Integrated Transport Research Lab

KTH VETENSKAP OCH KONST

2024 ANNUAL REPORT

A deacade of reasearch at the Integrated Transport Research Lab

Table of contents

Introduction

Executive summary

In 2024, the Integrated Transport Research Lab (ITRL) at KTH Royal Institute of Technology celebrated a decade of pioneering advancements in sustainable transport systems. This milestone marked not only a reflection on past achievements but also a renewed commitment to shaping the future of mobility.

A significant development this year was the renewal of ITRL's center agreement with core partners Scania and Region Stockholm, ensuring continued collaboration until the end of 2028, with strong support from Trafikverket as an adjunct partner.
ITRL also celebrated the graduation of three PhD students, further strengthening the research ecosystem and contributing valuable insights into the field. To accelerate innovation in key strategic areas, we launched three internally funded pre-studies, laying the foundation for future expansion and deeper exploration of critical transport challenges.

With a growing portfolio of impactful projects, new research initiatives, and an expanding knowledge base, ITRL remains committed to bridging academia, industry, and public stakeholders to drive system-level transformation in transport. This report outlines the center's progress, key achievements, and the road ahead as we continue to challenge conventional paradigms and create a sustainable, integrated transport future.

A decade of provoking progress

In 2024, the Integrated Transport Research Lab (ITRL) at KTH Royal Institute of Technology marked ten years of challenging the status quo in transport research. Over the past decade, ITRL has embraced productive discomfort—a mindset that pushes academia, industry, and public stakeholders to question assumptions, explore uncharted territories, and co-create transformative solutions. Through multidisciplinary collaboration, real-world demonstrations, and cutting-edge research, ITRL has established itself as a key player in shaping the future of sustainable mobility.

As we celebrate this milestone, we do so with a renewed commitment to long-term collaboration. This year, ITRL extended its center agreement with core partners Scania and Region Stockholm until the end of 2028, ensuring the continuity of our mission. With Trafikverket as an adjunct partner, our ecosystem of public and private stakeholders reinforces the center's ability to bridge research and practice in transport innovation.

Scaling research and building the future

ITRL's success is built on system-level thinking, integrating research across different domains to address the pressing challenges of decarbonization, efficiency, accessibility, and mobility. This year, we saw the graduation of three PhD students, each contributing to the evolution of transport systems:

Erik Almlöf: Beyond Technology: Understanding societal impacts of implementing self-driving vehicle systems on road transport.

Claudia Andruetto: Impacts of innovations and policies on sustainability within road freight transport: using a system thinking lens.

Albin Engholm: Automated driving in road freight transport: On system-level impacts, policy implications and the role of uncertainty.

In parallel, we launched three internally funded pre-studies in strategic research areas (more on page 4)—laying the groundwork for the next wave of innovation:

Pathways for Energy Transition of Road Transport.

Novel transport services emerging from collective decision-making.

Investigating Mobility Hubs–A Stakeholders' perspective.

These initiatives reflect ITRL's proactive approach to identifying emerging challenges and acting early to develop solutions with long-term impact. Beyond research, ITRL continues to serve as a testbed for innovation, where ideas evolve into practical solutions through system demonstrations, simulation-based

insights, and deep collaboration with stakeholders. As we move into our second decade, our mission remains clear: to challenge conventional thinking, explore systemic solutions, and create a more integrated, sustainable transport future.

What's in this report?

This annual report provides an overview of ITRL's key milestones in research, partnerships, education, and innovation. It highlights:

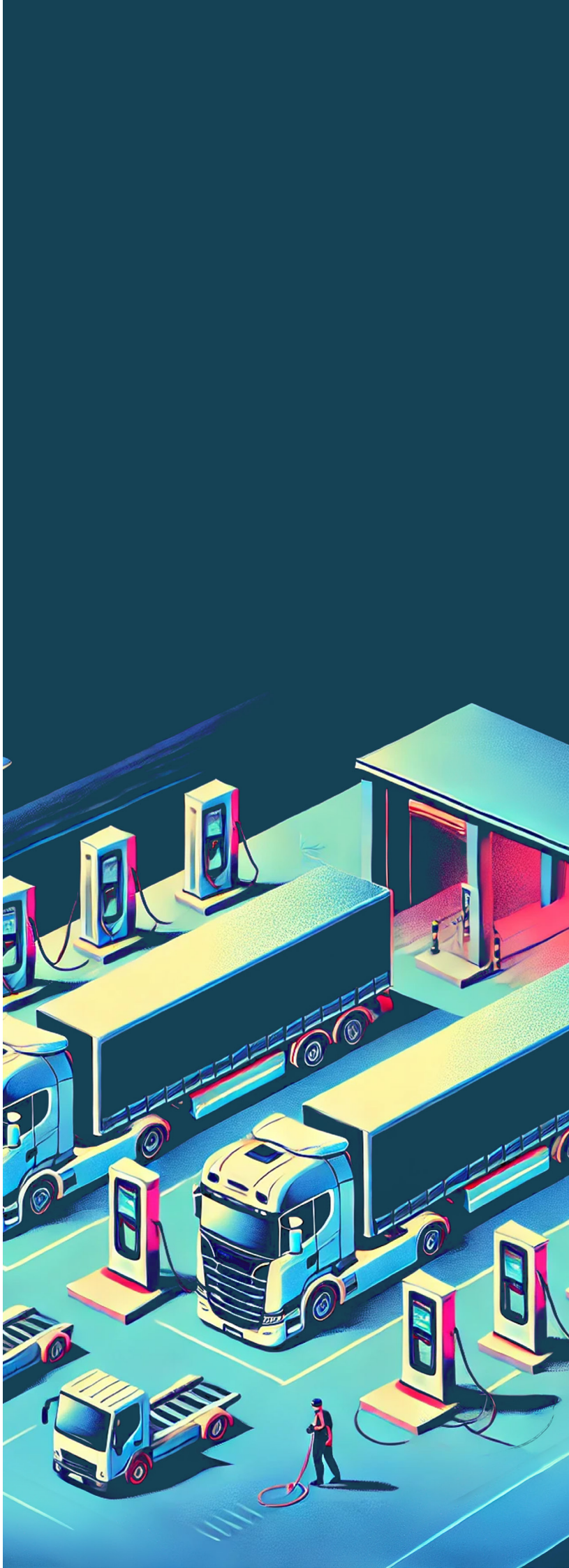
The center's strategic direction and its evolving role in the transport ecosystem,

Major projects, including new initiatives and ongoing research shaping the field,

The impact of our research, including publications, student contributions, and collaborative activities, and

How partners and stakeholders can engage with ITRL and contribute to the transformation of transport systems.

