Investigating Ongoing and Future Research Activities for the Advancement of Intelligent Access in Road Freight Transportation

A study of Intelligent Access in the Context of Digitization and Automation: Opportunities for Intelligent Transport Systems and National Road Authorities

Master's thesis in Supply Chain Management

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Abstract

The purpose of the master thesis project was to research the potential role of Intelligent Access (IA) in automation and digitization in road freight transportation by covering how IA can strengthen ongoing or future research activities in road freight transportation, and how these could help National Road Authorities (NRAs) in better utilizing existing infrastructure. The study aims to provide answers to the following research questions: What are the characteristics of IA in road freight transportation? What are the ongoing and future research activities in Intelligent Transport Systems (ITS) and how could these contribute to IA?

The research provided a detailed state-of-the-art for ongoing and future planned research activities in ITS that relate to IA. A total of 86 activities were found and ranked by a scoring system based on the abstract of each research activity by considering selected search words (ITS, IA, CCAM, Cooperative, Smart Infrastructure, Automation, Connectivity, Data, Road, Trucks, Freight, and High-Capacity Transportation (HCT)), in addition to the opinion of the two authors and based on literature study. To answer the research questions stated above, a total of 12 interviews were conducted. The interviewees were 6 experts in the area of IA and 6 project coordinators from the identified and selected research activities.

The findings reveal that little information regarding future research activities was obtained since these are still in an early stage of development. In contrast, ongoing research activities are well-documented in databases, complete with abstracts, and have been organized and validated by institutions, which justifies their funding. In addition to this, further research to support the development of IA is needed, as none of the research activities even included the search word IA in their project abstracts or on the websites.

For the characteristics of IA in road freight transportation, four analysis words (Smart Infrastructure, Connectivity, Data, and Automation) were asked to each interviewee to check their relevance and how they could contribute to IA. All recurring insights for each analysis word were collected and further analyzed.

Consequently, this thesis contributes to a better understanding of IA definition and its value within road freight transportation. The findings offer valuable guidance for NRAs and members looking to optimize road freight transportation by ensuring “the right vehicle on the right road at the right time”.

Abbreviations

Abbreviation	Meaning
AI	Artificial Intelligence
AHP	Analytical Hierarchy Process
BEV	Battery Electric Vehicle
CAD	Connected and Automated Driving
CCAM	Cooperative, Connected and Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
GDPR	General Data Protection Regulation
GHGE	Greenhouse Gas Emissions
HCT	High Capacity Transportation
IA	Intelligent Access
IAP	Intelligent Access Program
IoT	Internet of Things
ISAC	Intelligent Surface Access Community
ITS	Intelligent Transport Systems
LTL	Less-Than Truckload
NRAs	National Road Authorities
PEV	Plug-in Electric Vehicle
PDI	Physical and Digital Infrastructure
RSU	Roadside Unit
UVAR	Urban Vehicle Access Regulation
V2I	Vehicle to Infrastructure
V2N	Vehicle to Network
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything

Content

1. Introduction

The purpose of the master thesis project was to research the potential role of Intelligent Access (IA) in automation and digitization in road freight transportation by covering how IA can strengthen ongoing or future research activities in road freight transportation, and how these could help NRAs in better utilizing existing infrastructure. This chapter will develop and discuss the relevance and purpose of the project. Additionally, the problem will be outlined and defined. Finally, research questions will be raised along with the limitations of the thesis.

1.1. Background

According to Lumsden (2007), freight transportation encompasses all the stages and deployed means of transporting goods through different channels, such as road, rail, sea, and air. The global transport system moves billions of tons of goods around the globe yearly (*Greene*, 2023), creating a direct economic impact both nationally and internationally, while influencing logistics processes, transportation methods, and the resources used to reach the final destination *(Freight Transport | CEVA Logistics, s.f.)*. While focusing on road freight transportation, it is worth highlighting that it accounts for 25% of worldwide total transportation emissions and emits more than 1,75 billion metric tons of carbon dioxide ($GtCO_2$) yearly (*Statista*, 2024). Additionally, traditional transportation and fleet management have challenges due to reliance on manual processes, resulting in inefficiencies, resource wastage, increased costs, street congestion, and environmental degradation. Safety considerations, including accidents, vehicle maintenance difficulties, and driver conduct, are challenges in fleet management that need more attention (*Apata Stella Bolanle et al.*, 2024).

In addition to the problems mentioned above, there are also outspoken challenges in the areas of connectivity, vehicle misplacement, and digitization. The lack of mobile connectivity and sufficient broadband in rural areas results in a digital divide and reliable infrastructure, which is needed for technologically advanced solutions (Cottrill, 2018). An emergent need for innovation in skills, data management, and infrastructure has therefore been detected. To optimize existing infrastructure usage, and promote environmentally sustainable road freight transports from a supply chain perspective, it is essential to align road usage with conditions set by NRAs and facilitate IA (*ISAC Project – Intelligent Surface Access Community*, 2024). This will help in achieving, according to Asp & Wandel (2022): "To have the right vehicle with the right load on the right road at the right time".

IA is defined as a system that regulates vehicle access to road networks based on aspects such as weight, dimensions, emissions, and cargo, as well as how these align with infrastructure conditions to enhance road safety and environmental goals (*Kural et al.*, 2021). The main key enablers are ITS which can be explained as a technological architecture that combines cooperation, automation, data, and communication technologies (CCAM) (*Elassy et al., 2024; Noori,* 2013). In this context, CCAM integrates connectivity, automation, and cooperation among vehicles, infrastructure, and road users through real-time data sharing and seamless communication (*European Commission,* n.d.), while the concept of Connected and Automated Driving (CAD) focuses on real-time interaction between vehicles and their environment (other vehicles, infrastructure, pedestrians, etc) and advancing on autonomous vehicle ecosystems (*Connected Automated Driving*, 2024).

Connectivity is one of the main ITS technologies that enable seamless communication between vehicles, infrastructure, and users via vehicle-to-everything (V2X) technologies for better navigation, and decision-making to enhance proactive traffic management, hazard detection, and route optimization (*Singh*, 2023) through data sharing between vehicles and infrastructure, enabling real-time monitoring, predictive analytics, and decision-making. Types of data include static, historical, real-time, and dynamic, all crucial for improving safety and optimizing road usage (E*uropean Commission*, n.d.). Additionally, smart infrastructure can be known as the maintenance of the physical infrastructure by using sensors to collect data for further analysis and make a decision based on it, as well as adaptive signage, dynamic traffic management as well as geofencing (*Economic Role of Transport Infrastructure*, 2018). One of the main goals is to reduce human intervention by employing technologies for navigation and decision-making, from basic driver assistance to fully autonomous systems. For this reason, automation improves safety and reduces inefficiencies, while supporting environmental sustainability through optimized vehicle operations (*Overview of Driving Automation Levels*, 2016).

1.2. Background of the Intelligent Surface Access Community (ISAC)

In 2023, the ISAC project was launched as part of the Conference of European Directors of Road's (CEDR) Transnational Research Programme (TRP). CEDR TRP aims to produce research results that can be implemented by CEDR members, contributing to a safe, sustainable, and efficient road network across Europe. Participation in these programs is open to any legal European entity. The Call 2023 program specifically focused on IA, providing funds for research on optimizing infrastructure and advancing sustainable freight transport (*CEDR Research Call 2023*, 2023).

This thesis project is part of one of several work packages in the ISAC project, a collaborative initiative aimed at enhancing road infrastructure management and promoting sustainable freight transport. Engaging NRAs from countries including Finland, Ireland, the Netherlands, Norway, and Sweden, ISAC addresses critical issues in transport such as budget limitations and climate impact. The project focuses on leveraging digital transformation within both road management and logistics sectors to improve monitoring and control of road usage by road freight vehicles. The main objective of IA is to coordinate and manage vehicle usage with road conditions effectively by ensuring optimal infrastructure use and minimizing environmental impact. ISAC's research includes the creation of scenarios that demonstrate IA's potential to improve efficiency, safety, and environmental standards. Through these scenarios, guidelines and strategies for NRAs need to be offered to enhance sustainable road freight transportation both nationally and internationally (*ISAC Project – Intelligent Surface Access Community*, 2024).

1.3. Problem discussion

The ISAC project aims to find solutions that optimize road infrastructure use and enhance sustainability in freight transport across various European countries by helping NRAs, whose aim is to enhance traffic management thanks to a major shift towards digitalization (*Digitalisation: Driving The Transition Towards Smart And Sustainable Mobility*, 2024). NRAs face financial and environmental constraints in managing road infrastructure, prompting the need for innovative approaches. Through IA, ISAC seeks to use digital tools and data from connected vehicles to manage road usage effectively, promoting the goal of "*the right vehicle with the right load on the right road at the right time*" (*ISAC Project – Intelligent Surface Access Community*, 2024).

Two core concepts for IA are Connected and Automated Driving (CAD) and Cooperative, Connected, and Automated Mobility (CCAM). In brief, CAD supports vehicles to interact with the surrounding environment, make decisions in real time, and manage driving with different levels of involvement from humans. This is possible thanks to the integration of connectivity technologies such as V2X and different automation systems. Part of V2X is Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Pedestrian (V2P) communications, for example (*U.S. Department of Transportation*, n.d.). CCAM, on the other hand, takes more of a macro view and focuses on the transport system as a whole and the cooperation between vehicles among others, as explained through V2X (*European Commission*, n.d.). While CAD and CCAM are critical for IA, there are several outspoken challenges for the purpose of integration into current transport systems. Firstly, much research has been done in regard to ITS, CAD and CCAM separately, but there is little research on how these three topics can be combined to achieve IA. Gaps in existing data-sharing systems and standardizing practices across regions are required, making it difficult to align vehicle use with infrastructure capacity and environmental goals *(ISAC Project – Intelligent Surface Access Community,* 2024*).* Secondly, implementing IA in a complex logistics environment with multiple stakeholders is challenging, requiring the integration of digital infrastructure and cooperation across borders (*ITS Directive And Action Plan*, s. f.).

1.4. Purpose and research questions

The purpose of the master thesis project was to research the potential role of IA in automation and digitization in road freight transportation by covering how IA can strengthen ongoing or future research activities in road freight transportation, and how these could help NRAs in better utilizing existing infrastructure. The report will first present a state-of-the-art for ongoing and planned research activities in ITS that relate to IA. This review will focus on the selected search words: Cooperative, Smart Infrastructure, Automation, Connectivity, Data, Road, Trucks, and HCT. By examining these search words, the research aims to identify potential developments and future directions in ITS that intersect with IA. Following the state of the art, a selection of the most relevant research activities will be identified. To gain further insights, interviews were conducted with project coordinators as well as experts in ITS and IA. This combination of a literature review and gaining experts' insights support deepening the understanding of IA's current state and in conducting the final analysis based on the data collected. Based on the purpose discussed above, the following research questions were developed:

- **RQ1:** *What are the characteristics of IA in road freight transportation?*
- **RQ2:** *What are the ongoing and future research activities in ITS and how could these contribute to IA*?

The study seeks to contribute to the ISAC project providing valuable guidance for IA among all research activities in ITS.

1.5. Limitations

The study focuses on ITS as well as CAD and CCAM in road freight transports. Thus, rail, aviation, and sea transport are excluded, as well as public transportation and the transport of passenger cars. Even if ITS has many applications, the focus of this thesis will be on the selected search words: Intelligent Transport Systems (ITS), IA, Cooperative, Smart Infrastructure, Automation, Connected, Data, Road, Trucks, and High-Capacity Transportation (HCT) by following the Multi-Criteria Decision Analysis (MCDA). This helped in evaluating and selecting analysis words, a process explained in Chapter 3.2. A primary focus was on research activities in European countries, whilst a few additional single markets such as Australia were reviewed as well.

2. Frame of reference

In this chapter, the frame of reference will help in providing more context to the thesis project and the background of the research. Here, an emphasis to better understand the concepts will be put on ITS, Smart Infrastructure, Geofencing, CCAM and CAD as well as road freight transportation.Various resources have been used and they are referred to in the frame of reference.

2.1. CCAM and CAD

Connected, Cooperative and Automated Mobility, often abbreviated as CCAM, is a concept that integrates connectivity, cooperation, and automation for the purpose of increasing sustainability, efficiency, and safety in transport (European Commission, n.d.). Even if vehicles can be seen as connected devices today, communication between vehicles, infrastructure and other road users will increase due to CCAM. The general objectives of the CCAM Partnership are increasing safety in road transport, ensuring inclusive mobility and goods access for all, strengthening the competitiveness of European industries, reducing negative impacts from road transport on the environment, and capitalizing on knowledge to accelerate the development and deployment of CCAM solutions (*CCAM Partnership - CCAM*, 2022).

CAD stands for Connected and Automated Driving which enables communication between vehicles and other elements, both statically or dynamically, to share relevant information for fleet management (*Connected Automated Driving*, 2024).

2.1.1. Connectivity

According to the *World Bank Group - 2024*, connectivity involves all physical facilities and services to facilitate the transportation of goods and people within and across borders despite their position within a network. Connectivity permits navigation for real-time information, as well as safety, to find or avoid accidents when identifying the exact position or information about the road and weather conditions (*Vehicle Connectivity: Telematics and V2X Communication*, 2023). V2X communication implies connectivity with several elements such as with other vehicles, infrastructure, or pedestrians, for example, and sharing data or information in different directions, to optimize traffic flow, road safety, and the transportation environment (*Vehicle-to-everything (V2X) in the Autonomous Vehicles Domain – a Technical Review of Communication, Sensor, and AI Technologies for Road User Safety*, n.d.).

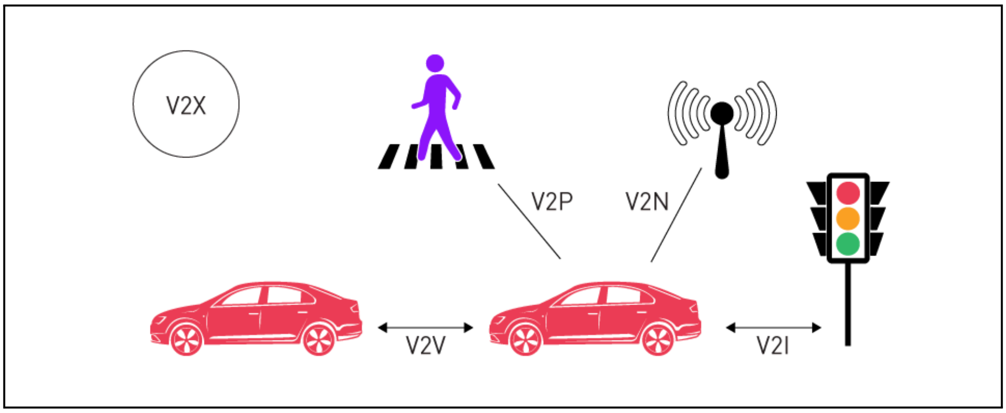

Figure 1: V2X Connectivity.
Source: Vehicle-to-everything (V2X) in the Autonomous Vehicles Domain – a Technical Review of Communication, Sensor, and AI Technologies for Road User Safety, n.d.

The main goal of V2V communication is to make driving safer. For instance, when a vehicle in front of another vehicle stops, it shares the information with the vehicle behind to avoid a possible accident. For autonomous vehicles, V2V becomes a common enabler for coordinated maneuvers (*Vehicle to Vehicle "V2V" Communication: Scope, Importance, Challenges, Research Directions and Future*, n.d.). V2I, on the other hand, is a concept where vehicles communicate with surrounding physical or digital infrastructure such as traffic lights, road signs, or road tolls. For instance, traffic lights can turn green or red depending on the situation and adapt to the traffic when necessary. Additionally, real-time V2I communication can enable drivers or automated vehicles to get updated about lane closures, road works, or detours (*An Empirical Study of Vehicle to Infrastructure Communications - an Intense Learning of Smart Infrastructure for Safety and Mobility*, n.d.). Vehicle-to-Pedestrian (V2P) enables vehicles to detect pedestrians in crossing sections if the driver does not see the pedestrian, as well as being an important feature for autonomous vehicles to reduce accidents with pedestrians, especially in urban areas (*An Overview on V2P Communication System: Architecture and Application*, n.d.)

Vehicle-to-Network (V2N) can be used to obtain information about real-time traffic updates in order to manage the optimal route to get from point A to B, as well as diagnosing vehicles remotely (*Singh*, 2023).

2.1.2. Automation

Automation in transportation refers to the use of new technologies to minimize human interaction (*New Technology and Automation in Freight Transport and Handling Systems*, n.d.). There are 5 different levels of automation regarding human interaction (*Overview of Driving Automation Levels*, 2016) which are presented below:

Level 0 (No Automation): Vehicles where the driver is totally responsible for all the driving tasks (steering, braking, acceleration, and controlling the surroundings and interaction with other vehicles). No automation is involved, except for simple warning systems such as collision alerts or warnings when switching lanes.

Level 1 (Driver Assistance): Implies simple automation characteristics in which vehicles are able to assist drivers when controlling steering or acceleration/braking. Despite this, the driver still remains responsible for all other aspects and has to be aware of the environment.

Level 2 (Partial Automation): The vehicle can either monitor both steering and acceleration or braking at the same time in determined situations or conditions. Despite this, the driver has to be aware of the surroundings in order to intervene if necessary.

Level 3 (Conditional Automation): Enables the vehicle to manage all driving tasks, such as surroundings within a defined operational domain (ODD). However, the driver must be prepared and take control if the situation requests it.

