futures, KTH researchers (Henrik Sandberg, György Dán, and Gyözö Gidofalvi) with partners from MIT investigate how to make traffic routing for logistics operators more sustainable by accounting for electromobility, operations and infrastructure costs, and environmental externalities. We look at how to calculate related costs and derive KPIs from data in simulations. We then formulate in a “green routing game” about how operators can trade-off sustainability against operational costs by allocating transport demands to vehicles of different types and routes. Using game theory and AI we then develop learning schemes that drive operators towards a social routing optimum.

Fast and accurate route and charging simulations are important foundation of this work. They allow to assess transport costs, queuing and charging times, emissions, infrastructure costs, and power demand profiles for different transport electrification scenarios, routes, and fleets. Based on an initial prototype we can see that the proper placement and dimensioning of charging infrastructure is key for successful large-scale transport electrification. In particular, under or over dimensioned or badly placed infrastructures lead to extreme queue times and transports costs or underutilized charging infrastructure. We plan to use the simulator in learning the best strategies for the green routing game as well as peak-shaving through day-ahead or real-time routing of fleets.

SustEV - Towards a sustainable use of electric vehicles

In this Swedish Environmental Protection Agency funded project, in order to combat the negative externalities of increased car use, that is a result of the low marginal costs after an initial electric vehicle purchase and adoption, KTH researchers (Gyözö Gidofalvi, Ehsan Saqib, Anastasios Skoufas, Iqbal Surahman, Jia Guo, Joram Langbroek, Joel Franklin, Yusak Susilio), designed and evaluated three incentives that aim to reduce private car trips into the already congested city centers. The incentives were a combination of 1) free EV parking and charging outside of the congestion area (of Stockholm) and an additional reduced-fare 2) public transport- or 3) e-scooter. To test the effectiveness of the incentives, we have designed a stated adaptation experiment and a custom web map based survey tool that most importantly allowed the respondents to record desired locations for their incentives, thereby providing an indication for public charging infrastructure- and “entrance parking” (infartsparkering) demand. We deployed the tool and analyzed the answers of 400 respondents with descriptive statistics and statistical travel behavior modelling. Selected modelling result interpretation include: 1) the incentives are more effective in deterring female, young (18–24), or parttime employed respondents from driving into the city centers than their male, older, or full-time employed; 2) parking is a good incentive for those who need it; and 3) reduced-fare public transport and e-scooter incentive is best for existing users. Finally, to utilize the results, we outlined several methodologies for stakeholder analysis and policy roadmap creation.

Outlook

We foresee a potential future where the adoption of commercial EV fleets will be faster than the investment into charging infrastructure and fleet and grid operators will face a situation where the charging demand is larger than the charging supply at least during some time periods and/or in some regions in space. For logistics providers this could lead to charging queues and delay costs and uncertainties in logistics and supply chains. For grid operators this could lead to difficult to manage demand peaks. Therefore, we plan to investigate how to provide operational decision support / control systems for actors to manage these difficulties. The solutions could vary largely in approach and could include pricing, booking, and prediction and probably will always involve some form of optimization which may involve learning optimal control with AI/ML via fast and effective simulations in connected digital twins.

Lab & Research Platforms

Experimentation and demonstration of research results are important parts of ITRL's activities. This is why we have developed various laboratory and research platforms that can be used to experiment on and demonstrate various aspects of the solutions we are working on. The platforms also serve as a meeting place for researchers, partners, engineers, and students.

This year we have worked on several upgrades in the ITRL Lab area. The aim is to support and meet the demands of upcoming projects which will take place at ITRL. We are housing a new lab in ITRL which will be dedicated for research on space robotics. This new lab space is built with a frictionless surface and a dedicated motion capture system, to support the work in the upcoming project, DISCOWER. Furthermore, we have built new and updated stations with modern equipment for mechanical and electronics work and assemblies. These upgraded assembly stations is already in use for the work on the RCV Dynamic vehicle and in REDO2 project.