As we reflect on a decade of progress and provocation, we invite our partners—both old and new—to continue this journey with us. The next phase of ITRL will be defined by bold ideas, deeper collaborations, and an unwavering commitment to pushing boundaries for a better transport future.



Connect & be a part of ITRL

ITRL membership

ITRL members are faculty, researchers and students who share ITRL's missions to build and convey knowledge on how new technologies should be used for the transition towards sustainable road transport through multidisciplinary research and innovation.

ITRL Senior members: KTH faculty, full-time researchers, and support personnel.

ITRL Affiliated member: Adjunct faculty, part-time researchers at KTH, R&D personnel from partner organizations, and faculty from universities engaged in ITRL.

ITRL Junior member: PhD students, postdocs, junior research engineers from KTH and affiliated with partner organizations.

How to apply?

To become an ITRL member, fill out the membership application form at the link below. Applications are reviewed by the ITRL Management Group and are processed within a week.

www.itrl.kth.se/about-us/become-a-member

ITRL partnership

ITRL is built on a strong collaboration between KTH, Scania, Region Stockholm, and Trafikverket. This unique partnership bridges academia, industry, and public-sector stakeholders, allowing us to integrate cutting-edge research with real-world applications. Through this collaboration, we tackle key challenges in Enabling the transition towards integrated and sustainable road transport.

ITRL's research spans a wide range of topics, including sustainable transport development, Mobility as a Service (MaaS), electric road systems, autonomous buses, and innovative freight transport solutions.

Interested in Partnering with ITRL?

If your organization wants to collaborate with us, get in touch.

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ITRL's growth

150 Project partners.

75 Successfully concluded projects.

16 Doctoral theses. **+2** This year.

250 Research publications.

28 Ongoing projects.

20 Faculty members.

Founded in **2014**

180MSEK
Raised in research funds.
10% will cover operation until 2028.
750 MSEK total project budget.

Extended until **2028**

Pre-studies funded in 2024

Pathways for Energy Transition of Road Transport: the aim was to define scenarios of possible logistics ecosystem solutions in different markets and regions with different electricity supply, grid capacity and charging infrastructure.

Novel transport services emerging from collective decision-making: the study aimed at identifying control algorithms, communication architectures and ITS services that have meaningful impact on autonomous transport.

Investigating Mobility Hubs–A Stakeholders' perspective: mobility hubs were investigated from the perspective of stakeholders to uncover the underlying challenges for implementation and enhancement, particularly in suburban contexts. Barriers include economic constraints, digital integration challenges, and high e-charging costs.

The next phase of ITRL

Scaling impact and deepening collaboration

As ITRL enters its second decade, the center is poised for an ambitious new phase of research, collaboration, and real-world impact.

With the renewal of the center agreement until 2028, supported by core partners KTH, Scania, and Region Stockholm, and with Trafikverket as an adjunct partner, ITRL is strengthening its foundation for tackling the most pressing challenges in sustainable transport.

Building on a decade of system-level thinking and interdisciplinary research, ITRL's next phase will emphasize:

Expanding System Demonstrations: Large-scale, real-world testing of sustainable transport innovations, bridging the gap between research and practical deployment.

Deepening Research in Key Strategic Areas: Strengthening efforts in electrification, automation, digitalization, and sustainable logistics, with a focus on the interplay between transport, energy, and digital infrastructure.

Stronger Engagement with Policy and Society: Enhancing collaboration with public stakeholders to shape policies that support the transition to sustainable transport systems.

Key initiatives for 2025-2028

Establishing the ITRL Research Program Committee To drive strategic research initiatives and shape key research questions, ITRL is launching a Research Program Committee to set long-term research directions, guide funding strategies, and support collaboration across disciplines and stakeholders. Composed of senior researchers, industry experts, and public-sector representatives.

Expanding Internally Funded Pre-Studies ITRL's internally funded projects, launched in 2024, will be further developed into larger, cross-disciplinary initiatives to address pressing transport challenges and create scalable solutions.

Broadening Industry and Public-Sector Collaboration ITRL will seek new partnerships to ensure a diverse and inclusive research environment, fostering knowledge exchange between academia, industry, and public agencies. Prioritizing actors in the electricity and logistics sectors.

Shaping the future of transport

The transition toward an integrated and sustainable transport system is one of the most pressing challenges of our time. Transport systems do not operate in isolation—they are deeply interconnected with societal, economic, and environmental systems. Decisions made in transport policy and planning can trigger rebound effects, influence energy demand, reshape urban environments, and impact public health outcomes.

At ITRL, we recognize that tackling these challenges requires a holistic, system-level approach, one that balances technological innovation with social, political, and economic considerations. The coming years will demand deeper collaboration between academia, industry, and public agencies to ensure that transport solutions are not only technically feasible but also scalable, adaptable, and resilient in the face of future disruptions.