Level 4 (High Automation): Enables vehicles to work in a completely autonomous way ODD without requiring human intervention. Even if the system encounters a situation outside its operational parameters, it can safely manage the situation, such as stopping or parking. Nevertheless, a driver is still needed for some specific use-cases.

Level 5 (Full Automation): Is the highest level of automation and where the vehicle is completely autonomous without any human input, steering wheel, or pedals, being able to handle any driving scenario.

2.1.3. Cooperative

Within supply chain management, Bengtsson and Kock (1999) identify cooperation as a strong or tight bond between companies to accomplish common goals, while Lambert et al. (1999) define cooperation as a *"tailored relationship based on mutual trust, openness, shared risk and shared rewards that yield a competitive advantage, resulting in business performance greater than would be achieved by firms individually"*.

There has been a call for better decision-making, stakeholder engagement, and technology integration by providing input on strategic goals and leading to better decision-making by incorporating diverse perspectives (*Wilson et al.*, 2003). Hence, technology development such as collaborative decision support systems as well as community-based planning efforts have been encouraged (*Jankowski et al.*, 1997).

2.1.4. Data

Data is crucial in ITS and allows stakeholders to develop, test, and optimize safety, infrastructure, and efficiency in transport (*Kessler et al.*, 2016). Thanks to technological advancements and digitalization with new concepts such as Smart Cities, the Internet of Things (IoT), new wireless technologies, as well as reduced costs in storing data, the importance of data will just continue to increase. Along with this, data sharing between vehicles and infrastructure will also increase significantly *(European Commission*, n.d.). Data used in ITS can be divided into 4 different types, namely static data, historical data, real-time data, and dynamic data. Static data doesn’t change over time and could be, for example, the length of a bridge or a tunnel. Historical data refers to data collected from previous events such as the number of trucks sold in a specific year. Real-time data is provided directly to different stakeholders upon collection such as real-time monitoring of traffic updates. Dynamic data, on the other hand, changes frequently and could be data for weather updates, shared daily.

2.1.5. Mobility

Since CCAM stands for Connected, Cooperative Automated Mobility, it plays a crucial role in enhancing the efficiency and effectiveness of freight transportation. In road freight transportation, mobility is understood as the efficient and effective movement of goods through road networks (*Mobility of Freight (Selected Cargo) | the Geography of Transport Systems*, 2022). Factors such as infrastructure quality, regulatory frameworks, technological advancements, and environmental considerations influence the speed, reliability, and sustainability of freight movement (*Stepper*, 2023).

2.2. Intelligent Transport Systems

The definition of ITS can be explained as a technological architecture dedicated to improve safety, efficiency and sustainability of transportation networks.
Through data, communication systems, and automation, ITS enables smarter decision-making in traffic management and infrastructure usage. Applications such as adaptive traffic signal systems, real-time congestion management, and mobility predictions ensure smoother traffic flows, reduced environmental impacts, and improved safety. ITS also facilitates the development of smart cities through innovations like V2X communication and IoT-driven analytics *(Elassy et al., 2024; Noori, 2013)*.

The concept of ITS originated as a response to increasing urbanization and its associated challenges, such as traffic congestion and emissions. Early systems focused on coordinating traffic signals and basic congestion monitoring. Over time, advancements in IoT, 5G networks, and Artificial Intelligence (AI) transformed ITS into a sophisticated ecosystem encompassing automated toll systems, real-time traffic analytics, and autonomous vehicle communication. Modern ITS solutions aim to reduce environmental footprints, energy usage efficiency, and support sustainable urban development *(Jeung et al., 2010; Singh & Nandi, 2019)*. ITS applications are diverse and transformative, addressing various aspects of transportation to enhance efficiency and sustainability:

- Traffic Management: ITS improves traffic flow and reduces delays using adaptive traffic signals and predictive congestion algorithms, enabling real-time route adjustments and reduced idle times *(Ferreira & d'Orey, 2012; Ang et al., 2019)*.
- Autonomous and Connected Vehicles: V2V and V2I communication technologies ensure safer and more efficient road usage by supporting vehicle navigation and hazard detection in order to enhance overall road safety *(Khalid et al., 2018; Javed et al., 2016)*.
- Public Transit Optimization: Real-time monitoring and predictive analytics help public transportation schedule optimization, improve reliability, and enhance user satisfaction *(Khattak et al., 2019)*.
- Environmental Sustainability: Traffic congestion reduction and fuel usage optimization, ITS directly contributes to lowering greenhouse gas emissions (GHGE).

Applications like eco-driving advisories and dynamic speed control further support environmental goals *(Al-Turjman & Lemayian, 2020; Noori, 2013)*.

- Smart Parking Solutions: ITS uses sensor networks and real-time data to identify available parking spaces, significantly reducing time spent searching for parking and lowering emissions *(Jeung et al., 2010)*.

ITS plays an important role by reducing travel times, improving road safety, and therefore optimizing fuel consumption and lowering emissions. Furthermore, ITS supports economic growth by reducing logistics costs and improving freight efficiency, which benefits industries and urban economies alike *(Ang et al., 2019; Singh & Nandi, 2019).* Despite its many benefits, ITS faces challenges in regard to data security and user privacy, particularly with the vast amount of sensitive data collected. Besides, both IT and physical infrastructure costs for upgrades and the need for collaboration and interoperability between systems are the main barriers to implementation. Additionally, public acceptance and trust are also critical, as the deployment of ITS often requires changes in regulatory frameworks and behavioral adjustments by users *(Javed et al., 2016; Khalid et al., 2018).* Since not long ago, ITS has become crucial for smart city development by integrating it with other urban systems and creating sustainable and livable environments. IoT, 5G, and big data analytics become the main pillars for ITS, while their integration ensures that the population can adapt to growing populations and changing mobility demands while maintaining environmental sustainability *(Khattak et al., 2019; Al-Turjman & Lemayian, 2020)*.

2.3. Smart Infrastructure

Smart infrastructure is the use of digital technologies to improve the efficiency, sustainability and maintenance of the physical infrastructure by using sensors to collect data and for decision-making. Based on that, it can be described as consisting of three basic elements: data management, sense-making, and decision-making (*Transportation, Land Use, and Environmental Planning*, 2019). In the new era of smart cities and digital advancements and improvements, smart infrastructure can be applied in several situations *(Smart Cities Cybersecurity and Privacy, 2018)*:

- Smart Infrastructure: Use of sensors as well as technologies such as water and energy networks, streets and buildings to support the infrastructure.
- Smart Mobility: Transportation networks with enhanced and real-time monitoring control systems.
- Smart Environment: Provides smart innovation and ICT *(Information and Communication Technologies, 2024)* in order to incorporate natural resource protection and supervision such as waste management or pollution sensor control.
- Smart Governance: Based on the urban space and linked with technology for service delivery and resource utilization (*Resource Utilisation*, 2024) in accordance with government policy.

According to the *Economic Role of Transport Infrastructure*, the term "smart" can be considered as a continuous interconnection between 1I which, based on the new technologies, will reduce human intervention in vehicle driving and manage traffic flows accordingly. Thanks to the adoption of ITS, smart infrastructure can be referred to as an enabler connector between vehicles and infrastructure and vice-versa. Dynamic signs and adapting speed limits on highways or roads enable drivers to modify their behavior based on the decision taken after the data has been analyzed and managed (*Economic Role of Transport Infrastructure*, 2018).

2.4. Geofencing

The authors have decided to include geofencing since the interviewees often mentioned it as an enabler for IA and as part of ITS for the first research question. The concept of geofencing has been around since the mid-90s and with a purpose to create a virtual perimeter covering a geographical area. Mobile devices are connected to the selected area and an alert is issued once any of the mobile devices cross the line of the virtual perimeter for controlling and monitoring citizens through their mobile devices (*Nait-Sidi-Moh et al.*, 2013). So-called Global navigation satellite systems (GNSS) are often further supporting the universal system for tracking and geofencing, other communication and information technology solutions are also used.

Not only does geofencing help in monitoring traffic, but its usage area goes far beyond that. Thanks to the technology, drivers can be informed digitally and through in-vehicle technology, rather than by building expensive infrastructure that communicates with drivers. Road conditions, information about accidents, the collection of payments for parking, and speed limits can all be shared through the concept of geofencing, for example (*Foss, Seter, & Arnesen*, 2019). Geofencing can also help in reducing emissions and improving air quality by limiting the use of larger vehicles or fossil-fueled vehicles in certain urban areas, as well as close to schools.

In Sweden, local partners and governments initiated a project to test geofencing following the terrorist attack in Stockholm in 2017, where five persons were killed as a truck ran through Drottninggatan (European Commission, 2020). Besides, certain bus lines such as 16 and 55 are hybrid or electric and where geofencing is adopted on both lines (*Geofencing: A New Tool to Make Urban Transport Safer and More Sustainable?*, 2024). By forcing vehicles to switch to electric engines in zones with many pedestrians or cyclists, the city has introduced digital transport regulations that reduce speeds, reduce noise, and enhance air quality.

2.5. Road freight transportation

Road freight transportation can be divided into national and international road freight transport. Here, national road freight transport refers to road transport between two locations (having loading and unloading points) within the same country, and where the vehicle must be registered in that country. International freight transport, on the other hand, involves road transport between two locations in different countries, regardless of where the vehicle is registered (*Glossary: Road Freight Transport,* 2023). Looking at its increase in popularity, the usage of road freight increased much from 1990 until 2005, specifically from 58.4% to 72.4% when measured in ton kilometers (tkm) (*Glossary: Tonne-kilometre (Tkm),* 2023), and where the remainder is allocated for railroad freight and waterborne freight. Contrary to what many believe, the usage of road freight will also continue increasing until 2030, accounting for as much as 75.4% of global freight. By comparison, rail freight will decrease from 27.9% to merely 15% by 2030, showing the increasing usage and importance of road freight in the future (*Kural et al.*, 2021).

Europe is not an exception where inland passenger traffic is greatly dependent on road traffic and infrastructure, accounting for 90% of the total passenger traffic. For inland freight transportation, road traffic accounts for 75%, being the dominant means of transportation. From 1990 to 2020, the length of Europe's highways increased from 30,000 km to 73,000 km, similar to efforts done in China and US projects (*Ignatov*, 2023). Here, Spain stands out, having the longest highway network in the EU, only third after China and the US. Portugal's highway network system was built solely after 1990 and is the EU's fifth longest. Many of the roads in the EU were finalized between 1990 - 2020 and we have seen a strong growth of the length of highways since the 1990s. Consequently, travel times have decreased by 8.6% in European regions. Comprising 27 member states, it is worth highlighting the differences in infrastructure quality between member countries that pertain to historical development, economic differences, and geographical constraints, for instance.

2.5.1. High Capacity Transportation

Studies state that HCT enables traffic reduction by requiring fewer trips, although stricter vehicle standards are needed for road safety, and compliance with regulations to minimize risks. Additionally, it has been proved that axle increase reduces axle loads and hence, contributes to lower wear on roads and bridges.

From a productivity perspective, changes on HCT can minimize the need for both drivers and vehicles while lowering energy consumption by enhancing operations and making them more cost-efficient.

Although these systems could provide considerable societal benefits, HCT reforms have not been widely implemented in many countries. In Sweden, for instance, it is estimated that increasing the maximum vehicle length from 25.25 meters to 34.5 meters while maintaining a gross weight of 64 tons could generate benefits up to 13 times the cost of infrastructure upgrades over a 40-year period *(Lindqvist et al., 2020)*. Furthermore, adopting such measures would significantly enhance efficiency by reducing CO2 emissions, costs, and the space required for infrastructure by 15-50% at the vehicle level and 8-15% at the freight system level, without increasing road wear, infrastructure degradation, or the frequency of accidents *(High Capacity Transport, 2019) (ITF Transport Outlook 2019, s. f.-b)*.

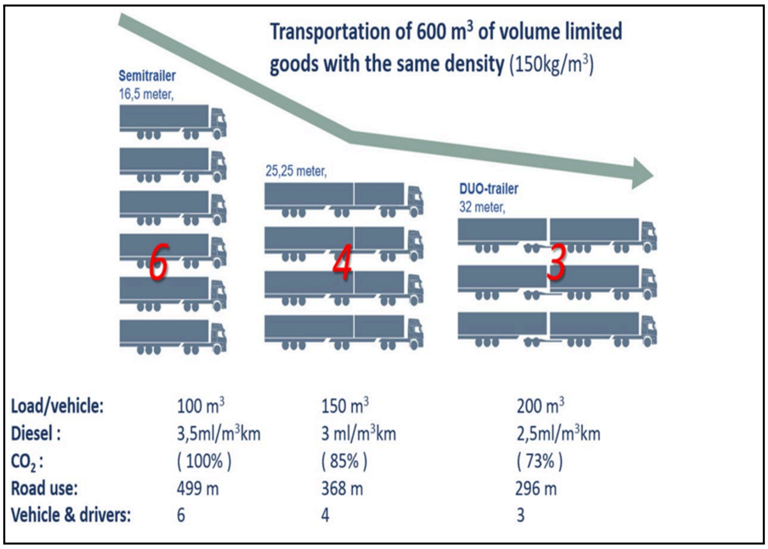

Figure 2: Transportation distribution.
Source: High Capacity Transport, 2019.

Despite these advantages, many nations are slow to adopt HCT systems. Reports from *ITF (*2017, 2018, 2019*)* suggest that political and public hesitancy could be mitigated through the integration of ITS technologies. Tools such as vehicle tracking, route optimization and geofencing have been recommended to enhance public confidence and minimize the need for infrastructure investments *(Aronietis & Voege,* 2018*)*. Similarly, *Moore, Regehr, and Rempel (*2014*)* emphasize the importance of additional measures to facilitate HCT reforms, as observed in jurisdictions where these policies have been successfully implemented.

2.5.2. Benefits of road freight transportation

There are plenty of outspoken benefits of road freight which have resulted in the surge of its popularity and usage, which can mainly be attributed to its reliability, flexibility, and quick deliveries (*Nkesah*, 2023) adopting a concept associated with Lean production and Just in Time, companies tend to keep less stock for consistent and continuous flows of deliveries and goods within shorter periods. Contrary to rail freight, road freight transportation allows the delivery of goods on time through alternative roads thanks to its flexible aspect of taking different routes when roads cannot be used due to weather conditions or congestion problems (*Reis & Macário*, 2019).

Looking at its economic viability, it is comparatively easy to enter the market as a third-party operator, requiring less investments and initial capital compared to sea and rail transport. Additionally, an outspoken benefit is therefore that the road freight sector enjoys healthy competition, as well as innovation, with a constant improvement of services (*Engström*, 2016). Its adaptability in managing both large and small shipment sizes, from HCT transports to Less-Than Truckload (LTL), along with its importance in multimodal transport and connecting with other transport modes, makes it highly important.

Road transport mostly manages the first and last segment for the other transport modes used (sea, air, rail, and inland transportation) as these transportation modes cannot offer delivery of goods door-to-door. This allows making products available in a flexible and timely way and makes road freight transport necessary, especially at the start and the end of a multimodal transport setup sometimes referred to as first and last-mile logistics.

2.5.3. Disadvantages of road freight transportation

Despite the benefits of road freight transport, there are various outspoken disadvantages. As mentioned earlier in the report, road freight is a great contributor to GHGE, where CO2 is a major culprit and other polluting substances include particulate matter and NOx which not only accelerate climate change but also affect air quality leading to various health issues among citizens globally (*Nkesah*, 2023). Diesel road freight transportation engines in particular emit large quantities of harmful pollutants, resulting in respiratory issues, cardiovascular diseases, increased risk of cancer, and premature death (*World Health Organization [WHO]*, 2005).

Worth mentioning in addition to increased road freight transports, passenger vehicles are set to double by 2050 (*Hao et al.*, 2016), posing even greater challenges to our environment and societies. As a result, businesses should focus more on sustainability and not only on reducing operating costs, which road freight transport can generally help with. New vehicle concepts such as HCT seem promising and get increasingly more interest from researchers. In brief, HCT refers to the concept of transporting goods with vehicles that are heavier and/or longer than accepted by existing regulations. The implementation of HCT vehicles could have a major impact in urban areas and reduce truck trips by 50%, while CO2 emissions can be reduced by as much as 40% (*Cederstav et al.*, 2023), having a major impact on the environment in the areas. The implementation of alternative vehicles such as battery electric vehicles (BEV) and plug-in electric vehicles (PEVs) have a significant impact on the reduction of GHGE from transportation unless other alternatives are also introduced.

2.6. Intelligent Access

IA can be described as a dynamic system that is designed to monitor and regulate vehicle access to different roads by using advanced technologies such as geofencing, telematics, and real-time data collection (*Kural et al*., 2021). The main goal of IA is to ensure compatibility between road infrastructure and vehicles by considering vehicle dimensions, weight, and emissions. By comparing and matching road conditions with these vehicle capabilities, IA can assist in increasing road safety, reducing infrastructure wear in bridges and tunnels, and supporting environmental sustainability.