Automated Vehicle Control Tower

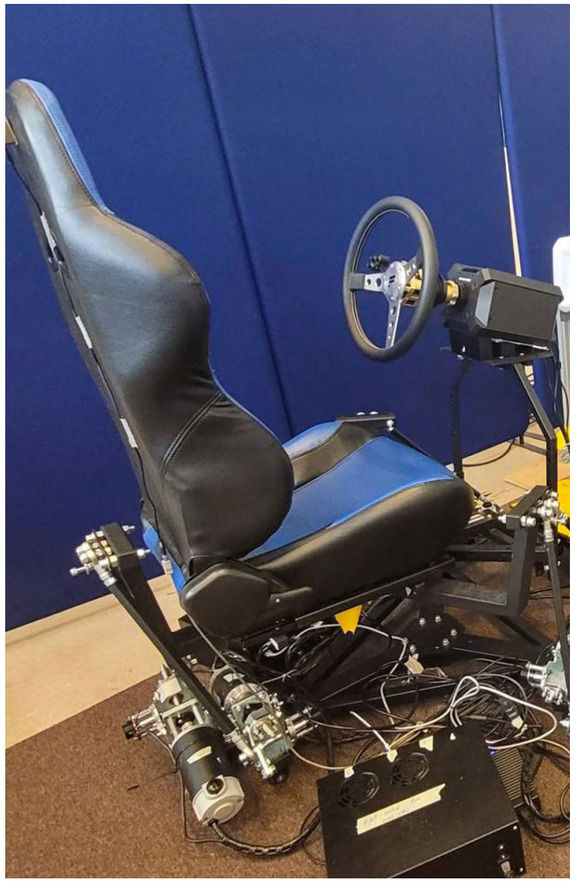
The Control Tower at ITRL has long served as a flagship demonstration station for many aspects of the research at ITRL. It is an asset for researchers to visualise and work on complex large-scale system pipelines. This year, we have made several improvements to the Control Tower to have a stronger integration between all platforms and labs at ITRL and to meet the demands of upcoming projects such as REDO2 and DISCOWER. The upgraded Control Tower will support development work on three different projects simultaneously. Researchers will have access to the powerful computers at the Control Tower which will support multiple opertating systems used within the different projects. Within the REDO2 project, the new Control Tower has a driving simulator which gives the user an immersive remote operation experience with sound, steering wheel force feedback, vibration actuators as well as motion in 6 degrees of freedom. Furthermore, we will be able to run at least two demonstrations at the same time, which means that all the new projects will be able to show off their great work all together with zero interuptions and total integration. We have also put a lot of effort on making the Control Tower look better and more welcoming than ever before. We look forward to show the upgraded control tower and workspace during the upcoming demos and workshops throughout the year.