Grand challenges towards integrated and sustainable road transport

As ITRL moves into its next phase (2025–2028), our research and initiatives will focus on addressing four interdependent grand challenges that define the future of sustainable mobility:

Enabling the Transition Towards Integrated and Sustainable Road Transport:

Transport systems are inherently complex and interdependent, making the transition to a cohesive, adaptable, and sustainable ecosystem a significant challenge. The ability to integrate new mobility solutions while aligning diverse stakeholder interests is critical. Additionally, rapid technological advancements, regulatory shifts, and the unpredictability of global disruptions demand that transport systems become more resilient and forward-thinking.

Decarbonizing and Reducing Environmental Impact: The shift towards clean fuels, electrification, and sustainable transport practices is key to reducing the environmental footprint of road transport. ITRL will continue to explore pathways for the implementation of alternative energy sources, advancements in vehicle technology, and the promotion of transport policies that support low-carbon mobility.

Enhancing Accessibility, Mobility, and Safety: A sustainable transport future must also be an equitable one. Research will focus on improving the viability of public transit, the integration of active transportation (walking, cycling), and the development of smart mobility solutions to enhance accessibility for all. Road safety remains a critical area of focus, as does ensuring transport inclusivity for underserved communities.

Strengthening Efficiency and Resilience: Modern transport systems must optimize logistics, reduce inefficiencies, and enhance overall resilience. ITRL will address challenges related to vehicle traffic management, freight logistics optimization, and the development of robust, adaptive transport infrastructures that can respond effectively to disruptions, whether from climate change, economic shifts, or emerging technologies.

Scaling impact through research and collaboration

The establishment of the ITRL Research Program Committee will ensure that our research priorities remain aligned with critical transport challenges. As we enter the next phase, ITRL remains committed to pushing boundaries, challenging assumptions, and co-developing knowledge that will shape the next generation of transport systems. The road ahead is complex, but with a strong network of partners and a decade of pioneering research behind us, ITRL is ready to drive the transition toward a smarter, cleaner, and more integrated transport future.

A word from our partners

Scania is one of the founders of ITRL contributing with funding, expertise and in-kind in projects. The 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 to better understand the transformation of transport systems and to reach the goals of the decarbonization of the transport system in time. A strong partnership is a must to gather competences from different disciplines, schools, industries and public sector is one of the key capabilities of ITRL.

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. Region Stockholm's commitment to research and development are 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 arenas.

Ericsson is an active core partner of ITRL from 2015 to 2023, contributing with expertise in wireless mobile connectivity to initiate and drive research projects leading the transition to a safe and sustainable transportation industry.

ITRL projects

On-going projects

Drive Sweden Business Model Lab

Business Model Lab (BML) operates through quarterly themes developed in collaboration with Drive Sweden's program office, particularly the Business Models theme area. These themes are informed by emerging trends and input from BML's members. Within each theme, the project delivers webinars to build and disseminate strategic knowledge and conducts collaborative workshops to foster idea generation among Drive Sweden's members and partners.

High-potential business ideas are supported through a structured process that includes in-depth business modeling, fostering new forms of collaboration, and initiating joint projects. For companies and projects with strong international scalability, BML provides targeted support in collaboration with Business Sweden to facilitate their global expansion.

The program addresses a critical gap where promising research and innovation projects often fail to reach commercialization despite their potential. By integrating business model development early in suitable projects, BML increases the likelihood of achieving commercial impact, ultimately driving sustainable technological solutions that benefit society.

Notable activities include thematic meetings and workshops on topics like urban logistics, mobility wallets, and autonomous public transport in rural areas. These efforts have already contributed to major project applications, including a European initiative for urban logistics hubs, and supported startups through Business Sweden's internationalization efforts.

In addition to these achievements, BML has facilitated the creation of new consortiums and collaborative projects, supported scale-up candidates, and advanced AI-driven solutions for sustainable mobility. Examples include aiding young companies focused on autonomous boat travel, road condition monitoring using video analytics, and optimizing routes and charging station placement for heavy-duty electric transport. BML is also evolving its own business model by exploring innovative collaboration formats, such as integrating project courses, to enhance its future impact and sustainability.

REDO2

The REDO2 project aims to expand the understanding of how to operate vehicles remotely from a distance. Building on earlier work and partnering with similar projects like HAVOC and CORD, REDO2 helps position Swedish industry and research at the forefront of this emerging field.

Remote operation is becoming increasingly important as we move toward fully self-driving vehicles, as it provides a way to ensure safety when no driver is present in the vehicle. The project focuses heavily on understanding how human operators interact with these systems and developing safe ways for them to control vehicles from afar.

At its core, REDO2 explores how to manage fleets of remotely operated vehicles effectively. This involves solving both technical challenges and addressing practical concerns like laws and traffic management. The project aims to develop the tools and methods needed to operate vehicles without drivers behind the wheel, opening up possibilities for new automated services.

Through extensive research and testing, the researchers and engineers in this project plan to establish guidelines for safe operation, examine how these systems work together, and provide insights on relevant regulations. KTH's research in REDO2 will continue through PhD candidate Lin Zhao, who will complete his doctoral studies during the project timeline. His research will deepen our understanding of remote driving systems, focusing on feedback mechanisms and control support features.

The project will also enhance KTH's existing research infrastructure - including the RCV-E platform, motion simulator, and traffic control tower - making these facilities more capable for conducting advanced experiments and demonstrations in the future.

STIFF

The transportation industry is undergoing several transformations, including the implementation of driverless trucks. The STIFF project is a collaboration between Scania and ITRL and is sponsored by Vinnova. It explores changes in the service market system due to the introduction of driverless vehicles, where the service market system can be defined as the business system that secures vehicle uptime by providing maintenance and repair services. Moreover, the STIFF project explores how design methods can contribute to organizations that work to enable system transformations.

The ongoing activities of the project are focused on data collection. In this project, we use design workshops involving employers from the Scania organization. Five workshops were conducted in 2024, and three more are planned for 2025, which will be the final data collection activities in the project. Moreover, in 2024, two papers from the project were published, and two master theses were finalized.