The Department of Transport and Main Roads in Australia (*Transport Certification Australia*, 2021), a country that has been very active in the area of IA, defines it as a technology-driven system, using satellite-based tracking (GNSS) and telematics to manage and monitor heavy vehicle transports on road systems. The main goal of IA is to make sure that vehicles use roads according to their weight, size, and operational needs, improving safety and protecting infrastructure at the same time. The National Heavy Vehicle Regulator in Australia explains more about the Intelligent Access Program (IAP) which is a partnership between road agencies in Australia (*National Heavy Vehicle Regulator*, n.d.) and that started in 2009. The IAP is considered one of the pioneering large-scale implementations of IA systems globally and was among the first government-run programs to integrate telematics, regulation, and industry participation into a unified framework. The IAP was created together with Australian road agencies which provides operators access or improved access to the road network and supports in monitoring and assuring compliance with access conditions provided by road managers. By using wireless communication and satellite tracking via the In-Vehicle Unit (IVU), the time, location and identity of vehicles can be monitored remotely. Thanks to IAP, operators can use heavier or larger vehicles, or bridges or roads that wouldn't be possible otherwise.

The applications of IA are plentyfold, which has clearly been shown in the IAP project. It has proven to increase road safety by monitoring trucks on designated roads, reducing the risk of accidents and assuring that vehicles assure safety regulations. This is particularly important for heavy vehicles such as trucks that present major risks to public safety because of their larger size, weight, and operational complexity. Through control and monitoring, the IAP can manage access to specific roads and highways, which helps in preserving infrastructure and reducing damage. This is especially important in Australia where the road network has older roads and bridges which are not designed to withstand the stress caused by modern heavy vehicles. Thanks to enforcing regulations on regulatory compliance such as those related to the weight of vehicles, the IAP can subsequently increase road safety and reduce wear and tear on infrastructure. Not to forget, thanks to the monitoring of vehicles, the IAP also enhances efficiency by reducing congestion and improving logistics (*National Transport Commission*, 2018).

Many NRAs see IA as an enforcement tool, supporting making sure that policies and road usage regulations are followed (Aarts et al., 2023). This is further supported by the Transport Committee in the EU with members of the parliament pushing for the introduction of IA and to introduce automatic control systems along main roads for the verification of dimension and weight limits for trucks (*European Parliament*, 2024). While some claim that IA can assure that regulations are being followed, from a practical point of view, it is primarily a monitoring tool. As European NRAs generally don't have the legal powers needed nor enforcement roles, utilizing IA as an enforcement tool would be difficult.

2.7. National Road Authorities

In Europe, NRAs are important organizations that supervise and manage road networks in order to ensure safety, efficiency, and sustainability in transport systems across their respective countries. These entities, which are typically public or semi-public bodies, operate under the guidance of national ministries of transport or infrastructure, implementing policies and maintaining critical road infrastructure. Notable examples include the Highways Agency in the UK, Rijkswaterstaat in the Netherlands, and Dirección General de Carreteras in Spain. They collaborate with both local and regional road agencies to align national objectives with local transportation needs *(CEDR, 2023)*.

The primary responsibilities of NRAs include long-term infrastructure planning, construction, operation, and maintenance of essential road systems, such as highways, bridges, and tunnels. They regulate traffic, enforce road safety standards, and promote sustainable practices, such as reducing carbon emissions and incorporating renewable energy into road designs. In addition to these tasks, NRAs gather and manage data related to traffic flow, road conditions, and accidents, using these insights to enhance decision-making and optimize road network operations *(Regeringen och Regeringskansliet, s. f.)*. Many NRAs are also involved in international organizations, such as the Conference of European Directors of Roads (CEDR), which fosters collaboration and knowledge exchange among European road authorities *(CEDR, 2023)*. Currently, NRAs face several challenges, including aging infrastructure, increasing traffic demand, and the need to meet strict environmental targets. Digitalization is key when transforming the management of road systems such as real real-time traffic monitoring, automated toll systems, and digital twin modeling. These innovations are complemented by sustainability initiatives, which aim to integrate multimodal transport systems and adapt infrastructure to improve climate resilience *(NAPCORE, 2024)*.

Furthermore, NRAs will need to strengthen cross-border collaboration to harmonize standards, facilitate innovation, and address shared transportation challenges *(Towards a Common European Mobility Data Space, 2023)*.

2.8. EU Regulations

The European Union is obliged to move towards an intelligent and sustainable mobility and transport sector in the interests of the environment, competitiveness and resilience. According to the Commission's Sustainable and Smart Mobility Strategy (SSMS) (*Sustainable And Smart Mobility Strategy – Putting European Transport On Track For The Future*, 2020), digitalization can help drive this transition, establishing a truly efficient and interconnected multimodal transport system for both passengers and freight that will help the EU to meet its European Green Deal, focusing on increasing the EU's climate ambition for 2030 and 2050 (*A Europe Fit For The Digital Age*, 2020).. The deal also focuses on accelerating the shift to sustainable and smart mobility, positioning the EU as a global leader, and implementing a European Climate Pact *(COMMUNICATION FROM THE COMMISSION*, 2019).

While the EU transport sector generates substantial data, the current data landscape remains fragmented across various ecosystems, making accessibility and interoperability challenging *(Creation of a Common European Mobility Data Space, 2023)*. In order to resolve this, the EU has proposed the creation of a Common European Mobility Data Space (EMDS), which aims to facilitate access and share mobility and transport data by harmonizing technical and legal frameworks by supporting sustainable and smart mobility through efficient transport services and reduced emissions *(Creation of a Common European Mobility Data Space, 2023)*. By involving all Member States in order to enhance the reuse of ITS data, NAPCORE activity aims to ensure harmonized data-sharing standards and interoperability *(NAPCORE, 2024; "On The Framework For The Deployment Of Intelligent Transport Systems," 2010)* via National Access Points (NAPs).

Being DATEX II part of NAPCORE framework, it enables harmonized and interoperable data-sharing for traffic and travel information exchange by accommodating light and heavy-duty vehicles by ensuring standardized communication of road conditions, temporary changes, and usage rules, reducing misunderstandings and enhancing data usability while aligning with EU delegated regulations, supporting the digitization and automation of road transport systems *(DATEX II Organisation, 2021)*. Additionally, regulations on dimensions and weights for HCT have also been outlined in Council Directive 96/53/EC, commonly referred to as the Weights and Dimensions Directive *(Directive - 96/53 - EN - EUR-LEX, s. f.)*, which have been updated through several amendments, specifically Directive (EU) 2015/719 (*Directive - 2015/719 - EN - EUR-LEX*, s. f.-b), Decision (EU) 2019/984 (*Decision - 2019/984 - EN - EUR-LEX*, s. f.), and Regulation (EU) 2019/1242 (*Regulation - 2019/1242 - EN - EUR-LEX*, s. f.). These updates introduced specific exemptions from the established maximum weights and dimensions for vehicles and vehicle combinations. The purpose of these changes is to encourage the use of alternative fuel powertrains, including zero-emission options, improve vehicle aerodynamics, support trials of modular systems (longer and/or heavier vehicle combinations made up of standard vehicle units, also known as European Modular Systems), and promote intermodal transport operations *(Directive - 96/53 - EN - EUR-LEX, s. f.)*.

2.9. General Data Protection Regulation

The General Data Protection Regulation (GDPR) governs how personal data of individuals within the EU is collected, stored, and processed. It is a data protection and security law, the strongest in the world, and with a purpose to protect rights and freedoms of people, related to personal data and ensuring free movement of the data within the EU (Council of the European Union, n.d.).

2.10. Artificial Intelligence

There's been a sharp rise in the research and adoption of Artificial Intelligence (AI) (European Central Bank, 2024), and the field of transportation is not an exception. While there is no exact definition of AI, the European Parliament (2020) defines it as: "AI is the ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity.". It furthers explains that technical systems can observe their surroundings thanks to AI, gather and interpret information, identify challenges, as well as taking actions to manage certain objectives. The technical systems collect pre-processed or collected data with the help of sensors, analyze the data, and create suitable responses. Worth mentioning is also that AI systems can change their behaviors and adapt based on the results from past actions, allowing for a degree of autonomy in decision making and when executing tasks.

3. Methodology

This chapter explains the process used when conducting the research for the project. The data collection and analysis processes used during the project are first presented below. This part is followed by a brief introduction of the state-of-the-art for the research activities and how they were selected, the research approach and the research questions.

3.1. Data Collection

Developing research questions in research activities provides guidance and to set a structure on how research activities should be executed, what data should be collected, and how the data should be analyzed (*Bryman*, 2007). In short, the research questions give a point of departure and support in the orientation when conducting the thesis. For this thesis project, two research questions were created to guide the project and better understand both the concept of and developments of IA in road freight transports. The research questions helped in better understanding the characteristics of IA, as well as in obtaining more information about current and future activities in IA, which support its development. To address the research questions, a combination of both literature reviews and expert interviews was conducted. Expert interviews are widely used and the success depends on both the quality and knowledge of the interviewees, as well as the number of interviewees. A minimum of ten interviews is advised (*Mergel et al.*, 2019). A semi-structured guide was created for the interviews, including questions that directly related to the research questions, RQ1 and RQ2. The interview guide can be found in Appendix B Interview Guide. In total, twelve interviews were conducted, including six interviews with experts and six interviews with project coordinators or activity managers. The activity coordinators or managers were responsible for or belonging to the shortlisted activities. The interviews aimed to provide a comprehensive understanding of IA, to see if there's a lack of research, and how IA can support in strengthening ongoing automation and digitization processes at NRAs and in the transport sector. The structure of the research questions and their specific objectives are outlined below.

A ranking of the 86 activities was conducted, resulting in shortlisted activities. The scores attributed to the highest ranking activities were based on both the search word density as described earlier, as well as a personal evaluation performed by the authors by reading the abstract of the research activity and considering how it can help IA. Subsequently, the project coordinators and experts in the field of ITS and/or IA were contacted to participate in semi-structured interviews, which were conducted using a predefined guide shown in Appendix B to ensure consistency and uniformity across all participants. Conducting semi-structured interviews was deemed the most suitable option to collect data for the thesis. First, conducting interviews offers a more effective method of data gathering compared to methods like systematic quantitative surveys or participatory observation (*Bogner et al.*, 2009). Besides, experts can share insider information that is otherwise difficult if not impossible to find, particularly for future research activities, or where research conducted is limited. Prior to choosing an interview format, the authors identified the three main interview formats as structured, semi-structured, and unstructured. The authors chose the semi-structured interview format as it allows for follow-up questions and for greater information exchange (*Adams*, 2015), and these allow interviewees to answer direct questions rather than be able to speak freely (*Fox*, 2000). For qualitative research, semi-structured interviews are also more useful as to obtain more detailed and in-depth information, while allowing for better adaptability and flexibility (*Ruslin et al.*, 2022). The questions were open-ended questions and not closed, allowing for the interviewees to elaborate more freely in their replies.

The meetings were held through video calls rather than in person as this helps to avoid travel costs (*Mergel et al.*, 2019), saving time, and the capability of gathering several persons at a specific time. This was particularly useful as many interviewees were based outside of Sweden and in countries such as Belgium, Italy, Australia, and Greece. All responses were captured accurately and rather than relying on note-taking, which allowed both the interviewers to focus fully on the conversation and ask follow-up or clarifying questions when necessary. After completing the interviews, each recording was transcribed to facilitate the data analysis and ensure that the information was documented. By transcribing the video calls, a substantial time could be saved (*McMullin*, 2021) and the authors could make sure that all relevant details were collected, assuring the quality of the information collected.

3.1.1. RQ1: What are the characteristics of IA in Road Freight Transportation?

The first research question supported the development of knowledge of the characteristics of IA in road freight transports. To understand how IA can support NRAs in utilizing existing infrastructure as efficiently as possible, it is required to know what IA is and what characterizes it. To ask the question to both experts and project coordinators, analysis words were used in interviews to reply to whether these could facilitate IA. The analysis words included: Automation, Connectivity, Smart Infrastructure, and Connectivity since, based on the MCDA in chapter 3.2, these were the ones that obtained the highest score value (100%).

3.1.2. RQ2: What are ongoing and future research activities in ITS and how can these contribute to IA?

The second research question was created to support identifying what ongoing or planned future research activities in ITS can contribute to IA. The search engines or databases used to search the activities are shown in Appendix A, considering ITS, IA, CCAM, Cooperative, Smart Infrastructure, Automation, Connectivity, Data, Road, Trucks, Freight, and HCT as relevant topics to search for research activities.

- Ongoing research activities: A focus on mapping existing activities and activities that could support IA. Evaluations of their scope, objectives, and outcomes were performed to identify whether the activities were suitable or not.x
- Future research activities: Identifying planned or proposed research activities that could address gaps or challenges in current IA implementations.

3.1.3. State-of-the-art

A state-of-the-art is useful in providing a holistic overview of the latest developments in selected research areas and can be described as the highest level of development for a device, technique or scientific field at a specific time (*Haase*, 2010). While literature reviews are crucial in the area of scientific research, helping in collecting, explaining, analyzing, and integrating vast amounts of data and information (*Barry et al.*, 2022), a state-of-the-art for the ongoing and future research activities within IA was deemed needed and searched for, either alone or in combination with each other.

3.2. Data Analysis

The methodology followed for the data analysis was divided into two different sections regarding RQ1 and RQ2.

For RQ1, all recurrent insights from the interviewees (both experts and project coordinators) were stated individually for each analysis word. After this, a review of each analysis word was performed based on the previous literature study, by providing relevant references and proving its importance.

For RQ2, the analysis words for each ITS research activity (attached on appendix D) was compared with the insights of all interviewees. The aim of this was to analyze if the research activities were on the right track from what the experts and project coordinators stated in order to facilitate IA in road freight transportation.

For this, chapter 3.2.1. explains the procedure to choose the relevant analysis words from the search words used for the ongoing and future planned research activities within ITS.

Additionally, chapter 3.2.2. explains the selection of activities and the scoring system applied to contact project coordinators. The aim of this is to find the relevance for IA in road freight transportation.

3.2.1. Selection of search words and analysis words

To search for the research activities, ten search words were selected to search the activities on the search engines shown in Appendix A. By following the Multi-Criteria Decision Analysis (MCDA) framework approach (*Marco Dean*, 2022) , each search word was scored based on five predefined criteria:

- Relevance (C1): Does the search word directly relate to the core concept of "Intelligent Access"?
- Coverage (C2): Does it cover subthemes or related topics within the domain of ITS?
- Applicability (C3): Is it commonly used or recognized in the context of ITS or Intelligent Access research?
- Impact (C4): Does the search word yield significant and relevant results in academic or practical applications?
- Originality (C5): Does it provide unique value or avoid redundancy with other selected search words?

Each criteria was equally weighted, and a binary scoring system (0 = no, 1 = yes) was applied for simplicity. The binary scoring and equal weights eliminated subjective biases and ensured a fair comparison across all search words, shown in table 1.

Search words	Relevance (C1)	Coverage (C2)	Applicability (C3)	Impact (C4)	Originality (C5)	Total
IA	1	1	1	0	1	**4**
ITS	1	1	1	1	0	**4**
CCAM	1	1	1	1	0	**4**
Cooperative	1	1	1	1	0	**4**
Smart Infrastructure	1	1	1	1	1	**5**
Automation	1	1	1	1	1	**5**
Connectivity	1	1	1	1	1	**5**
Data	1	1	1	1	1	**5**
Road/Trucks/Freight	0	1	1	1	0	**3**
HCT	0	1	1	1	0	**3**

Table 1: MCDA for the search word selection.

In a multi-criteria evaluation, it is common to define a minimum total score value. Terms meeting 60% (score of 3/5) can be considered to have reached a sufficient standard to add value (Samo Drobne & Anka Lisec, 2009). From the result, the chosen analysis words for the interviews were Automation, Connectivity, Smart Infrastructure, and Data.

3.2.2. Selection of activities

To evaluate the relevance of each activity for IA shown in appendix D, a structured prioritization scoring system was developed. The scoring system was based on two selection criteria: the presence of the chosen search words identified in the activity abstracts (search word density), as well as a personal evaluation performed by the authors.

The methodology proposed by *Kipper et al. (2014)* demonstrates the value of assigning numerical scores by applying a semi-quantitative approach which combines both qualitative insights and structured quantitative assessments in order to gain an effective activity prioritization by integrating strategic criteria and assigning weights based on relevance. Similarly, Multi-Criteria Analysis (MCA), as outlined in *Multi-Criteria Analysis: A Manual (Department for Communities and Local Government, 2009)*, provides a transparent and consistent framework for evaluating activities. Using techniques like weighting, MCA combines quantitative measures with subjective judgments to create an overall ranking, supporting objective and flexible decision-making processes.

In order to find ongoing and future activities on IA, the authors used a set of selected search words, which were either IA in itself or search words that were deemed relevant to IA: Intelligent Transport Systems (ITS), Cooperative, Automation, Connected, Data, High-Capacity Transports (HCT), as well as any of the search words Road, Truck, or Freight. Each activity website and abstract were reviewed and for every search word found, a score of 1 was given to the activity. If any of the search words Road, Truck or Freight were found alone or in combination, a point of only 1 was assigned. The accumulated score for each activity was the sum of all the search words identified in its abstract or the presentation of the activity on its respective website.