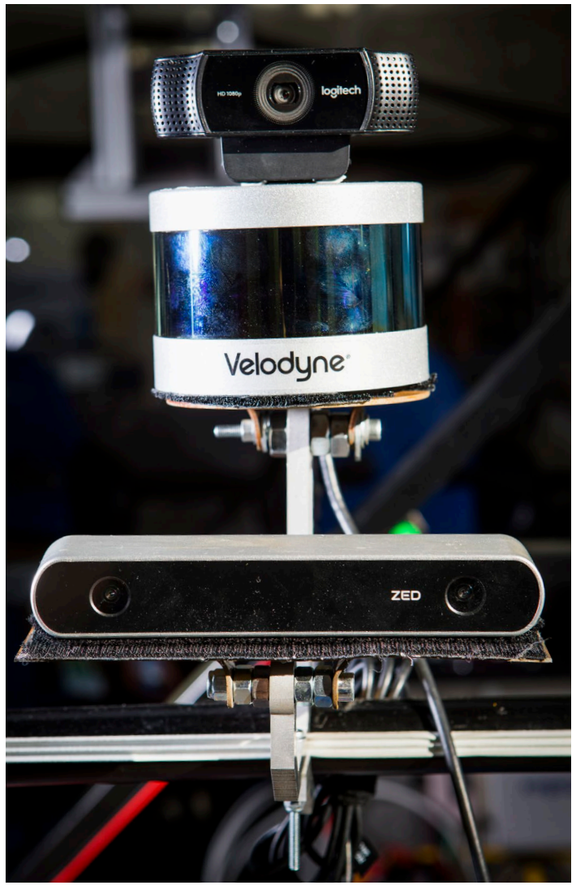
Research Concept Vehicles

The Research Concept Vehicles or RCVs at ITRL have as well been updated during the year since this is one stratgic idea with the platforms to have them continously updated and changed for coming research projects needs. The larger RCV-E vehicle used currently in REDO2 project extensively have been further improved in terms of the veghicles remote driving capabilities with better antennas, sensors and software integration. During the year we have also had a collaboration with University of Malaga in Spain where the brake system of the RCV-E have been furyther developed to be able to do research on brake-blending and self-learning ABS systems using Spiked Neural Networks.

The RCV-Dynamic vehicle is a new and updated design from the old RCV platform which have been in development during 2022. This is a project that is funded by strategic faculty funding from the Vehicle Dynamics research group at SCI school. This is a complicated updated design that require considerable itterations with the help from student porojects and master thesis projects since the idea is to have a platform that can actuate steering, camber, vertical wheel movement and accelerate and brake individually on all four wheels and doing this in highly dynamic conditions.

The Research Concept Vehicle.





Education

ITRL place great importance on our student engagement. Our students are key to solving the mobility challenges ahead and it is important for us to make sure they have the knowledge needed to enable a transition from the current transport system to a sustainable model.

ITRL established in 2018 its own PhD course, FSD3901 – Integrated Transport System, that will be running every second year. Since the start there have been more than 20 students participating and for the coming year in 2022 there is another 10 students participating in the course.

Bhavana Vaddadi became the first person to complete their doctorate entirely at ITRL, and Claudia Andruetto successfully defended her licentiate thesis in November.

Junior Research Community

The Junior Research Community (JRC) of ITRL is a group of young researchers that study problems related to ”sustainable transport systems” from different backgrounds, such as socio-technical system thinking, development of automation software, and robotics. It includes 50 researchers, mostly Ph.D. students, but also postdocs, research engineers, and MSc thesis students from different departments and divisions (ITRL, Decision and Control Systems, Vehicle Dynamics, Energy Systems, Strategic Sustainability Studies, Transport Planning, Stockholm School of Economics, Geoinformatics, Network and Systems Engineering, Speech, Music and Hearing, Structural Engineering and Bridges).
The activities organised by JRC are aimed at encouraging networking opportunities and integrated research collaborations between members and ITRL core partners. In 2022, JRC organised the following activities:

- JRC Mentorship Program: one-year-long program, where we paired young researchers from the JRC community with experienced and committed mentors from the ITRL network. This provides support for young researchers in their professional development and future career paths, gives them the opportunity to look at things from a fresh perspective, and to expand their network by connecting them with other transportation professionals.

- Scania study trip: JRC members had the opportunity to visit Scania, ITRL strategic partner. It started with a presentation of one of Scania’s newest electric trucks and a discussion on various transportation innovations and related research areas at Scania Tekniskt Centrum. The participants were then given an inspiring discussion on the possible career paths in Scania. The visit ended with a guided tour of the Scania test tracks

- Einride study trip: JRC members had the opportunity to visit Einride. The visit started with interesting presentations on Einride transportation innovation, and the participants had the opportunity to engage in an exciting case study: ”The World of the Remote Pod Operator,” followed by a guided tour of the remote operator facilities.

- Ericsson study trip: JRC members had the opportunity to visit Ericsson, ITRL strategic partner. During the visit, JRC members had a guided tour of the Ericsson Imagine Studio. Then there was the opportunity to mingle with Ericsson’s researchers and engineers about the most recent Ericsson innovations and how connectivity could lead to a more sustainable future. Finally, the participants engaged in interesting discussions on connected road transportation research.