TREE

The aim of the TREE project is to accelerate electrification of heavy freight transport through removing system barriers. In the project, forestry industry is used as a case. The TREE project is a system demonstration, where twelve electric trucks will be operated at seven sites distributed over Sweden. The project will study multiple aspects of electrification, including transport planning, business models, culture and behavior, influence of policies and regulations, and aspects of charging on the transport system and on the electric grid.

In particular, the project studies how the different challenges with electrification develop and change during upscaling of the system. The project has more than 20 partners and is funded by Vinnova FFI. The system demonstrator, where twelve electric trucks are operated is at the core of the project. In addition, practical trials with e-trailers and mobile off-grid charging stations will be performed. Based on the sites, knowledge will be built up on how to accelerate electrification from several different perspectives. This knowledge will be shared in scientific publications at to actors in the transport system.

Projects ended in 2024

PRESTO

The PRESTO project focuses on enhancing the reliability of wireless communication for vehicles with communication-critical applications, such as remotely operated vehicles. As vehicles navigate in dynamic environments, they encounter fluctuating wireless channel conditions that can lead to unpredictable communication quality.

Traditional model-based methods struggle to accurately forecast these rapid variations, making it difficult for networks to proactively allocate resources and prevent service disruptions. To address this challenge, PRESTO explores machine learning (ML) techniques to develop predictive Quality of Service (pQoS) models that improve communication reliability in high-mobility scenarios.

In recent work, we introduced an innovative ML-driven framework tailored for connected vehicles, leveraging federated learning (FL) to predict network performance in different geographical regions. Instead of relying on a single global model, as in previous works, the framework segments geographical areas, clusters them based on the wireless communication conditions, and optimizes predictive models for each cluster using FL.

This adaptive approach allows for more accurate QoS predictions compared to conventional methods. Moreover, by dynamically updating models with new data, the framework ensures that vehicles with communication-critical applications receive timely and reliable connectivity.

Digital Services

Led by Trafikverket, the Digital Services project aimed to enhance safety, efficiency, and sustainability within Sweden's transport system. The project's key objectives were to assess the readiness of freight operators and the transport system to adopt advanced digital services, identify physical infrastructure that could be replaced or optimized, and evaluate the socio-economic benefits of these services, including enhanced efficiency, safety, and cost reduction for road authorities and freight companies.

The project focused on five key digital service clusters: Intelligent Access Control, enabling regulated road network use to reduce wear and emissions; In-Vehicle Traffic Rules, enhancing

compliance with speed limits and traffic regulations; In-Vehicle Traffic Information, offering real-time updates to avoid congestion and hazards; Roadworks Warning, improving safety around construction zones; and Traffic Signal Optimization, minimizing delays and emissions through advanced traffic management. Four scenario conditions were developed to analyze these services, serving as a foundation for group model-building activities. This process included constructing causal loop diagrams for each service cluster to explore their socio-economic benefits.

Key insights revealed that these digital services could significantly reduce road maintenance costs, improve safety by minimizing accidents, and lower environmental impact through optimized routing and fuel efficiency. However, challenges such as high initial investment costs, technological readiness, and data integration barriers remain critical hurdles. Collaborative efforts, trust-building through pilot projects, and updated regulatory frameworks are essential to scaling these solutions. By addressing these challenges, digital services have the potential to transform freight transportation into a more sustainable, connected, and innovative system.

IOD-PT

The Inclusive On-Demand Public Transport (IOD-PT) project aimed to address mobility challenges in rural and low-density areas by exploring the potential of demand-responsive transport services. Traditional public transport often struggles to meet the needs of diverse user groups, particularly seniors, who face barriers such as limited-service availability and digital exclusion.

The project focused on X-linjen, an on-demand transport service in Säffle, Sweden, as a case study to understand user needs, improve service inclusivity, and reduce car dependency. With features like flexible routing and real-time responsiveness, on-demand transport offers a promising solution for underserved communities, provided barriers to adoption, such as trust, app usability, and service awareness, are effectively addressed.

The project revealed that X-linjen could significantly enhance mobility for seniors and other underserved groups by offering personalized, convenient transport. However, challenges such as app navigation difficulties, confusion around virtual bus stops, and the need for better alignment with user schedules highlighted areas for improvement.

Insights from Scandinavian peers like Ruter in Norway and Plustur in Denmark underscored the importance of user-centered design and multimodal integration. By simplifying interfaces, extending service hours, and improving communication, X-linjen could serve as a scalable model for inclusive and sustainable mobility in rural areas, promoting accessibility, reducing car dependency, and fostering social inclusion.

SEAMLESS

The SEAMLESS project aimed to evaluate the ecological, economic, and social impacts of Mobility as a Service (MaaS) to drive sustainable transport solutions. As urbanization accelerates and traditional transport systems fall short of meeting user needs, MaaS offers a promising alternative by integrating various transport modes through digital platforms. However, issues like low adoption rates, financial challenges, and technological barriers must be addressed. To tackle these, the project adopted a systematic, multidisciplinary approach to assess MaaS pilots and provide tools for evaluating its impacts across diverse contexts.

The project employed a variety of methods to analyze MaaS. A systematic literature review provided a multidisciplinary overview of evaluation frameworks, highlighting their opportunities and limitations. Data collection methods combined quantitative and qualitative approaches, while computer simulations modeled the long-term impacts of MaaS interventions. Scenario-based evaluations explored future pathways for MaaS, while participatory approaches like workshops and expert interviews gathered insights on user behavior and service design challenges. These methods revealed that MaaS can reduce car dependency and emissions, increase accessibility, and promote active transport modes.

However, findings also highlighted challenges such as data limitations, governance complexities, and the need for user-centered design. The importance of hybrid public-private models, robust evaluation tools, and stakeholder collaboration emerged as critical to overcoming these barriers. By leveraging its systematic approach, SEAMLESS provides actionable insights for scaling MaaS and integrating it into sustainable urban mobility systems.