In addition to the evaluation done via the search word research, and after conducting extensive literature reviews to gain a deeper understanding of the relevant concepts and topics, a personal evaluation was also done for each activity. The evaluation was done independently by both authors, expressed in the formula as Personal Valuation, where subindex n=1,2 considers both valuations from the thesis partners, being: 1 (Marcus) and 2 (Albert). The scale ranged from 1 to 4 and where 1 was given to activities with no relevance to IA in road freight transportation, and where 4 was given to activities with a high relevance to IA. Each activity was expressed as i=1…86 where the valuations were applied for each of them, obtaining individual scores. It is noted that for proper function optimization, a binary variable was considered:

$$x_{j,n,i} \in \{0,1\}$$

Where the Personal Valuation by the thesis partners was described as:

$$PersonalValuation_{n,i} = 1 \cdot x_{1,n,i} + 2 \cdot x_{2,n,i} + 3 \cdot x_{3,n,i} + 4 \cdot x_{4,n,i} \quad n = 1,2 \quad i = 1 \dots 86$$

Following the restriction:

$$x_{1,n,i} + x_{2,n,i} + x_{3,n,i} + x_{4,n,i} = 1, \quad n = 1,2 \quad i = 1 \dots 86$$

To combine these factors, a weighted scoring formula was applied. In this formula, the search word score was given a weight of 20%, while the average personal valuation was weighted at 80%, which aligns with the principles of the Analytical Hierarchy Process (AHP) described by *Saaty (1980) in The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. AHP enables the assignment of subjective weights to factors deemed more critical through judgment. This systematic and defensible approach emphasizes evaluation over objective data to determine the relevance of activities, ensuring a well-founded prioritization process. Hence, the formula was expressed as follows:

$$Total\ Score_i = \left(\sum_{k=1}^{10} Keyword_{k,i}\right) * 0,2 + \left(\frac{\sum_{n=1}^{2} Personal\ Valuation_{n,i}}{2}\right) * 0,8 \quad i = 1 \dots 86$$

By using the formula above, each activity was given a total score, resulting in a balance between both the frequency of search words found and a subjective evaluation done by the thesis partners. The activity coordinators of the highest-scoring activities were subsequently shortlisted and contacted for the purpose of setting up interviews. If they were unavailable or did not respond, an activity coordinator associated with a slightly lower-scoring activity was contacted, continuing sequentially down the ranking until a sufficient number of participants were found.

3.2.3. Selection of Project Coordinators

This chapter outlines the methodology used to interview project coordinators. As described in Chapter 3.2.2, "Selection of Activities," research activities were ranked based on their total score. Following this ranking, project coordinators were contacted according to their respective scores, prioritizing the most relevant research activities. The process continued until a total of six project coordinators had been reached.

3.2.4. Selection of Experts

In contrast, experts were selected and interviewed through a word-of-mouth approach rather than a structured ranking process. This method relied on recommendations and referrals from relevant stakeholders, ensuring that the selected experts had significant knowledge and experience in the field. A total of six experts were interviewed. Experts were defined as professionals with robust and specialized knowledge, strong academic records, practical experience, or decision-making authority in areas relevant to Intelligent Access (IA) and transport systems.

4. Empirical findings

The collected data is presented in this chapter without any subjective comments, considering both experts' and activity coordinators' insights and answers to the questions from the Interview guide attached in Appendix B. The findings are divided into activity coordinators and experts.

4.1. Experts

In interviews with experts, both research questions were addressed to gain IA insights. Discussions covered its definition, characteristics, relevant research activities, and how these activities contribute to advancing IA systems.

4.1.1. Expert 1

Title: Post-Doctoral Researcher.

RQ1

1. Automation

The interviewee expressed skepticism about automation's direct role in IA. Automation was related to autonomous vehicles by the interviewee, who noted that it does not directly enable IA, which is fundamentally a digital service. She emphasized that IA is more about data and regulatory processes than automation technology.

2. Connectivity

Connectivity was highlighted as essential for IA, particularly for V2I. For IT-infrastructure, the interviewee mentioned that platform implementation for communication between stakeholders (e.g., municipalities, regulatory authorities, and OEMs) is crucial for IA implementation.

3. Smart Infrastructure

Not considering smart infrastructure as a strict prerequisite for IA since it can function without significant infrastructure investments. It is more relevant to focus instead on digital platforms on the vehicles although geofencing and advanced sensors could enhance IA in specific use cases like regulating vehicle entry into sensitive urban zones or icy roads.

4. Data

Data is considered a main pillar of IA, emphasizing the need for both real-time and historical data. While real-time data can support dynamic decision-making, historical data is essential for long-term planning and regulatory compliance as well as vehicle characteristics such as vehicle weight, height, load, and route information were mentioned as critical for optimizing freight systems and reducing infrastructure wear and tear.

5. General comments

- Defining IA: digital service enabling the right vehicle on the right road at the right time, aligning with traffic regulations and infrastructure conditions. However, she noted that IA lacks a clear, universally accepted definition and varies based on its purpose and stakeholders.
- Digitalization as the Key Trend: Among automation, electrification, and digitalization, the interviewee identified digitalization as the most relevant trend for IA. It serves as the foundation for the service by enabling efficient data sharing and regulatory oversight.
- Purpose-Oriented Nature of IA: designed to reduce road maintenance costs and manage environmental zones as well as enhance traffic management in urban areas.
- Global Examples: The IAP Program IAP was cited as a leading example, demonstrating how IA can function as a regulatory framework for heavy vehicle access.
- Barriers to Adoption: challenges such as privacy concerns, regulatory fragmentation, and resistance from freight companies and drivers who may perceive IA as overly restrictive or time-consuming.
- Additional analysis word: Geofencing was mentioned as a specific application of IA for urban areas, allowing authorities to control vehicle access to sensitive zones based on predefined conditions.

RQ2

The interviewee did not mention any specific ongoing or future activities tied to IA for truck road transport, although activities related to digitalization, connectivity, and regulatory processes were discussed:

- Ongoing efforts with Trafikverket in Sweden: Exploration of digital platforms to reduce gradual deterioration to infrastructure by regulating heavy truck access. While this is not labeled as a specific activity, it reflects a focus area relevant to IA.
- Potential Vehicle Trials: The interviewee referred to discussions about conducting vehicle trials where trucks share data (e.g., weight, height, cargo) via a common platform for real-time access management and permit approvals. She indicated that this idea remains conceptual and has not yet materialized into a concrete activity.
- The IAP Program: The interviewee highlighted the Australian IAP as an established example of IA implementation.

Mention of Lack of Existing Activities: The interviewee also highlighted that IA-related services often exist only as small trials or conceptual discussions without substantial real-world implementation or strong government and industry backing in Sweden or Europe.

4.1.2. Expert 2

Title: Professor Emeritus in Engineering Logistics.

RQ1

1. Automation

The interviewee emphasized that automation and IA are interdependent. Automated vehicles require IA systems to ensure compliance with regulations, such as routing and load limits, while automation was defined as crucial for enabling efficiency in vehicle loading and unloading, particularly in controlled environments like mining and tunneling activities but no mention in road freight transportation. Sensor integration on vehicles and infrastructure is vital for automation systems to function properly.

2. Connectivity

Detected as a fundamental component of IA, the interviewee discussed its importance in enabling data exchange between vehicles (V2V), infrastructure (V2I), and centralized systems like cloud platforms and databases to provide dynamic routing based on conditions such as load limits and traffic by integrating vehicle sensors while accomplishing regulations. Connectivity also extends to V2V and V2I communication, particularly in contexts like HCT, where vehicles interact with infrastructure like loaders, cranes, or dynamic traffic control systems. mentioning the importance of creating an "information ecosystem" that integrates vehicle, infrastructure, and loading equipment data. He also noted ongoing work on connectivity standards in Sweden and Europe to enable consistent IA implementation.

3. Smart Infrastructure

Essential for supporting IA. Examples included:

- Weight in Motion Sensors: Systems that measure loads on axles as vehicles pass over bridges in order to ensure weight restriction limits.
- Dynamic Traffic Control: Adaptive systems to redirect traffic in case a major event occurs in order to prevent congestion and ensure smooth logistics.
- Road Condition Sensors: Sensors implemented on roads to detect frozen ground in order to adapt or modify load capacities. Databases were also emphasized to store detailed information about infrastructure capabilities, such as bridge load limits and road conditions, to aid in route planning.

Although infrastructure is critical, the most important element is maintaining accurate and accessible databases for infrastructure and vehicle data.

4. Data

Described as a key factor for IA, the interviewee mentioned vehicle weight, axle loads, road conditions, and environmental factors. The necessity of integrating vehicle data to optimize routing for managing infrastructure (e.g., bridges) onto a single database was mentioned. The importance of both static and real-time data for effective decision-making was also stated:

- Static Data: Infrastructure capacity, legal restrictions, and vehicle characteristics.
- Real-Time Data: Road conditions, vehicle positioning, and traffic flow.

The interviewee noted that weight data is among the most crucial for IA, as improper weight distribution causes safety and infrastructure risks. He also mentioned that data governance and ensuring trust among stakeholders are critical challenges for effective data sharing.

5. Additional Insights

- HCT: IA enables a safer and efficient operation for heavy and large vehicles in order to operate on designated or specific routes and therefore have robust monitoring systems.
- Regulatory and Institutional Challenges: Consistent regulations and institutions to manage IA systems are needed. Following the Australian model as an example where institutions like Transport Certification Australia (TCA) ensure rules are followed can be a potential framework for Europe.
- Fragmented regulations in Europe were identified as a barrier to the adoption of IA, especially on cross-border transport.
- Electrification and IA: The integration of electrified or hydrogen-powered trucks with IA systems was stated, emphasizing the charging infrastructure, where electric trucks require careful planning when charging and facilitating efficient route planning by integrating charging schedules together with freight operations.
- Social Acceptance and Stakeholder Incentives: Public perception and stakeholder benefits were seen as the main factors for IA adoption since transport operators might resist its adoption due to concerns about increased monitoring and potential penalties.
- Emerging Innovations: The interviewee highlighted innovations like "El-On-Road" systems, where vehicles are charged dynamically while driving, and battery-swapping systems as promising solutions to challenges in electrification and IA.

RQ2

The interviewee mentioned the following activities as ongoing activities:

- HCT: The interviewee is working on a project that involves high-capacity trucks for transporting heavy materials such as rocks and sand. This project involves testing connection systems, sensors, and data-driven platforms that align with IA to find the appropriate route and comply with access permissions.
- Aeroflex and CEFES: The interviewee mentioned the Aeroflex project, which has evolved into the CEFES project. These projects explore ways to integrate high-capacity vehicles and electrification into European freight transport systems.
- Frozen Roads: The interviewee refers to experiments using road temperature sensors to allow heavier trucks during winter when roads are frozen and more stable.

The following future activities and developments were also mentioned in order to support IA:

- Self-Service Permit System: discussions about creating a digital platform for self-service permits were highlighted. The system would allow transport operators to request access for oversized or overweight vehicles in real-time.
- Information System Development: development of an information platform in order to integrate road and bridge data with access management systems to provide planners with real-time insights into where heavy trucks can travel safely.
- Global Initiatives: The interviewee briefly refers to global efforts in developing IA frameworks, including projects in Australia and Europe (e.g., ISAC and P-ARC initiatives).

4.1.3. Expert 3

Title: Project Leader in HCT.

RQ1

1. Automation

The interviewee linked automation to IA by noting that machine-readable traffic regulations are essential for both automated vehicles and IA. Automation could ease the adoption of IA since automated vehicles inherently require data sharing, such as vehicle position, speed, and route details. The interviewee emphasized that while automation is not strictly necessary for IA, its presence reduces resistance to IA by normalizing data-sharing practices.

2. Connectivity

Connectivity was identified as critical, with an emphasis on V2V and V2I technologies. Ongoing discussions about standardized connected systems across Europe to ensure better communication were stated. Examples such as icy road warnings via connected vehicles with the ability to regulate speed dynamically through geofencing were mentioned.

3. Smart Infrastructure

Smart infrastructure in urban areas and sensitive locations like bridges were mentioned in addition to geofencing and advanced systems for frozen roads to enforce speed limits. However, it was stated that IA can operate without extensive smart infrastructure investments by utilizing existing vehicle technologies, such as fleet management systems.

4. Data

Described as a pillar for IA, key data types mentioned included vehicle weight, position, speed, and road conditions. The interviewee stressed the importance of integrating vehicle-generated data with infrastructure data to enable dynamic decision-making, such as rerouting heavy trucks to roads with higher capacity or frozen roads during winter.

5. General comments

- Geofencing: highlighted as a critical application of IA to enforce speed limits and route restrictions.
- Digital freight documentation: Was mentioned as a key enabler for cross-border IA adoption, with examples from Estonia and Italy.
- Traffic flow optimization: The interviewee discussed the potential for IA to reroute traffic dynamically, minimizing congestion and optimizing urban mobility.

RQ2

The interviewee mentioned the following ongoing research activities that could potentially facilitate IA.

- Frozen roads project: This project explores allowing heavier trucks to operate on frozen roads, which are more stable during winter. Sensors monitor road and bridge conditions to determine the allowable weight limits.
- Geofencing projects: Projects testing geofencing technologies to regulate vehicle speeds and weights in specific zones, such as bridges. These projects involve Volvo and Scania and include passive and active geofencing.
- Special transport projects: Projects focused on abnormal or special transports, requiring additional data collection and permit systems to manage oversized or overweight vehicles.

The interviewee also mentioned the following future research activities that could potentially support IA:

- Frozen Roads Project: A follow-up phase of the Frozen Roads Project, scheduled for the winter season of 2025-2026, aims to implement pilot testing of the technology and address legal and technical challenges.
- ISAC Project: A broader initiative to identify successful use cases for IA and explore the integration of IA principles into transport systems.
- European long vehicle project: Testing 42.5-meter-long vehicles (EMS2) in the Netherlands, where IA systems, including GPS tracking, will be necessary to ensure compliance with access regulations.

4.1.4. Expert 4

Title: General Manager, Strategy and Delivery.

RQ1

1. Automation

Automation was highlighted as a transformative element in IA, considering it as a decision-making process for enabling road network access to heavy vehicles and eliminating manual interventions as well as reducing administrative costs and providing real-time responses for permits. Automated braking and adherence to geo-fenced conditions (e.g., speed, time, or load restrictions) were also emphasized as a way to proactively ensure safety and compliance and considered automation in vehicle operations.

2. Connectivity

Identified as a foundational enabler of IA, several aspects were considered:

- V2I communication: allows vehicles to receive real-time updating such as route restrictions and speed adjustments to enhance regulations and operational efficiency.
- Cross-referencing data: Australian IA systems integrate onboard vehicle data such as weight in motion systems in order to verify restrictions and detect interfences or calibration errors in-vehicle sensors.
- Evolving connectivity: Modern vehicles generate data through engine management systems and electronic braking and provide insights into road safety issues, such as

severe braking zones, and inform infrastructure planning.

3. Smart Infrastructure

Smart infrastructure is a factor that complements IA but is not necessarily a facilitator:

- Australian context: IA reduced reliance on roadside infrastructure by utilizing in-vehicle technologies in order to maintain it, considering the large distances and sparse population.
- Dynamic capabilities: Adaptive traffic lights and digital signage are able to enhance IA, although it was stated that it has to remain independent of infrastructure limitations to ensure not only better cost-efficiency but flexibility.

4. Data

Described as a key aspect for IA, the points emphasized were:

- Types of data: GPS positioning, axle mass, vehicle configuration, and operational parameters (e.g., weight distribution) are critical for monitoring compliance and assessing infrastructure wear.
- Privacy and governance: The interviewee highlighted the importance of safeguarding data through independent oversight to address privacy concerns and protect commercially sensitive information.
- Operational insights: Data collection from IA systems can help NRAs to understand how roads, bridges, and other structures will last and allows them to plan maintenance and investments more effectively. For instance, tracking how vehicles use a bridge to see if it needs to be repaired or if it will last longer than expected.
- The interviewee underscored the need for standardized data formats to facilitate collaboration among technology providers, infrastructure managers, and regulators.
- He highlighted emerging data types like G-force metrics (harsh braking/cornering) and fuel consumption rates for environmental reporting.

5. General comments

- Evolution of IA: IA originally focused on enabling vehicles to access roads intelligently based on their characteristics (e.g., weight, size). Over time, its scope has expanded to include generating insights for infrastructure management and policy decisions.
- Harmonization challenges: The interviewee noted that regulatory fragmentation across regions complicates IA implementation, particularly for cross-border operations.
- Geofencing: For a vehicle to operate safely in certain environments, the interviewee mentioned inner city areas with low-speed limits and you might put a ring fence, a spatial sort of boundary, digitally around a road.
- Privacy and surveillance: The interviewee mentioned privacy and surveillance as a crucial part of IA. IA by its nature is a surveillance system and there needs to be protections and safeguards in place that give confidence to stakeholders.

RQ2

The interviewee mentioned the following ongoing research activities that could potentially facilitate IA.

- Australian IAP: The interviewee elaborated on the IAP, which has been in operation for years in Australia. This program uses telematics to monitor and regulate heavy vehicle access based on compliance with road infrastructure restrictions, such as weight limits and designated routes.
- SETOS (Smart Enforcement Technologies for Operations and Safety): This project focuses on smart enforcement technologies, including roadside and vehicle-based monitoring systems, to enhance safety and compliance in transport operations.
- European Long Vehicle Project: The interviewee briefly mentioned the trial involving 42.5-meter-long trucks (EMS2) in the Netherlands. This project explores the integration of GPS tracking and compliance systems to manage the access of such vehicles on European roads.

The interviewee also mentioned the following future research activities that could potentially support IA:

- IA trial in the Netherlands. The interviewee mentioned plans for a trial in the Netherlands to implement IA systems. The project is likely tied to European Commission funding and collaborations.