Project Courses

The following KTH student courses are held in collaboration with the Integrated Transport Research Lab – ITRL.

SCI | Aeronautical and Vehicle Engineering
- Vehicle Dynamics Project Course Part 1, 7.5 credits
- Vehicle Dynamics Project Course Part 2, 7.5 credits

EES | Automatic Control
- Automatic Control, Project Course, Smaller Course, 7.5 credits

ITM | Machine Design
- Advanced Machine Design, 18.0 credits
- Project Work, 6.0 credits
- Project Work in Mechatronics, 6.0 credits
- Mechatronics, Advanced Course Spring Semester, 9.0 credits
- Mechatronics, Advanced Course, Fall semester, 15.0 credits

The Junior Research Community visitng Scania.

Impact & Outreach

As a pioneer in realizing the future transport system, ITRL is aware of the importance that future users have. We therefore work actively with communicating our work to generate awareness and make sure the generated knowledge reaches relevant people.

Breakfast Seminars

Our popular series of seminars has continued with topics such as policy, noise, digitalised transport, 6G, and car-friendly cities. Currently the seminars average around 30 participants.

During the fall we've started to host the seminars at ITRL and offer breakfast to those attending in person. The participants are still mostly online but discussing the seminar in person has been appreciated among visitors.

Media

ITRL continued to appear and partake in news and media. Frank Jiang were interviewed for TV4 Nyheterna in a segment on control towers and autonomous vehicles. Albin Engholm visited Logistikpodden and discussed driverless trucks and Jonas Mårtensson talked autonomous technology with SVT Nyheter Södertälje. Erik Almlöf was also interviewed in Dagens Industri regarding future mobility trends. The 5G Ride project has also been highlighted in several news papers. Find the articles and links here.

ITRL was also featured several times in articles and interviews on kth.se.

Events

In September we invited partners, colleagues, collaborators and interested people to ITRL Open House, an opportunity to learn more about our work and get a closer look at the lab and demos. This was the first time since before the pandemic we were able to invite people in person to ITRL, and in total the event attracted circa 70 people from various organisations. KTH Hyperloop, KTH Formula Student, and JRC also joined with their own booths to show people their work as well. In February then Minister of Education Anna Ekström visited KTH and ITRL.

Social Media & Newsletter

LinkedIn continues to be ITRL's main social media. This year we gained 351 new followers, making the total number of followers 1312. Facebook remain as a secondary channel and is growing as well. Five newsletters were sent out during 2022.

Visits to ITRL

- Minister of Education Anna Ekström, February
- ITRL Open House, September
- Ericsson, Auto PoC group of 6 people, November

Conferences & Events

- Transport Research Arena, November
- Drive Sweden Forum, January

Demonstration in the Smart Mobility Lab during Open House.

Student Teams

ITRL is currently hosting two student teams, KTH Formula Student and KTH Hyperloop. This support can be for example providing facilities, mentorships, or financial.

DeV17.

KTH Formula Student

KTH Formula Student continues to develop their most innovative and complex car yet – DeV17. 2022 started with the qualifying for this year's competitions where the team succeeded qualify for Formula Student Germany, the biggest competition in Europe. The new car was revealed in May during a full-day event which included demonstrations of the manufacturing process and individual systems.

Shortly thereafter the team was invited by Lund Formula Student to the Nordic Test Event, where some of the Nordic Formula Student teams gather to exchange experiences and test their cars. The summer turned difficult as multiple systems were not ready and the team was unable to get the car working in time for the competition in Germany. Since then the team has been working on getting the car in perfect condition for 2023 as well as started the work on building the next car, DeV18. During spring they participated in multiple industry events, such as a visit at Polestar together with other Formula Student teams, exhibitions at Sandvik Tech-days, and workshops with Scania.

The KTH Formula Student team poses for a picture after the reveal of their new car.