Social Robots

The project was motivated by the rapid advancements in Autonomous Public Transport (APT) and the associated need to enhance passenger experience, safety, and trust. Autonomous buses, while promising in terms of cost-effectiveness and environmental benefits, lack the human presence traditionally provided by drivers or conductors who assist passengers and ensure order. This gap can hinder passenger adoption, especially in scenarios requiring assistance or reassurance. The project seeks to bridge this gap by introducing robots as "hosts" in autonomous buses. These robots are envisioned to provide guidance, assist with travel-related inquiries, and offer a sense of security, thus fostering user confidence and acceptance of APT systems

The project provided critical insights into the implementation of social robots in public transport settings. It demonstrated that while robots can play a vital role in enhancing passenger experience and filling the absence of a human operator, their effectiveness depends on meeting diverse user expectations. The trial highlighted the importance of designing robots that balance authority and approachability, addressing safety concerns, and offering meaningful assistance. Additionally, it brought attention to challenges such as the perception of robots' limited authority in emergencies and privacy concerns in shared spaces. These findings underline the importance of iterative development and stakeholder involvement to ensure that robots in APT systems are practical, trustworthy, and user-friendly.

Tracer

In this Trafikverket/TripleF-funded PhD project, KTH researchers, in collaboration with Ellevio, PostNord, and Trafikverket, aim to accelerate heavy freight transport electrification by providing data-driven decision support for charging infrastructure planning and operations.
In 2023, the research focused on developing demand-centric optimization methods for planning battery electric vehicle (BEV) charging infrastructure. Through co-creation with stakeholders, the team identified key analytic features needed for decision-making under uncertainty and integrated these into a Spatial Decision Support System (SDSS) for adaptive planning. Empirical evaluations provided insights into how charging station placement affects network performance under varying conditions.

Key findings highlight the importance of integrating transport route data into planning and the value of an SDSS for scenario evaluation and informed decision-making. Results are summarized in the Licentiate thesis “Effective Spatial Decision Support for Charging Infrastructure Planning” (https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-356237).
Future research will extend optimization methods to include dynamic charging on electric roads, evaluate network resilience under disruptions, and explore ways to enhance charging infrastructure utilization and reliability in electrified logistics.

WASP bridge

The WASP Bridge Project, a collaboration between ITRL, Ericsson, and Scania, explored how 5G-enabled intelligent transportation systems (ITS) can improve intersection safety and efficiency. The project focused on cooperative localization and centralized decision-making at the network edge, using ITRL’s SVEA platform to develop a scaled-down intelligent intersection at Kista Innovation Park (KIP) and later testing full-scale scenarios at Scania’s test track.

Key outcomes included demonstrating how V2X communication, cooperative localization, and edge computing enhance autonomous navigation, supporting the concept of autonomy-as-a-service. The project also provided early insights into 5G quality-of-service metrics for automotive applications. Collaboration between industry and academia facilitated real-world testing in both small- and full-scale environments.

Future research should refine control algorithms, communication architectures, and safety frameworks to enable scalable autonomous transport. The study underscores the potential of 5G for vehicle-network integration, particularly in constrained environments like intersections and transport hubs. The project’s success has laid the foundation for further exploration of connectivity-driven autonomous mobility solutions.

MUST

The Managing Deep Uncertainty in planning for Sustainable Transport (MUST) project, funded by Trafikverket and carried out by KTH ITRL and VTI, aims to enhance long-term transport planning by addressing the challenges posed by deep uncertainty. Traditional forecasting relies on single-point projections, making policies highly sensitive to assumptions and vulnerable to unexpected technological or societal shifts. To address this, MUST explores Decision Making under Deep Uncertainty (DMDU) and Exploratory Modeling and Analysis (EMA) to help policymakers design resilient transport strategies. The research concluded in autumn 2024, with final reports expected in 2025.

In its first phase, the project conducted workshops and a literature review to identify key uncertainties and existing methods for handling them. Findings showed scenario uncertainty as a major challenge. A Many-Objective Robust Decision Making (MORDM) approach was tested on Swedish climate policies, emphasizing the role of vehicle electrification in meeting 2045 targets.

The study highlighted risks tied to adoption costs and trade-offs in biofuel use, electricity demand, and transport costs, underscoring the need for flexible policies that accommodate multiple energy pathways. The second phase applied EMA to Sweden's national freight model Samgods, analyzing over 300 scenarios on truck electrification and automation.

Results show electric and driverless trucks could range from 0% to nearly 100% of domestic road freight, with automation potentially offsetting electrification costs and increasing road mode shares. Even partial highway automation could cover over 75% of tonne-kilometers under favorable conditions. The project highlights the need for flexible strategies that anticipate multiple technology pathways rather than relying on single-point forecasts.

SCOES

The SCOES Sustainable Commuting Obstacle Exploration Study supported the Urban Bike Flow pilot in Borlänge, which tested electric bikes, connected bike racks, and a mobile app to track commuting patterns. Conducted with startups and employers, the study identified everyday barriers to sustainable commuting through interviews and observations. Findings were shared in a workshop with employers and local authorities to explore solutions.

The study revealed key obstacles to cycling adoption, the role of attitudes and habits, and how employers and municipalities can support sustainable commuting. It also assessed the effectiveness of electric bikes, bike racks, and the mobile app in reducing car dependency. Results emphasized the need for structured interventions to encourage active transport.

Future efforts should focus on improved cycling infrastructure, stronger employer support, and raising awareness of car dependency costs. The study highlights the importance of addressing mobility challenges in suburban and smaller towns. By 2035, increased employer commitments and climate reporting could drive lasting changes in commuting behavior.