4.1.5. Expert 5

Title: CEO and Business Advisor.

RQ1

1. Automation

Discussed as a broad concept, he emphasized automation's role in reducing human error to improve operational efficiency. The examples included:
- Automated Toll Systems: Cameras are used instead of manual processes, allowing trucks to pass through without stopping. This saves fuel and reduces delays.
- Dangerous Goods Monitoring: Cameras can identify dangerous goods and guide vehicles to approved routes and limitate the total number of vehicles for safety reasons.
- Cabotage Monitoring: Automated systems use vehicle identification numbers (VINs) to match trucks to the correct trailers and ensure that they are paired properly in order to make operations smoother and help follow the rules.

2. Connectivity

Described as a fundamental factor for enabling IA, key points were included:
- End-to-End Tracking: Connectivity allows goods tracking throughout the logistics process, from the factory to their final destination, using unique identifiers like VINs for trucks, trailers, and containers.
- Trailer Data Broadcasting: Trailers send out their IDs using EBS, which truck manufacturers can use to improve tracking and operations.
- Collaboration Challenges: Companies often hesitate to share data due to competition and concerns about confidentiality, which slows down progress in connectivity.

3. Smart Infrastructure

Smart infrastructure was described as a complement to IA by providing tools to enhance safety and efficiency. Examples were included:

- VIN Handshake Systems: Connecting truck and trailer VINs ensures proper pairing and can block a trailer's brakes in case of a mismatch, reducing theft.
- Bluetooth Integration: TPMS (Tire Pressure Monitoring Systems) with Bluetooth can provide data to roadside infrastructure, through its range and cost limit application.
- Barriers to Implementation: Political, commercial, and GDPR-related challenges complicate the deployment of smart infrastructure in Europe.

4. Data

Data was highlighted as the backbone of IA, with specific types emphasized:

- Vehicle Data as a Foundation: Truck and trailer data are critical for IA, but harmonization and standardization across the industry are needed for effective use.
- Types of Data: Real-time, historical, and environmental data are all vital for optimizing IA systems.
- Challenges with GDPR: Privacy regulations (e.g., GDPR) and competitive concerns limit the effective sharing and use of data.
- EVs: The lack of standardized data for electric trucks makes their integration into IA systems difficult.

5. General comments

- GDPR: Highlighted as a significant regulatory barrier to data sharing and development.
- EVs: Discussed in terms of their limited market, data standardization issues, and infrastructure challenges.
- Harmonization: Stressed as vital for aligning data descriptions and delivery across systems and brands.

RQ2

No ongoing or future research activities were mentioned that could facilitate IA. Yet, the following projects were mentioned by the interviewee:

Current research activities:

- Handshake Between Truck and Trailer: A project that focuses on the interoperability or communication between trailers and trucks. The project could support the area of ITS.
- Algorithmic Research for Traffic Estimation: The development of algorithms that could foresee traffic queues and analyze various other data.
- Trafikverket ITS Projects: Work to utilize data and existing infrastructure for traffic solutions to avoid new road constructions.

4.1.6. Expert 6

Title: Project Leader.

RQ1

1. Automation

Automation could benefit IA in controlled environments such as construction zones or mining sites, although no outside zoned were mentioned. Automation can improve efficiency, safety, and accuracy on confined areas, although the interviewee was skeptical about full automation on public roads in the near future due to legal issues, regulations, and public acceptance in case of accidents. The complexity of hybrid systems was also stated, in which human drivers and automated vehicles work together.

2. Connectivity

Connectivity was stated as essential for IA to work effectively, since connected vehicles and infrastructure help to ensure regulations with access rules such as geofencing, which can define areas where specific vehicles are allowed as well as controlling speed limits in urban zones. However, they warned against relying too much on virtually braking or stopping vehicles since it can be harmful for passengers' health. Therefore, connectivity should focus on communication by giving drivers real time updates in order to ensure regulations without direct interference.

3. Smart Infrastructure

The interviewee emphasized the role of smart infrastructure in supporting IA, especially in managing HCT vehicles. For example, digital tools could speed up the permit application process for HCT vehicles, which currently takes months. Smart infrastructure can also improve traffic flow and reduce congestion by guiding vehicles to appropriate routes, although high costs and the need for strong regulations were pointed out in order to ensure consistent implementation across regions.

4. Data

Described as crucial for IA, weight, and GPS location were stated as key data. Considering that many vehicles do not have onboard weight measurement systems nowadays, this leads to inefficiencies and sometimes legal violations, so it was suggested to add standardized digital scales for heavy trucks, following Finland as a good example, where portable axle-weight scales are used effectively.

5. Additional Insights

- Geofencing: Considered as a key tool for IA, especially in urban areas by managing vehicle speeds as well as limiting access to sensitive areas to protect infrastructures such as bridges.
- Legal and Societal Challenges: Legal definitions such as GDPR compliance and public acceptance are the major barriers to automation and connectivity. Additionally, the public's perception of safety with driverless vehicles is a significant obstacle.

- Regulatory Fragmentation: The lack of harmonized rules across municipalities and countries was stated as a major issue. Hence national and European-level regulations are needed to ensure consistent IA implementation.
- Lessons from Finland: The interviewee pointed to Finland as a good example of IA done well, particularly in vehicle weight management and using portable scales for enforcement.

RQ2

The following ongoing research activities that could potentially support in the area of IA were mentioned:

- Confined Areas and Automation: The interviewee referred to projects in confined areas, such as collaborations with Skanska in Stockholm. These projects involve AVs operating in areas not open to public traffic, like construction sites or depots.
- Geofencing initiatives: Its potential use for creating digital zones where specific vehicle rules apply (e.g., speed limits or access restrictions for heavier trucks) was stated.
- HCT: The interviewee referred to ongoing work with HCT systems and discussed the challenges of coordinating permissions for longer or heavier vehicles, especially across Sweden’s 290 municipalities.

4.2. Project Coordinators

In interviews with project coordinators, all three research questions were addressed to gain insights into IA. Discussions covered its definition, characteristics, relevant research activities, and how these activities contribute to advancing IA systems.

4.2.1. Project Coordinator 1

Title: Project Coordinator - Electronic & Electrical Engineer.

RQ1

1. Automation

Automation was considered pivotal for IA by addressing the truck driver shortage across Europe and optimizing supply chain operations. Automation enables tasks like pre assigning trucks to warehouses and logistic hubs in a JIT manner. Automation was noted to reduce manual intervention and eliminate inefficiencies in freight processes, by applying regulatory challenges and public acceptance are significant barriers to widespread adoption.

2. Connectivity

Connectivity was described as one of the main pillars of IA, being essential for V2I, V2V, and multimodal transport communications in order to get the most appropriate vehicle for specific tasks depending on weight or dimensions, as well as the ability to adapt and function during unexpected events, such as road closures, accidents, or natural disasters. By dynamically rerouting or reassigning vehicles, it ensures that operations continue smoothly and disruptions are minimized.

Connectivity is key for collision prevention between vehicles as well as energy-efficient travel.

3. Smart Infrastructure

Smart infrastructure components such as adaptive traffic lights, weight sensors, and real-time traffic monitoring systems are considered a prerequisite for IA. It also helps maintain regulatory compliance, manage traffic flow, and redirect freight vehicles during disruptions as well as adaptability or flexibility to accommodate for punctual or situational needs, such as high tourist traffic or accidents.

4. Data

Real-time and historical data are crucial for IA. Traffic conditions, infrastructure status, load capacities, and road event forecasting (e.g., floods or wildfires) were the examples given. Additionally, satellite and video analytics data were noted as valuable tools for real-time monitoring.

Predictive analysis was also pointed out in optimizing road usage and supporting just-in-time freight logistics.

5. Additional Insights

- Regulations: clear and consistent regulatory frameworks are needed. Existing regulations frequently fail to keep pace with technological progress, posing difficulties for the effective implementation of IA.

RQ2

The following ongoing research activities were mentioned. He did not mention any future research activities. The interviewee didn't explicitly mention why the projects could potentially contribute to IA.

- FOREMAST: Funded by the Horizon Europe program, the project aims to revolutionize urban and coastal freight transport by developing small, flexible, automated and zero-emission (SFAZ) vessels, which are designed to facilitate the sustainable movement of goods along inland waterways to alleviate road congestion, reduce emissions and enhance accessibility in densely populated areas.
- DISCO: Stands for Data-driven, Integrated, Synchromodal, Collaborative, and Optimised Urban Freight Meta-Model and aims to revolutionize urban logistics and planning through advanced data sharing and digitalization, guided by the principles of the Physical Internet (PI).
- AutoMoTIF: Focuses on developing strategies, business and governance models, regulatory recommendations, and synergies to integrate and ensure the interoperability of automated transport systems, with the goal of achieving operational automation of multimodal cargo flows and logistics supply chains within the intra-European network.

No future research activities were recognized or mentioned by the interviewee.

4.2.2. Project Coordinator 2

Title: Project Coordinator - Ph.D., AICP, LEED AP l Professor

RQ1

1. Automation

Automation was considered pivotal when optimizing logistics and personal traffic flows, which, supported by connected infrastructure, can align with both climate and economic goals by selecting appropriate vehicle platforms and metering traffic. However, further advancements are needed for full orchestration of automated systems with the current generation of Level 4 vehicles.

2. Connectivity

Vehicle connectivity is not essential for IA, therefore connected infrastructure is relevant, which can guide vehicles through visual, auditory, or physical feedback without requiring direct digital vehicle connection in order to avoid the complexities of varying manufacturer standards and offer more scalable solutions for IA.

3. Smart Infrastructure

Described as an essential aspect of IA, examples like advanced broadcasting of road conditions, connected traffic signals, and physical or digital information sensors were highlighted. Such infrastructure can alert drivers or automated systems to hazards, road obstacles, or construction zones. Additionally, the integration of geofenced zones or dynamic lane markings can optimize traffic flow in order to improve road user's safety.

4. Data

Although two-way data sharing is rare due to confidentiality and technical issues, public agencies share road data conditions with private companies. Additionally, while historical data aids traffic management, real-time data becomes vital for emergencies and road worker safety.

5. Additional Insights

- Geo-Fencing: Its aim is to restrict specific vehicle types such as automated cars or delivery fleets from certain zones in order to support dynamic pricing, charging vehicles to access restricted areas.

RQ2

The interviewee didn't mention any other current and future research activities. He highlighted the potential for future research in digital and physical systems to protect roadway workers, enhance emergency response prioritization, and support the development of geofenced urban areas. Specific projects were not named.

For the interviewee's responsible project, he mentioned it focuses on autonomous vehicles and ITS by playing a significant role in optimizing traffic flow and congestion reduction by ensuring vehicles are efficiently routed based on real-time data by enhancing infrastructure utilization in addition to aligning to the principles of IA by promoting smarter and more sustainable vehicle operation.

Additionally, orchestration of vehicles can happen in a unidirectional way without direct V2I connectivity. As long as governments can build smarter roads that provide for driving policy and access requirements they can facilitate getting the right vehicle on the right road at the right time.

4.2.3. Project Coordinator 3

Title: Project Coordinator - Full Professor in Control Systems Engineering.

RQ1

1. Automation

The potential of automation to enhance IA was stated since it reduces human involvement and enables better and more efficient decision-making. Specific applications mentioned are:
- AI for Decision-Making: Automation through AI trained agents can process complex inputs like traffic, weather, and infrastructure conditions in order to determine and find optimal routes for freight transport.
- Historical and Real-Time Data Integration: These data types are used to support decision-making, and ensure route adjustments based on evolving conditions.
- Last-Mile Delivery Optimization: Automated systems are able to prioritize deliveries in order to optimize efficiency while minimizing costs and emissions.
- Challenges: Integrating automation with existing systems remain as significant obstacles, as well as social acceptance of automated technologies in case of accidents.

2. Connectivity

Connectivity was highlighted as essential for IA through:
- V2V and V2I Communication: Connectivity enables vehicles to exchange information dynamically, such as traffic conditions, infrastructure status, and route restrictions.
- Geofencing: Connected systems can enforce geofenced rules, such as access to specific zones or dynamic routing for vehicles based on their size and load.
- Real-Time Updates: Communication networks allow vehicles to receive live updates in order to facilitate adjustments to routes or schedules in response to unexpected changes. It was stressed that connectivity is essential for taking decisions in a fast and changing transport environment.

3. Smart Infrastructure

Discussed as a complement to IA, especially in urban environments. Points included:
- Charging Infrastructure for EVs: Mapping and managing recharging points were considered into smart nfrastructure key aspects, considering the grid availability together with the energy demands.
- Integration Challenges: Collaboration among stakeholders is required.

4. Data

Data was identified as the foundation of IA, emphasis were made on:

- Historical data: Long-term traffic patterns and high-traffic routes based on time of day and season were mentioned as key historical data examples.
- Real-time data: Considered critical for dynamic decision-making for adjusting into routes in order to avoid congestion and accommodate weather changes.
- EVs: Charging station availability, data on car battery level and grid power are considered vital for planning routes in order to minimize energy usage and emissions. Additionally, the integration of both historical and real time data for comprehensive decision-making were stressed as a key aspect.

5. Additional Insights

- Routing vs. Access: The term of "routing" was suggested as a more appropriate term than "access" following this context since it reflects the dynamic nature of IA, which includes time-sensitive routing constraints and geofenced conditions.
- Digital twins: creating virtual representations of infrastructure to simulate and optimize traffic management. Digital twins require sensors, data platforms, and simulators to analyze traffic patterns and support decision-making.

RQ2

Current research activities:

- Carpooling Optimization Project: Developing intelligent routing for cars to optimize pickup and drop-off sequences for shared vehicles.
- Electric Vehicle Routing Research: Route planning optimization considering recharging points availability and the battery capacity on electrical vehicles.

Future research activities:

- Autonomous Vehicle Carpooling Project: Research on intelligent routing for autonomous vehicles, focusing on carpooling applications.
- Last-Mile Delivery Optimization: Research aimed at improving the routing for goods delivery in urban areas, focusing on maximizing delivery efficiency and emissions reduction.

The interviewee's team contributes through research on:

- Autonomous vehicles and their routing needs.
- Electric vehicle routing solutions that consider energy constraints and recharging logistics.
- Optimization methods such as integer linear programming complemented by AI-trained agents enhance decision-making for transportation systems.

4.2.4. Project Coordinator 4

Title: Project Coordinator - Depute Head of Department Business Transformation

RQ1

1. Automation

Automation was considered as a significant potential for IA by optimizing processes and reducing manual labor in the logistics sector in order to enhance efficiency, particularly in data sharing and regulatory compliance. However, automation must be preceded by groundwork which includes defining clear processes, interfaces, and data governance frameworks. Besides, acceptance among stakeholders remains crucial as long as they trust the systems and have clarity about data usage, as this can pose problems.

2. Connectivity

Connectivity was identified as a key enabler of IA, especially in V2X systems. It was stated that real-time data sharing between vehicles (V2V) and infrastructure (V2I) is essential for effective routing, especially in complex scenarios such as border crossings or dynamic rerouting during emergencies. He also mentioned the importance of interfacing with map providers (e.g., Google Maps, TomTom) to access real-time traffic data and communicate disruptions.

3. Smart Infrastructure

Smart infrastructure needs to be deployed in strategic locations in order to provide the greatest benefit such as at dangerous intersections or critical crossings. The interviewee warned about over-investing in costly infrastructure upgrades, supporting a balanced approach to prioritize cost-efficiency. The role of targeted smart infrastructure in improving safety and supporting IA was emphasized, especially in high-risk areas.

The interviewee highlighted the dual role of physical and digital infrastructure (PDI) in IA. Examples included:

- Sensors and Weighing Plates: Monitoring road and bridge usage to support predictive maintenance.
- Dynamic Traffic Management: Adaptive traffic lights and speed limits that respond to real-time conditions were considered as traffic flow enablers. While acknowledging the value of smart infrastructure, it was warned about the fact of excessive investment in physical systems such as road sensors, advocating instead for obtaining data from vehicles to reduce costs and maintenance burdens.

4. Data

The importance of data for IA was stated, which included vehicle type, axle load, cargo details, and driving restrictions. Not only vehicle positioning and traffic updates were considered for real time data, but also the need for seasonal and regional data (e.g., frozen road conditions or snowfall risks) was also stated. Battery capacity data and charging infrastructure available for EVs have also been considered as key data aspects.

5. Additional Insights

- Data Governance: Rules for data usage become essential to build trust. A framework must address concerns around privacy and competition due to the fragmented nature of the logistics sector. GDPR and related regulations were noted as barriers that complicate data-sharing efforts, particularly for person-related data linked to vehicle drivers.
- Stakeholder Collaboration: The interviewee stressed the importance of including all stakeholders, public authorities, private companies, and drivers in the development

of IA systems and working together for collaboration in order to facilitate better implementation and ensure broader acceptance.

- Cost and Feasibility: The need for cost-effective solutions was stated, focusing on utilizing existing technologies (e.g., telematics in trucks) rather than deploying or implementing costly smart infrastructure.
- Challenges in Europe: The difference in regulations across European countries complicates cross-border transport. Therefore, harmonizing data standards and communication protocols was identified as critical for effective IA implementation.