KTH Hyperloop

KTH Hyperloop is a student organisation from KTH Royal Institute of Technology that focuses on research and development of the Hyperloop concept. Since the year it was established in 2018, we have come a long way, from taking part in the Space-X competition placing top 50 amongst over a thousand other student teams. competition. As an organisation, 2022 was a big step for KTH-Hyperloop because we were represented in the competition European Hyperloop Week for the second year in a row which has international viewership. We presented our idea with many other student organisations in the competition, sharing and communicating, learning and teaching.

This year the team published a research paper regarding a potential LIM for the pod, titled "Performance Mapping of a Linear Induction Machine for Hyperloop Applications", written by a few of the members in collaboration with professor Mikael Nybacka.

Apart from manufacturing a glass-fibre shell and our wheels for the pod, we have also entered the final stages of designing the rest of our components so they can be manufactured in the beginning of 2023. During the year we have also been allowed access to a plot of land close to ITRL where we can build a test track for the complete pod once we have finished manufacturing.

The KTH Hyperloop pod.

Center partner

Scania

Scania one of the founders of ITRL and is still one of its core partners contributing with funding, expertise and in-kind in projects.

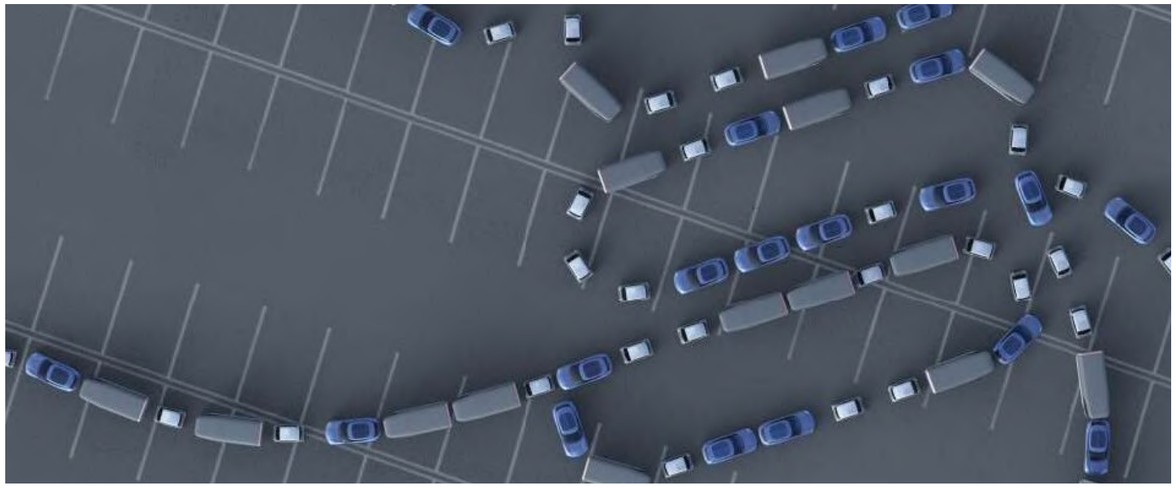
Scania engagement in ITRL is driven by the objective that we together can drive the shift to a sustainable transport system. Integrated system research and innovation is necessary in order to better understand the transformation of transport systems and to reach the goals of the decarbonisation of the transport system in time. We are convinced that a strong partnership is a must for driving the shift and to gather competences from different disciplines, schools, industries and public sector is one of the key capabilities of ITRL.

and researching innovative urban logistics solutions that can solve the urban last mile challenges. In beginning of 2022 had two more years of funding approved from Vinnova for continued research and innovation Besides HITS Scania engagement in ITRL has mainly been in new project like SLICE-T, Future 5G Ride and Uptime for AV.

Tony Sandberg is chairman in steering group and Ulf Ceder is co-director and member of ITRL management group. During the year Erik Dahlberg has replaced Sigvard Orre in the steering group.

Center partner

Ericsson



Ericsson is an active core partner of ITRL contributing with expertise in wireless mobile connectivity to initiate and drive research projects leading the transition to a safe and sustainable transportation industry.