MISTRA SAMS 2

The Mistra SAMS2 project, funded by The Swedish foundation for strategic environmental research (Mistra) and hosted by KTH in collaboration with VTI, explored sustainable accessibility and mobility services from 2017 to 2024. The program investigated how digitalization, policy measures, and new mobility solutions can contribute to more sustainable urban transport. Key research areas included shared mobility, Mobility-as-a-Service (MaaS), and behavioral shifts toward sustainable travel. The project aimed to bridge the gap between research and real-world implementation through pilot studies and collaborations with public and private stakeholders.

Findings indicate that digital solutions, such as mobility platforms and demand-responsive transport, can significantly improve accessibility while reducing car dependency. However, challenges remain in integrating these services into existing transport ecosystems. Governance models, public-private partnerships, and user engagement strategies play a critical role in ensuring the success of sustainable mobility solutions. The project also highlighted the importance of considering equity and inclusivity when designing future transport services.

The project calls for continued policy support, investment in digital mobility infrastructure, and more large-scale pilot projects to test and refine new mobility solutions. By fostering stronger collaboration among researchers, policymakers, and industry stakeholders, Mistra SAMS2 envisions a future where digitalized mobility services help create more accessible, efficient, and environmentally friendly transport systems.

HITS2

The HITS2 project, funded by FFI (Fordonsstrategisk forskning och innovation), focused on optimizing urban freight distribution through off-peak deliveries. The study demonstrated that off-peak deliveries, both manned and unmanned, are feasible but require overcoming key challenges. Digitalization plays a crucial role in improving accountability and ensuring delivery quality. Findings highlighted the need for better coordination among stakeholders, regulatory adjustments, and infrastructure adaptations to scale up off-peak delivery solutions effectively.

The project evaluated various delivery methods, including automated and electric vehicle-based deliveries, to reduce congestion and emissions in urban areas. By analyzing operational data and conducting real-world trials, the study identified best practices for implementing off-peak logistics. Key enablers include smart routing systems, policy incentives for night deliveries, and improved collaboration between

municipalities and logistics providers.

Moving forward, the report recommends expanding off-peak delivery pilots, refining digital tools for monitoring logistics performance, and engaging policymakers to support regulatory adaptations. The long-term vision is a more efficient and sustainable urban freight system that reduces daytime congestion, enhances delivery reliability, and minimizes environmental impact.

EFFECT

The EFFECT-Persika project, funded by Digital Futures and the Swedish Energy Agency, explores the costs, benefits, and optimization of electrified construction. Led by KTH researchers in collaboration with the City of Stockholm and industry partners, it gathers data from the Persika living lab in Södermalm and develops a digital twin to analyze and improve electrified operations. The project assesses cost-benefit trade-offs, optimal configurations of batteries and chargers, and the impact of smart charging.

In 2024, researchers extracted operational data, modeled battery charging, and built a digital twin for scenario testing. Initial findings show that, in warmer months, existing grid capacity meets energy needs, though fast charging is required at specific times. While infrastructure is slightly over-dimensioned, additional battery storage and fast charging may be needed during colder months or peak workloads. Insights from EFFECT-Persika will inform larger electrified construction projects, supporting the transition to sustainable construction through improved planning and optimization.

DATASETS+GEOMETRIC

A key 2024 development was the training of models to estimate traffic flows using standalone noise sensors. The methodology involved several stages: first, a two-year collection of traffic noise data and traffic event recordings from ANPR cameras. These data sources were used to validate the identification of vehicle pass-by events based on noise sensor readings.

This initial phase also enabled the fitting of log-linear regression models to directly estimate traffic flows from noise levels. The next step focuses on identifying key acoustic metrics that serve as robust proxies for traffic flow across different measurement locations. This work is now being extended to develop self-calibrating noise sensors, ensuring their adaptability across different locations for cost-effective traffic flow estimation, while maintaining their primary function of noise monitoring.

With this dual functionality, these sensors play a key role in advancing our combined experimental and numerical approach to estimating microscopic traffic patterns and assessing exposure to noise and pollutant emissions. The GEOMETRIC project ultimately aims at providing dynamic map representations of these.

MERGEN

The MERGEN project explores biometric data collection and analysis to assess cognitive load and risk perception in transport scenarios. It focuses on implicit data sources like heart rate variability (HRV) and EEG, along with behavioral data such as acceleration and steering inputs. The methods developed have been applied in collaborations with REDO (Remote Driving Operations) and DAVeMoS (Digitalisation and Automatisation in Transport and Mobility Systems), extending research into remote driving and micro-mobility contexts.

In collaboration with REDO, experiments were conducted to compare cognitive load in conventional, remote, and simulator-based driving. These took place at test tracks in Arlanda and ITRL. Building on this, MERGEN worked with DAVeMoS at BOKU in Vienna, focusing on micro-mobility by comparing cognitive load and risk assessment in real-world and virtual e-scooter riding scenarios.

Key findings show that HRV and EEG provide a more effective measure of cognitive load than traditional methods, as they allow participants to focus on tasks without distraction. MERGEN also identified optimal sensor types for various use cases and reinforced the value of simulators in studying human-vehicle and human-environment interactions. However, maintaining participant engagement in simulators remains a challenge, requiring further research—ideally using MERGEN methods to measure improvements.

Labs & 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.

As with last year, 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 have built new and updated stations with modern equipment for mechanical and electronics work and assemblies. These upgraded assembly stations are already in use for work on the **RCV Dynamic vehicle, DISCOWER and the 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 visualize and work on complex large-scale system pipelines. This year, we have made several improvements to the Control Tower to strengthen 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 powerful computers at the Control Tower, which will support multiple operating systems used within different projects. Within the REDO2 project, the new Control Tower features a driving simulator that provides an immersive remote operation experience with sound, steering wheel force feedback, vibration actuators, and motion in six degrees of freedom. Furthermore, we will be able to run at least two demonstrations at the same time, allowing all new projects to showcase their work with zero interruptions and total integration.