RQ2
Current research activities:

- ReMuNet: Focused on multimodal transport networks, which include road, rail, and inland waterways. It emphasizes digital solutions over physical infrastructure and explores self-learning transport networks using machine learning.
- Stoffel Project: Aims to develop a platform for trailer and load exchanges to optimize logistics and driver work cycles, particularly for EVs..

Future research activities:

- ALICE (Alliance for Logistics Innovation through Collaboration in Europe): roadmap and its vision of the physical internet as a key area for future research, focusing on interconnectivity and creating a digital twin of the transport sector.

4.2.5. Project Coordinator 5

Title: Project Coordinator - Mobility Consultant.

RQ1

1. Automation

Automation was described as beneficial for improving IA when focusing in terms of human error reduction and distractions. Automation potential was stated especially in controlled environments such as industrial zones and distribution centers in which vehicles can operate on private roads, while in urban settings like Antwerp, concerns about the unpredictability of pedestrians and cyclists were stated. The unpredictability was considered as a complication on the implementation of automated vehicles, especially in cities.

2. Connectivity

Identified as crucial for implementing IA, particularly through systems like geofencing and connected traffic management. The interviewee highlighted the city's use of Automatic Number Plate Recognition (ANPR) cameras to monitor low-emission zones. These systems identify vehicles that enter into restricted areas and ensure they accomplish emission standards, although it was stated that advanced connectivity systems such as V2I communication are not yet integrated into Antwerp's logistics, which remains largely limited to data collection for enforcement rather than for dynamic interactions for V2I connectivity.

3. Smart Infrastructure

The city of Antwerp has invested in smart infrastructure such as intelligent traffic lights and route planners for freight vehicles. The interviewee explained that these tools are used to optimize routing, avoid school zones during peak hours, and navigate areas with height restrictions or sharp turns. However, the infrastructure does not yet support real-time communication for vehicles, like providing navigation updates directly to drivers. The interviewee also mentioned that the city's focus has been more on passenger mobility since freight-related smart infrastructure isn't yet a high priority.

4. Data

The importance of data in facilitating IA was stated, but challenges in data collection and utilization were mentioned. While the city ANPR cameras collect data, there is a lack of integration with national vehicle databases, which makes it difficult to identify vehicle types or their purposes and limits the ability to analyze freight movements in an accurate way. Therefore, trust and clear agreements on data sharing and usage between both private companies and cities remain essential.

5. Additional Insights

- Harmonization of Rules: Harmonized regulations across cities and countries in order to avoid logistical complexities for transport operators were stated. He cited examples of differing low-emission zone requirements in Belgian cities and cross-border challenges with the Netherlands. Harmonization would simplify operations and improve compliance rates.
- Zero-Emission Zones: The city is preparing for the implementation of zero-emission zones, where only vehicles meeting stringent emission criteria will be allowed to enter.
- Trust in Data Sharing: The importance of building trust between private and public stakeholders to facilitate data sharing was stated. Initiatives in shared mobility where operators of e-scooters and bikes are required to share data with the city as a condition for operating were mentioned.

RQ2

The interviewee's responsible project was stated as a key solution for freight transport improvement since it involves the development of route planners in order to guide trucks into the city while prioritizing road safety and efficiency, offering static plans rather than dynamic navigation.

Current research activities:

- AI for Loading Zones: The city is testing AI enabled cameras to monitor loading and unloading zones in order to improve enforcement and usage optimization.

Future research activities:

- Harmonized Urban Logistics Policies: The interviewee mentioned efforts to standardize regulations across Belgian cities to simplify compliance for freight operators.
- Smart City Distribution Platform: Consists on a virtual platform where logistics

partners input detailed data about vehicle types, cargo, and routes. This could support cargo consolidation at city borders, although it still requires significant administrative input.

4.2.6. Project Coordinator 6

The last Project Coordinator interviewed was not selected following the procedure on the scoring system on Selection of Activities 3.2.2. section, but recommended by Drive Sweden.

Title: Project Coordinator - Research Leader.

RQ1

1. Automation

Automation can support IA by enabling vehicles to serve as data sources for infrastructure and road authorities. Automated vehicles can contribute to having the right vehicle on the right road by aligning with digital road transport strategies, such as Trafikverket's roadmap for the digitization of the transport system.

2. Connectivity

Connectivity was emphasized as critical for IA, particularly for enabling vehicles to act as sensors. The interviewee noted that Trafikverket prioritizes vehicle-generated data over costly smart infrastructure investments. Connectivity facilitates real-time information sharing between vehicles and road authorities, which can optimize road usage and enable efficient maintenance operations.

3. Smart Infrastructure

Cost-efficiency concerns were mentioned about the deployment of smart infrastructure so focusing on strategic deployment into specific areas such as dangerous crossings or roads that require real-time monitoring was considered a better decision. This follows the same path as Trafikverket, whose vision is on relying more on vehicle data rather than deploying extensive physical infrastructure.

4. Data

Data was identified as a cornerstone for IA. Key types of data mentioned include vehicle-generated data (position, speed, weight) and infrastructure condition data. Cost-efficient data collection and distribution were highlighted as important by utilizing existing vehicle sensors to minimize additional investments in physical infrastructure upgrades.

5. Additional Insights

- Geo-Fencing: Discussed as a tool for restricting or regulating vehicle movements in specific zones based on real-time conditions, such as icy roads or urban areas with high pedestrian traffic.
- Vulnerable Road Users: Highlighted as an emerging area of focus, with examples

of technologies such as bicycle-mounted transmitters that communicate with vehicles to improve safety.
- Legal and Business Challenges: The interviewee emphasized the need for trust mechanisms between vehicle manufacturers and road authorities to ensure reliable data sharing and communication.

RQ2

The interviewee mentioned the below-listed ongoing research activities as being part of AstaZero. He did not mention any future research activities. The interviewee didn't explicitly mention why the projects could potentially contribute to IA.

- Digital Proving Ground: Ongoing research to test vehicle automation and connectivity in a controlled environment, simulating real-world conditions.
- CyberInfra: project investigating the use of truck-mounted attenuator (TMA) vehicle data for traffic management and road maintenance. Partners include Trafikverket, Halmstad University, and private organizations.

Future research activities:

- Decision expected today on funding approval: wireless data exchange for cost-effective traffic management solutions (acronym: WIDGETS)
- Planned Project:
  Together with Trafikverket (Swedish Transport Administration) and other stakeholders, define the digital road traffic infrastructure for connected and automated vehicles (Project X, no official name yet).

5. Analysis

The aim of this chapter is to analyze the empirical findings presented previously by applying the frame of reference. The chapter has been divided into two sections where the first section is aimed towards RQ1 and the other towards RQ2, where information has been collected in order to follow patterns in a combined analysis of experts and project coordinators and also a specific analysis for each group. Additionally, insights on project coordinators and experts have been attached on appendix C in order to check the recurring themes individually.

5.1. Analysis related to RQ1

The purpose of the RQ1 analysis was to identify and define the key characteristics of IA in road freight transport. To achieve this, a detailed examination of the analysis words mentioned by the authors was conducted, giving a summary of the insights of both experts and project coordinators together, as well as project coordinators and experts insights as separated groups. By doing this, each analysis word was analyzed individually in order to assess its relevance and contribution to understanding IA. This process aims to establish a comprehensive definition by highlighting recurring concepts and ideas based on the perception by both project coordinators and experts.

5.1.1. Automation Insights

- Recurring Themes:
  - Automation can be seen as an enabler for human error reduction in order to enhance efficiency and improve compliance with regulations (e.g., geofencing, toll systems).
  - Its direct role in IA varies: while some interviewees highlight automation as critical, others view it as complementary to IA's digital nature.
  - Applications mentioned include routing optimization, autonomous decision-making, addressing driver shortages, streamlining logistics, and automating compliance with rules and regulations.
  - Barriers to adoption include societal acceptance, regulatory challenges and the coexistence of human and automated systems.
  - The role of automation is frequently linked to controlled environments in order to avoid unpredictability such as mining sites, depots, etc.
- Quantitative Insights:
  - 9/12 interviewees identified automation as relevant for IA.
  - 4/12 interviewees related automation to IA's operational efficiency, especially in controlled scenarios.
- Additional Recurring Topics:
  - Integration with sensors and digital platforms: Highlighted as necessary to enable automation within IA frameworks.
  - Support for high-risk operations: Automation is seen as helpful in emergency logistics or hazardous transport.

5.1.1.1. Analysis of Automation

In regards to automation's support for compliance and human error reduction, there is various academic research that confirms this. The U.S. Department of Transportation, for example, explains that automation can reduce human errors by managing repetitive and complex tasks. This in turn helps to increase efficiency and safety in traffic systems (*Federal Highway Administration*, 1995). The same organization confirms that automated systems can increase compliance with regulations as these systems follow protocols in a more stringent way compared to humans. The systems can also help in traffic management, making decisions and supporting the enforcement of regulations and traffic laws. Yet, an important addition is that such systems should assist human decision-making and not replace it completely, for the purpose of avoiding errors and increased workload. This is further supported by Haight & Caringi (2007) who claim that it is crucial in finding a good balance between human intervention and automation, leading to optimal performance and efficiency.

Whether automation is critical or complementary, mixed answers were received from the interviewees with half of the experts saying it is critical with the reasoning that it can assist in reducing human errors, assure compliance, and increase efficiency. Research supports both claims that automation is critical and complementary for IA, it primarily depends on the applications. In the development of smart cities, for example, AI has been proven pivotal. Its usage in communication systems for V2I and V2V improves both safety and efficiency on roads (*Bharadiya*, 2023). Thus, automation as supported by AI is crucial for advanced transport systems in the application of smart cities. Yet, other research also claims that automation is more complementary as it relies much on the collection and processing of accurate and robust data. ITS can indeed see advantages from automation, but its functions predominantly rely on how data is collected and transformed into useful information. Thus, from such a point of view, automation complements data gathering and transformation, which is needed for ITS, rather than serving as a sole driver (*Zhang et al.*, 2011), making it more of a complementary tool.

The authors also note that the adoption of automation and automated systems in transportation is heavily affected by public perception, which covers both ethical and safety concerns, as well as job displacement (*Nordhoff*, 2023). With trust and safety being the main concerns for adoption, societal acceptance is important for the introduction of automation in transportation systems, which resonates with the interviewees' statements. Regulatory challenges were frequently mentioned as a barrier to the introduction of automation, which is further confirmed by the European Commission. It shares that the existing regulations don't optimally allow for the introduction of AVs, for instance (*De Bruin*, 2016). Europe currently faces problems with the development and deployment of automated transportation systems due to great regulatory challenges in the region. Additional outspoken risks to the introduction of AVs mentioned by the European Parliament include cybersecurity, civil liability, insurance, data protection, as well as the technical infrastructure required (*European Parliament*, 2018). A harmonized regulatory system as well as the creation of guidelines to meet the mentioned risks should therefore be prioritized.

Referring to the literature, automation is often deployed in controlled environments such as mines and depots for the avoidance of unpredictable events and to increase productivity and safety. Examples of implementations include electric robots in mining facilities and in other complex geological environments to increase operational efficiency (*Yan et al.*, 2021). The introduction of intelligent mining technology has also increased with emphasis on the use of automated equipment that operates in controlled environments, helping workers avoid exposure to hazardous conditions (*Li & Zhan*, 2018).

5.1.2. Connectivity Insights

- Recurring Themes:
  - Recognized as one of the main enablers of IA, which facilitates communication between vehicles, infrastructure, and central systems.
  - Applications include V2V and V2I communication, geofencing, hazard alerts, and dynamic routing.
  - The development of information ecosystems were mentioned since vehicle data, infrastructures, and logistics systems are integrated for better operations.
  - Standardization challenges on cross-border connectivity were common concerns.
- Quantitative Insights:
  - 12/12 interviewees recognized connectivity as a fundamental aspect of IA.
  - 8/12 interviewees linked connectivity to enabling real-time data sharing and aligned with IA frameworks.
- Additional Recurring Topics:
  - Vehicle-generated data is a priority over large-scale infrastructure investments.
  - Emergency management: Connectivity enables vehicles the possibility to choose different routes dynamically in response to road closures or weather conditions.
  - Collaboration with private technology providers: Discussed as essential to enhance connectivity standards and systems.

5.1.2.1. Analysis of Connectivity

Various literature confirms the interviewees' statement that connectivity is a strong enabler in IA and ITS, supporting applications such as V2V and V2I communication, traffic routing, and geofencing solutions. Without connectivity, V2X wouldn't exist and that contributes to increasing efficiency, reducing accidents, and reducing the negative impact on the environment *(U.S. Department of Transportation*, 2024). To take one example, one interesting use case where connectivity played a vital role was for connected snowplows in Salt Lake City where snowplows were connected to the roadside infrastructure. Prior, snowplows experienced reduced effectiveness due to traffic signal timing and traffic flow. Post-implementation, they saw fewer unnecessary stops, fewer roadway crashes, and better compliance with local speed regulations. Without the V2I connectivity, the implementation and improvement wouldn't be possible. A topic that got increasingly more attention is also 5G and its positive impact on connectivity in ITS and IA. 5G technology has a core function in the transformation and advancement of ITS systems, especially considering autonomous driving and intelligent highways (*Liu et al.*, 2022). 5G has sprung up as a key solution to modernize connectivity in the transportation sector.

Even if there's abundant research that proves the importance of connectivity, there are gaps. First, research primarily focuses on technologies such as 5G and V2X, but doesn't focus as deeply on practical implementation and how the technologies can be implemented on a large scale (*Ficzere et al.*, 2023). Secondly, socio-economic issues related to digital connectivity and accessibility are not explored as much. Internet access and usage among different socio-economic groups differ and education, income and geographic location can all affect people's ability to partake in the digital society (*Cohendet,* 2003). The collaboration between technical areas and behavioral science, urban planning, and public policy also sees room for improvement. For instance, experts in technical engineering such as engineering often work separately from experts in behavioral science and urban planning. Studies show that teamwork between the areas is crucial for the creation of solutions that include both the needs of people and cities in a holistic way (*Pellegrin et al.*, 2021).

5.1.3. Smart Infrastructure Insights

- Recurring Themes:
  - Smart infrastructure is often seen as a complement to IA, rather than a strict requirement.
  - Examples include adaptive traffic lights, geofencing, weight-in-motion sensors, and road condition monitoring.
  - Strategic deployment in high-priority areas, like urban zones and critical intersections, is emphasized.
  - Budget limitations and trust in vehicle-generated data rather than large-scale infrastructure investments were frequently discussed.
- Quantitative Insights:
  - 7/12 considered it complementary rather than essential for IA.
  - 5/12 interviewees considered cost efficiency as a barrier to broader deployment.
- Additional Recurring Topics:
  - Geofencing-enabled infrastructure: Highlighted for regulating vehicle access to sensitive zones or enforcing dynamic speed limits.
  - Digital twins: Mentioned as a key innovation to simulate and optimize road and traffic management systems.
  - Seasonal or environmental challenges: Such as icy roads, were discussed as areas where smart infrastructure could enhance safety and efficiency.

5.1.3.1. Analysis of Smart Infrastructure

While the literature doesn't explicitly mention whether smart infrastructure facilitates IA, we have to look at specific use cases. From the research conducted by the authors, it is clear that it depends on the applications, and if smart infrastructure is either just complementary or important. If IA focuses on compliance, routing, or vehicle-specific regulations, fewer infrastructure requirements and investments are needed as built-in vehicle sensors and satellite-based tracking such as GNSS could be used. In these scenarios, smart infrastructure is therefore considered complementary only. In other use cases, it is clear that real-time data needs to be collected from the physical environment, including information sharing for the weight of vehicles via Weigh-in-Motion (WIM) sensors (*U.S. Department of Transportation, Federal Highway Administration*, 2018), as well as road condition status. The detection of potholes is another example of where physical sensors are crucial for early detection and to prevent damage to roads. Image Processing Techniques and Ultrasonic Sensors can support detecting potholes (*Srikanth & B. G.*, 2019), as a result, smart infrastructure plays an important role and is considered essential in such use cases.

In the future, it is clear that in-vehicle technology will reduce the need for costly, physical roadside infrastructure and units. One example is the dEASY project that has been conducted in the US. The project shows that when in-vehicle technologies are integrated with algorithms and autonomous data sharing, the need for infrastructure-heavy traffic management systems is reduced (*Akabane et al.*, 2019). Thanks to data-sharing between vehicles, dEASY allows vehicles to find the best strategically positioned vehicle for data gathering and routing selections. This is just one example of projects that reduce the need for roadside units (RSU) and can be useful in areas where it is either too impractical or expensive to set up physical infrastructure.

5.1.4. Data Insights

- Recurring Themes:
  - Data is unanimously identified as the foundation of IA, supporting compliance, optimization, and decision-making.
  - Both real-time and historical data are seen as critical.
  - Key types of data include vehicle weight, GPS position, road conditions, infrastructure capacities, and traffic patterns.
  - Privacy concerns and governance challenges, particularly GDPR compliance, were widely discussed barriers.
- Quantitative Insights:
  - 12/12 interviewees considered data an essential aspect of IA.
  - 10/12 interviewees considered real-time data a critical aspect for dynamic routing and decision making.
- Additional Recurring Topics:
  - Predictive analytics and forecasting: Frequently discussed tools in order to optimize road usage for better infrastructure planning and maintenance.
  - EV data: Relevant for route planning and charging schedules for energy-efficient transport systems.
  - Sensor data integration: Vital when combining vehicle and infrastructure data in an effective way.