The transportation industry is changing as a result of four megatrends: connectivity, electrification, autonomous driving and shared offerings for transportation and mobility. The software-defined transportation system and surrounding ecosystem can make transportation safer, more sustainable and improve efficiency. Cellular connectivity is enabling this change, and the ecosystem will facilitate it all by sharing connected car data and knowledge that will directly benefit society as a whole. Ericsson sees ITRL as a key research center enabling innovation and exploring the effects of this transformation by bringing together researchers from different domains.

During 2022 Ericsson's focus in ITRL has been on starting up connectivity focused transport research projects, primarily:

- SLICE-T (System Level Impacts of Cellular Connectivity-Enhanced Transport) takes a horizontal perspective on 5G and 6G connectivity and cost requirements imposed by different service types and investigates how novel connectivity techniques can fulfill these requirements in a cost-efficient manner. One goal of the project is to sum up the requirements from difference services and to propose deployment best practices that meet requirements in a cost and energy efficient manner. During 2022 the SLICE-T project has been focusing on implementing a simulator for solving optimization problems related to wireless networks and evaluating the performance of the solutions.

- The PRESTO (Predictive Quality of Service Management for Transport Services) project focuses on cellular quality of service prediction along roads to enable improved support for a variety of transport services. PRESTO started 2H 2021 and has during 2022 been focusing on comparing the performance of different AI-based prediction techniques.

- The FUTURE 5G RIDE project has during second half of 2022 focused on use case discussions including connected infrastructure sensors and how these contribute to better environment perception aiding driverless vehicles' efficiency and safety. Preparations for tests and evaluation of the ITRL SVEA platform over Ericsson's 5G network in Kista has taken place. Evaluations of traffic management from an edge cloud using 5G is planned for 2023.

Håkan Olofsson is a member of the ITRL steering group and Johan Söder is co-director and member of the ITRL management team. Ericsson is contributing with cash funding as well as in-kind contributions in selected research projects.

Center partner

Region Stockholm

Region Stockholm is responsible for healthcare, public transport, regional planning and culture across 26 municipalities in the capital city region. Region Stockholm contributes with support for research in healthcare, transport, technology, social sciences and natural sciences.

By funding research, making the region's infrastructure accessible and welcoming researchers to Region Stockholm's operations, the new knowledge that research creates can contribute to improving quality and efficiency. Region Stockholm's commitment to research and development is intended to create the right conditions for the region's inhabitants to have access to operations and services that are constantly improving and developing.

Region Stockholm contributes to the financing of KTH/ITRL and supports with test arena. The region is actively taking part in different parts when the research is of interest for the region's responsibilities. During 2022 Region Stockholm participated in projects FOKA, PSSST, 5G Ride, and ElSouth.

Collaboration is organized by a coordination group for innovation, which prepares and produces proposals for decisions on joint strategic innovation initiatives for Region Stockholm. The purpose is to strategically create the right conditions for innovation projects, to raise the level of understanding and expertise in innovation and to increase opportunities for systematics, collaboration, dissemination and implementation. With strong universities, many research institutes and a wide range of business actors and highly skilled labour in the Stockholm Region, research and innovation is a policy area of particular importance.

The public transport authority of Stockholm County, SL, carries out comprehensive shared transportation, mainly for people. The public transport system is commonly ranked as second best in the world. Based on the development program Region Stockholm is constantly seeking new efficient and environmentally friendly solutions. Trains and buses in Stockholm have been using 100% renewable energy since 2017 and the aim is to provide the most sustainable public transport in the world. For light rail, commuter trains, metro lines, trams and buses SL procures and uses only electricity from renewable sources. Next steps for the Stockholm region is continued electrification of buses and boats as well as automation.