We have also put significant effort into making the Control Tower more visually appealing and welcoming than ever before. We look forward to showcasing the upgraded Control Tower and workspace during the upcoming demos and workshops throughout the year.

Research Concept Vehicles

The Research Concept Vehicles (RCVs) at ITRL have been updated throughout the year, as part of our strategic approach to continuously improving platforms to meet the evolving needs of research projects. The larger RCV-E vehicle, currently used extensively in the REDO2 project, has been further improved in terms of remote driving capabilities with better antennas, sensors, and software integration.

The RCV-Dynamic vehicle is a new and updated design from the old RCV platform, which has been in development since 2022. This project is funded by strategic faculty funding from the Vehicle Dynamics research group at the SCI school. This is a complex, updated design that requires multiple iterations, with support from student projects and master's thesis projects. The goal is to develop a platform capable of actuating steering, camber, vertical wheel movement, acceleration, and braking individually on all four wheels, all within highly dynamic conditions. Making the vehicle flexible in terms on what vehicle functions to use and explore.

We are developing a testbed in a private, fully controlled 5G network at Kista Innovation Park, in collaboration with Ericsson. By utilizing this private network, we can test advanced 5G features such as time-critical communication, network slicing, and quality of service maintenance.

Smart Mobility Lab and SVEA Vehicles for Evaluating Connected Vehicle Applications

During 2023, we designed and developed a testbed specifically for evaluating the real-life performance of advanced 5G-based C-V2X applications. This testbed enables low-cost experimentation on advanced C-V2X applications while allowing precise evaluation of network, compute hardware, and software performance.

To reduce experimentation costs, we built the testbed around 1/10th scale vehicles, called SVEA (Small VEhicle for Automation). While these scaled-down vehicles do not replicate the full physics and dynamics of full-scale vehicles, they provide a cost-effective way to evaluate V2X applications with real network, hardware, and software in the loop.

Additionally, 1/10th scale vehicles offer the ability to

conduct preliminary studies with motion, providing insights into how results might translate to full-scale vehicles. To ensure precise and reliable evaluation of network performance, we have integrated state-of-the-art measurement tools and methodologies.

The Space Robotics Lab

A small area in the ITRL labs is now dedicated to a testbed investigating weightless scenarios. The Space Robotics Lab is a testbed for micro-gravity robotic experiments, where the team plans to demonstrate novel control and planning algorithms for space applications. This new lab is part of the DISCOWER WASP NEST project, which started in April 2022 and will run until April 2027.

In this project, they aim at looking into the space and subsea environments - as they informally call them, weightless environments - from an holistic approach to control and planning, trying to develop methods that work across these two scenarios. Here they showcase in realistic demos multiple application cases that they target in the DISCOWER.

In connection to ITRL, the project are also planning to setup a large container-based pool to demonstrate the subsea component of DISCOWER and run experiments that simultaneously happen in both underwater and micro-gravity conditions, which is a quite unique combination.

Junior researhers community of ITRL

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 70 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 organized by JRC are aimed at encouraging networking opportunities and integrated research collaborations between members and ITRL core partners. In 2024, JRC organized the following activities:

JRC mini conference and guided tour at Stockholm Transport Museum.

Slussen and Region Stockholm study visit.

Scania HR Talk and Networking event.

Impact and publications

ITRL turns 10!

A key event to highlight this year was ITRL's 10 year anniversary celebration on 28th November, where we celebrated a decade of provoking progress. This event also marked the beginning of the centre's next phase and its renewed, extended collaboration with core and project partners. The ITRL coalition is now consolidating the experiences of the past decade and looking ahead for ways to challenge each other to create impactful new research in the field of future transport.At the 10-year anniversary celebrations, the centre Director Jonas Mårtensson posed a question to the partners that caught everyone's attention:

"Do you want to be challenged? And how?"

This question encapsulates not only the ethos of ITRL but also the driving force behind its success in transforming sustainable transport systems. As transport shifts toward electrification and software-driven systems, the need for systemic thinking has never been greater. ITRL invites new partners to join the conversation, challenge assumptions, and shape the next decade of innovation.

Astronauts at ITRL

On the 28th of August, the Space Robotics Laboratory (SRL) at ITRL – Integrated Transport Research Lab had the privilege of hosting an exceptional visit from the four astronauts of the Axiom-3 mission, alongside the Director of the Swedish National Space Agency (SNSA/Rymdstyrelsen), Anna Rathsman and Sweden's first astronaut, Christer Fuglesang. During their visit, Pedro Roque & Elias Krantz showcased our facilities and conducted a live demonstration, where the Axiom-3 crew attempted a synchronized rendezvous with robotic platforms developed at SRL as part of the WASP – Wallenberg AI, Autonomous Systems and Software Program NEST DISCOWER project.

Publications from ITRL in 2024

ITRL noted, at least, 12 journal publications, 8 conference papers, 3 doctoral theses and 11 master project theses. These publications are listed below:

Journal Papers

Almlöf, Erik, *"Beyond the hype: A critical look at the motivations driving automated driving systems research,"* Transportation Research Interdisciplinary Perspectives, vol. 24, 2024.

Andruetto, Claudia et al., *"Towards sustainable urban logistics: Exploring the implementation of city hubs through system dynamics,"* Transportation Research Interdisciplinary Perspectives, vol. 27, 2024.

Brunet, Maude et al., *"Exploring the Connections Between Project Management Offices and Organizational Design,"* Project Management Journal, vol. 55, no. 5, pp. 463-472, 2024.

Engholm, Albin et al., *"Exploring cost performance tradeoffs and uncertainties for electric- and autonomous electric trucks using computational experiments,"* European Transport Research Review, vol. 16, no. 1, article id 41, 2024.