5.1.4.1. Analysis of Data

There is a clear consensus between all interviewees and the literature study that data plays a critical role for IA and ITS. As an example, a survey on ITS was carried out, stating the importance of data in optimizing system performance (*Fei-Yue Wang et Al.*, 2010). Additionally, data is a key enabler for transport optimization and enhancement of efficiency and safety since the U.S. Department of Transportation's ITS research includes Data Access and Exchanges, as crucial for the integration of automated vehicles and the optimization of transportation systems (*Intelligent Transportation Systems - Joint Program Office Home Page*, n.d.). Furthermore, the development of National Access Points (NAPs) for ITS data aims for data harvesting, processing, and sharing, thereby supporting informed decision-making (*Aifantopoulou et al*., 2020).

For the types of data, both real-time and historical data are considered key enablers for ITS effectiveness and how they can optimize signal timing in response to traffic conditions (*U.S. Department of Transportation*, n.d.). While historical traffic data can help create transport models as well as identify bottlenecks and determine the cause of accidents (*Hoang Phuong Nguyen*, 2022), real-time data becomes essential for monitoring and managing transportation and enhancing public transit networks *(Thair a. Salih*, 2021).

Vehicle weight data prevents structural damage to roads and bridges by detecting overloaded vehicles and enables an effective enforcement of weight regulations (*Kural et al.*, 2018), while GPS positioning data supports navigation, traffic management, and incident response in order to optimize overall traffic flow (*Danish & Ashfaq*, 2018). Additionally, road conditions monitoring is also essential for optimizing traffic management by equipping sensors that detect hazards such as ice, accidents, trafficworks in order to enhance situational awareness and reduce risks (*Vishwakarma*, 2020) as well as matching vehicles appropriately with infrastructure capabilities, promoting transport efficiency (*Kural et al.*, 2018), while traffic patterns can be analyzed through the prediction and management of congestion and reduce travel times (*Aniekan Essienubong Ikpe & Jephtar*, 2024).

For privacy concerns, ITS solutions require data collection and data such as vehicle locations, travel patterns, user identities as well as information regarding the cargo and vehicle characteristics, which becomes essential for system functionality but leads to the exposure of sensitive information (*Arslan*, 2019). and raise privacy risks, particularly concerning GDPR considerations (*Benmayor*, 2022).

5.1.5. Other Aspects and Insights

- Recurring Themes:
    - Geofencing is seen as a key IA tool for regulating vehicle access to specific zones dynamically.
    - Regulatory fragmentation, social acceptance and stakeholder resilience are the main barriers to IA adoption.
    - Australia's IAP has been a successful implementation and followed as a benchmark.
- Quantitative Insights:
    - 10/12 interviewees highlighted geofencing as a critical enabler for IA.
    - 6/12 interviewees considered that fragmented regulations become a significant barrier.
- Additional Recurring Topics:
    - Stakeholder collaboration and trust: Were emphasized as crucial for successful IA adoption.
    - Sustainability goals: IA enables emission reduction and freight systems optimization.
    - Emerging innovations: Dynamic pricing mechanisms and "El-on-Road" charging systems were frequently mentioned as potential enhancements.

5.1.5.1. Analysis of Other Aspects

According to Thomas Asp et al. (2021), geofencing is explained as a logical extension of Urban Vehicle Access Regulations (UVAR), facilitating "the right vehicle on the right road at the right time” in order to enhance traffic efficiency and safety by ensuring that only authorized vehicles enter designated zones. Additionally, the integration of Cooperative Intelligent Transport Systems (C-ITS) with geofencing is being explored for emergency vehicles in order to inform, warn, or control aspects of driving and enhance overall traffic safety (*Kajsa Weibull et al.*, 2022).

In terms of regulatory fragmentation, a lack of undivided government attention such as unclear legal structures and inherent bureaucracy are considered significant barriers for the development of ITS projects and lead to challenges in interoperability and integration of IA technologies across regions, while limited public awareness and insufficient information regarding existing and new ITS applications contribute to resistance among potential users (*Phong Thanh Nguyen et al.*, 2021).

The IAP program enables heavy vehicles to work more efficiently by giving access to determined controlled routes in order to reduce road damage and improve safety (*Telematics And Intelligent Access Programs | NHVR*, s. f.). However, some problems include confusion between policies and the program, a need for more telematics options, and issues with complicated rules and reports, which can make it more expensive for transport operators (*Transport Certification Australia*, 2018).

5.2. Analysis related to RQ2

After all the research activities were listed, the amount of search words was counted in each research activity abstract to understand the relevance and keyword density of the research activities. The analysis words Automation, Connectivity, Smart Infrastructure, and Data were used, as included in the interviews. The overview can be found in Table 2 below. As can be seen, the analysis words were found in the following amount of research activities, measured in percent - Automation: 47 (54,7%), Connectivity: 46 (53,5%), Smart Infrastructure: 3 (3,5%), and Data: 48 (55,8%). This gave an indication of the importance of the analysis words within the field of ITS.

	ITS	IA	CCAM	Cooperative	Smart Infrastructure	Automation	Connectivity	Data	Road/ Trucks/Freight	HCT
No. of times found in the activities	11	0	23	31	**3**	**47**	**46**	**48**	54	3
% of total activities	12,8 %	0,0 %	26,7 %	36,0 %	**3,5 %**	**54,7 %**	**53,5%**	**55,8 %**	62,7 %	3,5 %

Table 2: Search words found for each research activity.

After interviewing the experts and project coordinators, the authors created a point system for the importance of each analysis word and how these could facilitate IA, based on the results from the interviews. A score of 0, 0,5, or 1 was given, using the following definition:

- 0 = Not so relevant
- 0,5 = A bit relevant, complementary, or relevant for specific use cases like closed-off areas
- 1 = Relevant

This procedure was followed and is shown in table 3. The authors therefore obtained the total percentage after the analysis of each interviewee and analysis word for IA.

	Automation	Connectivity	Smart Infrastructure	Data
Interviewee 1	0	1	0,5	1
Interviewee 2	1	1	1	1
Interviewee 3	0,5	1	0,5	1
Interviewee 4	1	1	0	1
Interviewee 5	1	1	0,5	1
Interviewee 6	0,5	1	0,5	1
Interviewee 7	1	1	1	1
Interviewee 8	1	1	1	1
Interviewee 9	1	1	0,5	1
Interviewee 10	0,5	1	1	1
Interviewee 11	0,5	1	0,5	1
Interviewee 12	1	1	0	1
Total	**9**	**12**	**7**	**12**
%	**75%**	**100%**	**58,33%**	**100%**

Table 3: Analysis words for each research activity.

Additionally, a comparison was carried out as shown in Table 4 to compare the difference between the current research activities on IA and how the interviewees viewed each analysis word.

Analysis words	Automation	Connectivity	Smart Infrastructure	Data
Projects' analysis word-density in abstracts and on project websites	**54,7 %**	**53,5%**	**3,5 %**	**55,8 %**
Importance of analysis words according to interviewees	**75%**	**100%**	**58,33%**	**100%**

Table 4: Results comparison.

6. Discussions

This discussion section compares the findings of the thesis in relation to the two research questions. It explores the characteristics of IA in road freight transportation (RQ1), focusing on the analysis words Connectivity, Data, Automation, and Smart Infrastructure, as well as the challenges implementing it. Additionally, the section analyzes the contribution of ongoing and future research activities in ITS and IA (RQ2), highlighting gaps in future research activities documentation and opportunities for further development.

6.1. RQ1: What are the characteristics of IA in Road Freight Transportation?

In discussing RQ1, it became evident that the concept of IA is not widely recognized, as it had to be explained to some interviewees beforehand. This highlights a lack of familiarity with IA and suggests that limited research has been conducted. Furthermore, the use of various terms and analysis words used during the interviews required clarification or illustration through examples for understanding. Nevertheless, with all the research done in the thesis project, IA can be defined as a digital service framework designed to enable the right vehicle to use the right road at the right time, based on a dynamic integration of real-time and historical data, regulations, and infrastructure conditions. The aim of IA is to improve the efficiency, safety and sustainability of road freight transport through combining connectivity, data driven information, automation, and optional smart infrastructure. One of the main challenges and barriers detected is the regulatory fragmentation on several standards across regions as well as the data governance and privacy. Challenges such as ensuring GDPR regulations, data security, and stakeholder trust are critical, as well as trust and cooperation among public authorities, private companies, and vehicle operators and balancing investment in smart infrastructure and leveraging existing vehicle-generated data remains a key concern.

Considering connectivity as a key analysis word for IA, it enables communication between vehicles, infrastructure, and centralized systems, while technologies like V2V and V2I communication facilitate real time updates, dynamic routing and accomplish regulations in order to create an information ecosystem in which data from vehicles, infrastructure, and logistics systems is properly integrated.

Data is defined as the foundation of IA, encompassing real-time and historical data for decision-making and long-term planning. Key data types include vehicle weight, axle loads, road conditions, infrastructure capacity, GPS positioning, and traffic patterns are considered an essential part for alignment, predictive maintenance, and optimizing freight systems. However, challenges such as GDPR compliance, trust among stakeholders and standardization remain as the main data barriers.

Automation is considered a complementary tool to support IA in order to reduce human intervention, optimize logistics processes and improve regulations. Applications include routing optimization, automated toll collection, geofencing enforcement, and dynamic decision-making for freight vehicles, being particularly valuable in controlled environments (e.g., depots, mining sites), while its broader application faces barriers such as societal acceptance and regulatory fragmentation.

Although it can be stated that Smart Infrastructure is not strictly necessary, it provides tools such as adaptive traffic lights, weight in motion sensors, and road condition monitoring systems, which can be applied on urban zones and hazardous intersections in order to maximize cost-efficiency. Digital twins can simulate and optimize traffic management, logistics and infrastructure maintenance.

In addition, Geofencing is included as another relevant analysis word and considered a key enabler of IA, which helps in monitoring traffic by informing drivers through in-vehicle technology regarding road conditions, information about accidents, the collection of payments for parking, speed limits (*Foss, Seter, & Arnesen*, 2019), and emission control by limiting the use of larger vehicles or fossil-fueled vehicles into specific areas.

In regards to geographical differences, it was seen that Project Coordinator 2, from the United States, stated that vehicle connectivity is not essential for IA; instead, connected infrastructure provides scalable solutions through visual, auditory, or physical feedback, avoiding compatibility issues with different vehicle manufacturers. Additionally, smart infrastructure was seen as a key component of IA, enhancing road safety and traffic flow through features like advanced road condition alerts, connected traffic signals, geofenced zones, and dynamic lane markings. This provided a slight different vision compared to what thr other project coordinators and experts shared.

Additionally, Expert 4 was from Australia and provided a unique perspective compared to other experts and project coordinators, especially as Australia has already implemented aspects of IA widely. While many Europeans discussed automation as an enabler for reducing human errors, for instance, he downplayed the role of vehicle automation in IA but emphasized *regulatory* automation, where vehicles must comply with IA rules automatically through digital enforcement systems. While interviews with Europeans focused on developing connected transport networks, Expert 5 described Australia's already functioning connectivity framework, where telematics data is used for IA enforcement. Besides, while Europe is still debating how to manage IA data, Australia already uses it for real-time decision-making and enforcement. Finally, he challenged the idea that IA requires large investments in smart infrastructure, mentioning that a strong regulatory framework combined with telematics and compliance systems is more effective.

6.2. RQ2: What are the ongoing and future research activities in ITS and how can these contribute to IA?

The answers provided by the interviewees were analyzed and included in Chapter 4, which also explains how these can contribute to the concept of IA. Additionally, the interviewees suggested several search engines that were already used during the literature review on ongoing and future research activities (as detailed in Appendix A). These research activities are all shown in Appendix D. Regarding future research activities, it can now be concluded that finding information about them was highly challenging. This is because such data is not available online and can primarily be accessed by experts actively involved in research activities. Little information regarding future research activities were given by the interviewees as they were most often not aware of any specific future research activities that could support IA, either directly or indirectly. Furthermore, as future research activities are still in the early stages of development, no substantial information can be obtained from them. In contrast, ongoing research activities are well-documented in databases, complete with abstracts, and have been organized and validated by institutions, which justifies their funding.

From Table 4 above, the analysis word Automation was mentioned in 54,7% of the activities, although 75% of the interviewees confirmed Automation as relevant and that it can contribute to IA. While Connectivity was mentioned in 53.5% of the activities, 100% of the interviewees indicated that it is highly relevant and could contribute to IA. Smart Infrastructure was highlighted in merely 3.5% of the activities in ITS, yet 58.33% of the interviewees recognized its importance and potential contribution to IA. For data, it was mentioned in 55.8% of the activities identified, and 100% of the interviewees confirmed that it is essential and can significantly contribute to IA. This highlights the need for further research to support the development of IA, as none of the research activities even included the search word Intelligent Access in their project abstracts or on the websites.

In regards to the analysis words and the need for future research, for Automation, some disagreement was noticed between interviewees with some believing it as an important enabler for efficiency and compliance. At the same time, some informed IA is primarily digital in its nature and does not require advanced automation. Thus, the authors believe that more research is needed to understand when IA benefits most from automation, i.e. when physical systems are used for decision making, and when this should be prioritized over digital enforcement tools such as with geofencing. The key question here should be when automation actually supports and improves IA results and when it's not needed and a digital-only approach is enough. For Connectivity, the authors noticed that much research is being done and the interviewees mentioned it as important, but there's a gap with wider implementation due to standardization issues in cross-border connectivity, for instance. Thus, more studies should focus on large-scale deployment of connectivity solutions, focusing on cross-border standardization and digital accessibility, for instance.

Regarding Data, the interviewees found it essential but there were outspoken issues related to governance, standardization, and privacy. Even if many activities included the word data, more research should be done focusing on how data can be standardized across European countries and what policies are paying attention to, particularly in regards to ensuring secure and ethical data use. For Smart Infrastructure, it was mentioned in the interviews but seems understudied, considering how rarely it was mentioned in research activities. A key-question for future projects should be what level of physical smart infrastructure investment is necessary for IA, and how existing infrastructure can be used for IA purposes. Here, more research should be done considering how smart infrastructure can be integrated into IA, particularly in cost-effective and scalable ways.

7. Conclusion

The purpose of the master thesis project was to research the potential role of IA in automation and digitization in road freight transportation by covering how IA can strengthen ongoing or future research activities in road freight transportation, and how these could help NRAs in better utilizing existing infrastructure. Two research questions were raised: What are the characteristics of IA in road freight transportation? and What are the ongoing and future research activities in ITS and how could these contribute to IA in road freight transportation? By conducting a literature review, analyzing 86 research activities, and holding 12 interviews with experts and project coordinators, the thesis has contributed to a better understanding of IA and its value within this context.

The findings reveal that IA is not widely recognized, as it had to be explained to most interviewees, highlighting a lack of familiarity with the concept. Based on the research conducted, IA can be defined as a digital service framework designed to enable the right vehicle with the right load to use the right road at the right time, based on a dynamic integration of real-time and historical data, regulations, and infrastructure conditions. Its aim is to improve the efficiency, safety, and sustainability of road freight transport by combining connectivity, data, automation, geofencing and optional smart infrastructure.

For RQ1, the analysis identified 4 key characteristics of IA. *Connectivity* enables communication between vehicles, infrastructure, and centralized systems. Technologies such as V2V and V2I communication facilitate real-time updates, dynamic routing, and compliance with regulations, creating an information ecosystem in which data from vehicles, infrastructure, and logistics systems is properly integrated. *Data* serves as the foundation of IA, encompassing real-time and historical data for decision-making and long-term planning. Key data types include vehicle weight, axle loads, road conditions, infrastructure capacity, GPS positioning, and traffic patterns. However, challenges such as GDPR compliance, trust among stakeholders, and standardization remain significant barriers. *Automation* supports IA by reducing human intervention and optimizing logistics processes. Applications include routing optimization, automated toll collection, geofencing enforcement, and dynamic decision-making for freight vehicles. While automation is particularly valuable in controlled environments, broader application faces barriers such as societal acceptance and regulatory fragmentation. While *Smart Infrastructure* is not strictly necessary, it provides valuable tools, such as adaptive traffic lights, weight-in-motion sensors, and road condition monitoring systems. These tools are especially useful in urban zones and hazardous intersections, enhancing cost-efficiency and safety. Additionally, *Geofencing* emerged as a key enabler of IA, helping monitor traffic, inform drivers, collect payments for parking, enforce speed limits, and control emissions by limiting access to specific areas.

For RQ2, the research highlighted significant gaps in understanding and documenting future research activities. The information on future research activities was difficult to obtain, as it is not publicly available and is typically limited to experts directly involved in such initiatives. Future research activities are in early stages of development and lack detailed descriptions or established objectives. In contrast, ongoing research activities are well-documented, organized, and validated by institutions. However, none of the research activities explicitly addressed IA, either in abstracts or on websites. This indicates a significant gap in integrating IA as a core concept within ITS research and highlights the need for greater alignment and targeted efforts to support its development.

This thesis contributes to a better understanding of IA and its value within road freight transportation. It provides valuable guidance for NRAs and stakeholders looking to optimize road freight transportation by ensuring "the right vehicle on the right road at the right time." Further research should address regulatory fragmentation, data governance, and privacy challenges to enable the full development and implementation of IA.