Publications

Journal articles

- E. Almlöf et al., "Will leisure trips be more affected than work trips by autonomous technology? : Modelling self-driving public transport and cars in Stockholm, Sweden," Transportation Research Part A : Policy and Practice, vol. 165, pp. 1-19, 2022.
- Almlöf, E., Zhao, X., Pernestål, A., Jenelius, E., Nybacka, M., 2022. Frameworks for assessing societal impacts of automated driving technology. Transp. Plan. Technol. 45, 545–572.
- Chen, H., Hatzenbühler, J. and Jenelius, E. (2022) Pick-up and delivery problem for sequentially consolidated urban transportation with mixed and multi-purpose vehicle fleet. Journal of Advanced Transportation 2022
- O. L. D. B. Gorosabel, M. Xylia and S. Silveira, "A framework for the assessment of electric bus charging station construction : A case study for Stockholm's inner city," Sustainable cities and society, vol. 78, 2022.
- J. Guo et al., "Word of mouth and behavioural intentions of the automated bus service," Cities, vol. 126, pp. 103668, 2022.
- J. Hatzenbühler, O. Cats and E. Jenelius, "Network design for line-based autonomous bus services," Transportation, vol. 49, no. 2, 2022.
- R. Palmberg et al., "Towards a better understanding of the health impacts of one's movement in space and time," Journal of Literature and Science, pp. 1-24, 2022.
- L. Rylander and M. Eneberg, "Designing for change in complex socio-technical systems," in Expanding the frontiers of design : A blessing or a curse?, 2022, pp. 478-491.
- P. Sadeghian et al., "A stepwise methodology for transport mode detection in GPS tracking data," Travel Behaviour & Society, vol. 26, pp. 159-167, 2022.
- X. Tao et al., "Short-term maintenance planning of autonomous trucks for minimizing economic risk," Reliability Engineering & System Safety, vol. 220, pp. 108251-108251, 2022.
- B. Vaddadi et al., "Do they work? Exploring possible potentials of neighbourhood Telecommuting centres in supporting sustainable travel," Travel Behaviour & Society, vol. 29, pp. 34-41, 2022.
- X. Zhang et al., "Finding Critical Scenarios for Automated Driving Systems: A Systematic Mapping Study," IEEE Transactions on Software Engineering, pp. 1-1, 2022.
- X. Zhao, Y. O. Susilo and A. Pernestål Brenden, "The dynamic and long-term changes of automated bus service adoption," Transportation Research Part A : Policy and Practice, vol. 155, pp. 450-463, 2022.

Conference

- L. Zhao et al., "Study of different steering feedback models influence during remote driving," i Proceedings of the 27th IAVSD Symposium on Dynamics of Vehicles on Roads and Tracks, 2021.
- W. Zhang et al., "Exploring over-actuation and model complexity for trajectory planning of autonomous vehicles in critical manoeuvres," i 15th International Symposium on Advanced Vehicle Control, AVEC'22., 2022.

Doctoral thesis/Licentiate

- B. Vadaddi, 2022. Understanding the system-level for Mobility as a Service: A framework to evaluate full-scale impacts of MaaS. KTH Royal Institute of Technology, Stockholm, Sweden.
- Almlöf, E., 2022. Exploring societal impacts of self-driving public transport using four-step transport models. KTH Royal Institute of Technology, Stockholm, Sweden.
- Hatzenbühler, J. 2022. Simulation and optimization of innovative urban transportation systems. KTH Royal Institute of Technology, Stockholm, Sweden.

Other

- M. Parseh, M. Nybacka och F. Asplund, "Motion Planning for Autonomous Vehicles with the Inclusion of Post-impact Motions for Minimizing Collision Risk," (Manuscript).

MSc

- M. Chala Penagos and A. Skoufas, "Evaluation of bus networks designed by a metaheuristic algorithm: A case study in Södertälje, Sweden". KTH Royal Institute of Technology, Stockholm, Sweden. diva2:1670195

BsC

- M. Ramberg, "Covid-19-pandemins påverkan på kollektivtrafiken i Hallands län: En kvalitativ studie", KTH Royal Institute of Technology, Stockholm, Sweden. diva2:1684341

ITRL — INTEGRATED TRANSPORT RESEARCH LAB

KTH ROYAL INSTITUTE OF TECHNOLOGY

Thank you all for 2022!

Newsletter

To get updates on projects, seminars and more,
sign up for the newsletter here.