Hassan, Syeda Erum et al., *"The role of battery electric vehicles in off-peak hour deliveries: Sustainability assessment of a case study in Stockholm,"* Cleaner Logistics and Supply Chain, vol. 13, pp. 100175-100175, 2024.

Johansson, Alexander et al., *"Hub-Based Platoon Formation: Optimal Release Policies and Approximate Solutions,"* IEEE Transactions on Intelligent Transportation Systems (Print), vol. 25, no. 6, pp. 5755-5766, 2024.

Nyberg, Truls et al., *"Share the Unseen: Sequential Reasoning About Occlusions Using Vehicle-to-Everything Technology,"* IEEE Transactions on Control Systems Technology, pp. 1-14, 2024.

Raja, Shyamprasad Natarajan et al., "*High-bandwidth low-current measurement system for automated and scalable probing of tunnel junctions in liquids,"* Review of Scientific Instruments, vol. 95, no. 7, article id 074710, 2024.

Rylander, Lina et al., *"Conceptual fault-handling system design for driverless trucks – A case study based on industry practices in Sweden,"* Transportation Research Interdisciplinary Perspectives, vol. 25, article id 101123, 2024.

Tanriverdi, Selim et al., *"Elasto-inertial focusing and particle migration in high aspect ratio microchannels for high-throughput separation,"* Microsystems and Nanoengineering, vol. 10, no. 1, article id 87, 2024.

Xin, Tao et al., *"Design of an intelligent post-diagnosis decision support system for highly automated trucks,"* Transportation Research Interdisciplinary Perspectives, vol. 28, article id 101284, 2024.

Zhao, Lin et al., *"The Influence of Motion-Cueing, Sound and Vibration Feedback on Driving Behavior and Experience: A Virtual Teleoperation Experiment,"* IEEE Transactions on Intelligent Transportation Systems (Print), vol. 25, no. 8, pp. 9797-9809, 2024.

Conference Papers

Andreolli, Raphael et al., *"Energy Consumption Evaluation of Emerging and Current Vehicle Fleets in Urban Logistics,"* 10th Transportation Research Arena, Dublin, Ireland, 15-18 April 2024, 2024.

Axelsson, Agnes et al., "*Robots in autonomous buses: Who hosts when no human is there?"* HRI 2024 Companion - Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction, Association for Computing Machinery (ACM), 2024, pp. 1278-1280.

Bai, Ting et al., *"Distributed Charging Coordination of Electric Trucks with Limited Charging Resources,"* 2024 European Control Conference, ECC 2024, Institute of Electrical and Electronics Engineers (IEEE), 2024, pp. 2897-2902.

Mamaghan, Amir Mohammad Karimi et al., *"Challenges and Considerations in the Evaluation of Bayesian Causal Discovery,"* International Conference on Machine Learning, ICML 2024, ML Research Press, 2024, pp. 23215-23237.

Riveiros, Alejandro Penacho et al., "*Real-Time Anomaly Detection and Categorization for Satellite Reaction Wheels,"* 2024 European Control Conference, ECC 2024, Institute of Electrical and Electronics Engineers (IEEE), 2024, pp. 253-260.

Song, Xujing et al., *"A Study on the Influence of Steer-by-Wire Failure Modes on Driving Safety,"* Advances in Dynamics of Vehicles on Roads and Tracks III - Proceedings of the 28th Symposium of the International Association of Vehicle System Dynamics, IAVSD 2023, Road Vehicles, Springer Science and Business Media Deutschland GmbH, 2024, pp. 671-683.

Wang, Lingfei et al., *"Maximizing social power in multiple independent Friedkin-Johnsen models,"* 2024 European Control Conference, ECC 2024, Institute of Electrical and Electronics Engineers Inc., 2024, pp. 3422-3427.

Xu, Gehui et al., *"Non-Convex Potential Games for Finding Global Solutions to Sensor Network Localization,"* 2024 European Control Conference, ECC 2024, Institute of Electrical and Electronics Engineers (IEEE), 2024, pp. 2921-2926.

Doctoral Theses

Almlöf, Erik, *Beyond Technology: Understanding societal impacts of implementing self-driving vehicle systems on road transport*, Doctoral thesis, comprehensive summary, 2024.

Andruetto, Claudia, *Impacts of innovations and policies on sustainability within road freight transport: using a system thinking lens*, Doctoral thesis, comprehensive summary, 2024.

Engholm, Albin, *Automated driving in road freight transport: On system-level impacts, policy implications and the role of uncertainty*, Doctoral thesis, comprehensive summary, 2024.

All ITRL associated student theses can be found on the KTH DiVA portal.

Connect & be a part of ITRL

ITRL membership

ITRL members are faculty, researchers and students who share ITRL's missions to build and convey knowledge on how new technologies should be used for the transition towards sustainable road transport through multidisciplinary research and innovation.

ITRL Senior members: KTH faculty, full-time researchers, and support personnel.

ITRL Affiliated member: Adjunct faculty, part-time researchers at KTH, R&D personnel from partner organizations, and faculty from universities engaged in ITRL.

ITRL Junior member: PhD students, postdocs, junior research engineers from KTH and affiliated with partner organizations.

How to apply?

To become an ITRL member, fill out the membership application form at the link below. Applications are reviewed by the ITRL Management Group and are processed within a week.

www.itrl.kth.se/about-us/become-a-member

ITRL partnership

ITRL is built on a strong collaboration between KTH, Scania, Region Stockholm, and Trafikverket. This unique partnership bridges academia, industry, and public-sector stakeholders, allowing us to integrate cutting-edge research with real-world applications. Through this collaboration, we tackle key challenges in Enabling the transition towards integrated and sustainable road transport.

ITRL's research spans a wide range of topics, including sustainable transport development, Mobility as a Service (MaaS), electric road systems, autonomous buses, and innovative freight transport solutions.

Interested in Partnering with ITRL?

If your organization wants to collaborate with us, get in touch.

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