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Appendices

A Databases

Database	Website
TRIMIS	TRIMIS Search Hub | TRIMIS
CCAM	CCAM - Projects
Finnish Transport Infrastructure Agency	Frontpage - Finnish Transport Infrastructure Agency
VINNOVA	Search for a project that has received funding from Vinnova | Vinnova
CDTI	Home | CDTI
CORDIS	Horizon Europe – the Framework Programme for Research and Innovation (2021 to 2027)
EU Funding & Tenders Portal	EU Funded projects | EU Funding & Tenders Portal
Rijkswaterstaat	International projects
CIVITAS	Projects | CIVITAS
Fraunhofer	Flagship projects
RISE	Projects | RISE
Vrije Universiteit Brussel	Find Research Projects - Vrije Universiteit Brussel
SBUF	Project results | SBUF
DRIVE SWEDEN	Projects | Drive Sweden
ALICE	ALICE Projects – ALICE Alliance for Logistics Innovation through Collaboration in Europe
TRAFIKVERKET	fudinfo.trafikverket.se/fudinfoexternwebb/pages/ProjektListaNy.aspx
Future Mobility	Innovation projects | Future Mobility
Connected Automated Driving	Find a project - Connected Automated Driving
CHALMERS	Chalmers Research

B Interview guide

General

• Do you know or are working yourself on any ongoing research activities that could support further development to have the right vehicle on the right road, for efficient infrastructure usage?
• Do you know or have any planned future research activities that could support further development in having the right vehicle on the right road, for efficient infrastructure usage?
• Any other things related to this area?

RQ1. Characteristics of Intelligent Access (IA) in road freight transports

• In which way do you think Automation can help to have the right vehicle on the right road, for efficient infrastructure usage?
• In which way do you think Connectivity can help to have the right vehicle on the right road, for efficient infrastructure usage?
• In which way do you think Smart Infrastructure can help to have the right vehicle on the right road, for efficient infrastructure usage?
• What type of data is needed to have the right vehicle on the right road, for efficient infrastructure usage?
• Which other aspects are relevant to have the right vehicle on the right road, for efficient infrastructure usage?
• Any other things that you can think of contributing to have the right vehicle on the right road, for efficient infrastructure usage?

RQ2. Ongoing and future research activities and how they can contribute to IA

• Do you know or are working yourself on any ongoing research activities that could support further development to have the right vehicle on the right road, for efficient infrastructure usage?
• Do you know or have any planned future research activities that could support further development in having the right vehicle on the right road, for efficient infrastructure usage?
• Any other things related to this area?
• In what way can your activities contribute to having the right vehicle on the right road, for efficient infrastructure usage?
• In what way can other activities that you mentioned before contribute to having the right vehicle on the right road, for efficient infrastructure usage?
• Any other things related to this area?

C Experts & Project Coordinators Insights

1. Automation.

1.1. Expert Insights.

- 6/6 experts discussed automation.
  - 3 experts viewed automation as complementary rather than essential, emphasizing IA's focus on digitalization and regulatory processes.
  - Specific skepticism about the feasibility of automation on public roads was raised, with support instead for confined areas (e.g., depots or industrial zones).
  - Barriers identified were societal acceptance, legal restrictions as well as integration challenges.

1.2. Project Coordinator Insights.

- 6/6 project coordinators related automation to practical IA use cases.
  - 4 coordinators emphasized automation's key aspect to assist driver shortages and logistic process optimization such as automated vehicle logistics as well as preassigned truck schedules.
  - Automated toll collection, warehouse logistics, and streamlining freight operations in order to improve supply chain efficiency were stated.

2. Connectivity.

2.1. Expert Insights.

- 6/6 experts emphasized that connectivity was critical for IA.
  - 5/6 experts highlighted V2I systems as essential for dynamic decision-making, compliance, and efficiency.
  - The need for consistent European connectivity protocols was stated, as well as technical limitations in integrating vehicle sensors with cloud platforms were mentioned.

2.2. Project Coordinator Insights.

- 6/6 project coordinators focused on operational aspects of connectivity.
  - 4 coordinators discussed practical implementations, such as connected traffic lights, geofencing, and freight vehicle prioritization in urban areas.
  - Examples included real-time communication to reroute heavy trucks dynamically and compliance with low-emission zones.

3. Smart Infrastructure.

3.1. Expert Insights.

- 5/6 experts mentioned smart infrastructure.
  - 3 experts focused on its supplementary role, advocating for prioritizing vehicle data instead of heavy infrastructure investments.
  - Examples provided include sensors to monitor weight, axle loads, and dynamic traffic systems.

3.2. Project Coordinator Insights.

- 4/6 project coordinators emphasized practical uses of smart infrastructure.
  - Applications include adaptive traffic systems, geofenced zones, and technologies to optimize freight vehicle routing.
  - Cost concerns were frequently raised, with coordinators advocating for leveraging existing tools and resources to minimize investments.

4. Data.

4.1. Expert Insights.

- 6/6 experts focused on data challenges.
  - 4 experts highlighted governance issues, including GDPR and trust among stakeholders.
  - Examples included databases for infrastructure conditions, vehicle characteristics, and regulatory compliance.

4.2. Project Coordinator Insights.

- 6/6 project coordinators emphasized practical data applications.
  - Use cases included real-time traffic monitoring, predictive maintenance for roads and bridges, and optimizing vehicle routing.
  - Integration of public and private datasets was often mentioned as a critical enabler.

5. Other Aspects.

5.1. Expert Insights.

- 5/6 experts discussed geofencing.
  - Examples included managing access to urban zones and dynamically regulating speed limits.
  - Regulatory challenges, particularly for cross-border transport, were highlighted.

5.2. Project Coordinator Insights.

- 5/6 project coordinators focused on practical geofencing applications, such as low-emission zones and freight prioritization.
  - Harmonized regulations and stakeholder collaboration were emphasized as critical to implementation.

D Research Activities

Nr	Research activity name	ITS	IA	CCAM	Cooperative	SI	Automation	Connected	Data	Road/Trucks/Freight	HCT	Researcher 1	Researcher 2	Mean	Points	Abstract
1	MODI			1	1		1	1	1	1		4	4	4	4,4	The overall objective of the MODI project is to accelerate the introduction of connected, cooperative, and automated mobility (CCAM) vehicles for logistics through demonstrations and to overcome barriers to the roll-out of automated transport systems and solutions in logistics. It focuses on interactions between vehicles and logistics processes, traffic safety, security, optimal utilization of infrastructure, and recommendations for infrastructure design or adaptation. The project aims to demonstrate the requirements for automated freight transport across a corridor spanning five European countries. It involves implementing the latest technology, defining infrastructure and regulation adaptations, demonstrating business models, and performing socio-economic impact assessments of CCAM solutions.
2	AUGMENTEDCCAM			1	1		1	1	1	1		4	4	4	4,4	Physical and digital infrastructure (PDI) represents a key resource for enabling and supporting the integration of vehicles into the whole transport system. The EU-funded AUGMENTED CCAM project intends to understand, harmonise and assess adapted and innovative PDI support solutions.
3	CONDUCTOR			1	1		1	1	1	1		4	4	4	4,4	The project will build upon advanced fleet and traffic management solutions in the CCAM ecosystem and develop leading-edge simulation models and tools empowered by machine learning and data fusion. CONDUCTOR will upgrade existing technologies increasing the capabilities of transport authorities and operators, allowing a higher level of safety and flexible, responsive, and centralised control leading to less urban traffic and congestion and less pollution.
4	PoDIUM			1	1		1	1	1	1		4	4	4	4,4	PoDIUM will tackle all the different requirements for availability and performance of connectivity as well as the different cooperation enablers per UC. The proposed UCs aim to advance a set of key technologies both in the physical and digital part of the infrastructure. A multi-connectivity approach is followed to ensure reliability, availability and redundancy of the PDI system (i.e., ITS-G5, 5G, LTE, 5G mmWave, 60GHz-WiFi, etc.). As part of the proposed PDI system, a distributed, interoperable and hybrid (MEC and cloud-based) data management environment will be implemented, which will include suitable advanced environment perception models and digital twins to facilitate seamless and efficient exchange of data (in low latency), thus enabling real-time analytics and opening up new business opportunities. Software integrity and data truthfulness of external data are important aspects that will be considered throughout the PDI to address existing gaps. New and standardised C-ITS messages will be integrated to support advanced functionalities, whereas new designs of RSUs and OBUs will allow advanced environmental modelling and digital twins based on locally generated data. Last but not least, a major focus will be laid on the integration of VRUs in the overall PDI. All those elements will be integrated under the umbrella of the three layered PoDIUM reference architecture, which is flexible and applicable in different road environments based on the available infrastructure equipment enabling different kinds of services.

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5	metaCCAZE			1	1		1	1	1	1		4	4	4	4,4	Accelerates the user-centred deployment of smart systems and services that combine electric automated and connected mobility and related infrastructure across European cities. metaCCAZE organizes a series of MetaDesign activities with multisector-stakeholders and different population groups to develop metadesigned shared zero-emission mobility use cases, collaborative business and governance models. A toolkit called MetaInnovations, is developed consisting of six main smart technologies (1. Align: grid supply-fleet-demand; 2. Harmonise: AI-Datawarehouse; 3. Charge: inductive automated charging; 4. Automate: i. remote control center, ii. Advanced Driver Assistance System; iii. 5. Connect: V2X protocols; 6. Manage & Operate: i. electric vehicle scheduling and demand; 6. Digital twin optimisation). MetaInnovations are pioneered in passenger and freight services (public transport, on-demand mini buses, bike sharing, deliveries) and related infrastructure (mobility and logistics hubs, traffic management centres, charging infrastructure) and widely demonstrated in 4 trailblazer cities (Amsterdam, Munich, Limassol, Tampere). Successful use cases, MetaInnovations and MetaServices are transferred, implemented and demonstrated in 6 follower cities (Athens, Krakow, Gonzo, Milan, Miskolc, Paris region). Demonstrations are monitored to ensure that their impact aligns with the MISSION and SUMP/SULP targets, and that the society embrace them. The MetaSkills Hub is developed and utilizes the lessons learned to deliver a series of cross-sectorial interactive training courses. The MetaPolicy Package is developed to contribute to updates of urban and transport policies and feed the strategic research and innovation agendas (SRIA) of CCAM, 2ZERO and other initiatives. metaCCAZE is a project, and an initiative to transition cities to the green metamobility era that the Green Deal, 2ZERO, CCAM, Mission and other EU partnerships envisage by 2030 and beyond.
6	NordicWay	1			1		1	1	1	1		4	4	4	4,4	NordicWay aims to scale up existing C-ITS services by supporting cloud to cloud hybrid communication. Services and choice of technical solutions aim at covering the whole Nordic network and have a potential to reach high penetration without further infrastructure investments. NordicWay will contribute to European CCAM (Cooperative, Connected and Automated Mobility) harmonisation through C-ROADS. NordicWay will continue to explore the use of existing mobile communication for C-ITS services. E.g. the feasibility of Day 1 and Day 1,5 services on rural routes with poor cellular connectivity. The interoperability of several C-ITS services will be tested throughout the NordicWay network. NordicWay will map and assess the infrastructure readiness for connected and automated driving on major freight routes. NordicWay will demonstrate and highlight future services and challenges connected to vehicles with higher automation levels (SAE levels)

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7	5G-SEAGULL			1			1	1	1	1		4	4	4	4,2	Provide uninterrupted 5G connectivity, based on 3GPP Rel.16 SA, capable of supporting select advanced CAM UCs, focusing on the Orient/East-Med corridor traversing the GR-BG borders, including the border-crossing of Promahonas/Kulata. Support the effective interconnection of the COSMOTE and A1BG PLMNs (Public Land Mobile Network) and investigate the optimal roaming configurations to support CAM traffic. Validate the network (and applications) performance and the usefulness of 5G connectivity for automotive traffic via field trials targeting 5G AA use cases. Deliver a thorough Business and Techno-economic analysis regarding cross border and national highway corridor 5G deployments.
8	SHOW				1		1	1	1	1		4	4	4	4,2	The SHOW project aims to advance sustainable urban transport through technical solutions, business models and priority scenarios for impact assessment, by deploying shared, connected, electrified fleets of automated vehicles in coordinated Public Transport (PT), Demand Responsive Transport (DRT), Mobility as a Service (MaaS) and Logistics as a Service (LaaS) operational chains in real-life urban demonstrations all across Europe.
9	DATEX II: Europe’s universal traffic language	1					1	1	1	1		4	4	4	4,2	Standards such as DATEX II are the backbone of interoperability among traffic control centres, driving the evolution and harmonised application of intelligent transport systems (ITS). Consider the rise of autonomous vehicles. They rely on clear instructions, something DATEX II is perfectly equipped to provide.
10	Autosup						1	1	1	1		4	4	4	4	AUTOSUP will identify the strain points, improve the links between nodes and hubs and will run alternative simulation scenarios towards identifying the parameters that optimise the operations of the network considering technological, operational, regulatory and governance aspects. This will be achieved through the development of Digital Twin (DT) models of automated Supply Chains (SC), integrated in an open, ready-to-use data-driven Decision Support System (DSS).
11	Mediterranean-Atlantic Transport Intelligent Systems (MATIS)	1				1			1	1		4	4	4	4	MATIS is a project aiming at the acceleration of deployment of Smart Advanced ITS solutions for more Sustainable, Safer and Resilient Road transportation networks and services crossing a wide European region from the Mediterranean Sea to the Atlantic Ocean.
12	AUTOFREIGHT 2				1			1		1	1	4	4	4	4	Utveckla ny kunskap samt testa lösningar från andra projekt, bas är containertransport med mellan Göteborgs hamn och E-handelscentrum, Viared i Borås. Projektet tar ett systemperspektiv och täcker bl.a in affärsmodeller, avancerade förarstöd, uppkopplade system, trafiksäkerhet, effekter av eldrift, HCT-fordon och logistik.

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13	R3CAV						1	1	1	1		4	4	4	4	The R3CAV project aims to research and develop new connected technologies, as well as to design and develop a new adaptable architecture—both hardware and software—for the future connected autonomous vehicle, capable of operating at different levels of autonomy, ranging from advanced predictive driving assistance systems to completely autonomous systems without a driver. The development of a new Level 4 prototype; highly automated vehicles capable of operating in controlled environments, able to manage complex interactions with the surroundings thanks to advanced infrastructure, which will serve as a redundant source of information for the vehicle. The development of a new platform for an autonomous and connected electric vehicle for future use as an adaptable and modular shuttle for transporting people in urban circuits, whose level of automation will progressively increase from Level 2 (advanced driver assistance systems) to Level 3 (with low supervision). The development of 5G communication technology for connected vehicles, such as an advanced driver assistance system. This challenge aims to inform and recommend the most appropriate actions to the driver, taking control of the vehicle if necessary.
14	PERCEPCIÓN INTELIGENTE PARA LOS VEHÍCULOS AUTÓNOMOS Y CONECTADOS				1		1	1	1			4	4	4	4	Addressing cross-cutting aspects such as safety, autonomy, and sustainability in future transportation. Acquisition of new 360º external perception systems (multi-sensor): Vehicle systems with improved resolution and greater reliability and performance in detecting traffic elements, both dynamic and static, especially vulnerable users, regardless of the environment or operating conditions. Development of an interior perception system for monitoring the driver and occupants: Along with interior and exterior Human-Machine Interface (HMI) systems that allow interaction with vehicle occupants as well as other road users, and anticipate risk situations. Development of advanced positioning and connectivity technologies: For safe and reliable interaction between vehicles, infrastructure, and other road users (cooperative perception). Development of situational awareness based on AI models: For understanding the environment and real-time decision-making capable of operating in extreme conditions, expanding the operational design domain (ODD) of autonomous driving functions. Data management and new ADAS functions: To enable high vehicle autonomy (Level 4) and increase safety. Demonstration of the positive impact of developments in complex use cases of Smart Cities and fleet management.º
15	IN2CCAM			1			1	1		1		4	4	4	4	The goal is providing benefits to all citizens by implementing a full integration of CCAM services in the transport system. The main expected positive impacts for society are: i) safety (i.e. reducing the number of road accidents caused by human error; ii) environment (i.e. reducing transport emissions and congestion by smoothening traffic flow and avoiding unnecessary trips); iii) inclusiveness (i. e. ensuring inclusive mobility and good access for all). To this aim the approach is based on the implementation and integration of enhanced Physical, Digital and Operational Infrastructures to enrich CCAM services and increase safety and traffic efficiency.

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16	DELPHI			1			1	1	1	1		3	4	3,5	3,8	DELPHI focuses on the strategic dimension of integrating passenger and freight transport in a single system aiming to deliver the enablers - both on technical and governance/regulatory level, towards a federated network of platforms for multimodal passenger and freight transport, capable of sharing in a seamless and secure manner, cross-sectoral, multi-modal passenger and freight transport data, as well as traffic management systems information. Moreover, DELPHI will utilise novel and ultra-efficient methodologies for traffic monitoring such as UAS-powered monitoring, multi-/inter-modal optimisation, AI/ML-powered algorithms and frameworks, and will exploit diverse modes for hybrid passenger and freight transport in different ecosystem types. To achieve its maximum potential, utmost interoperability and best optimisation results, DELPHI's digital framework and transversal tools will be validated in the context of 4 pilots with complementary requirements and features.
17	SINFONICA			1	1		1	1		1		3	4	3,5	3,8	SINFONICA aims to develop functional, efficient, and innovative strategies, methods and tools to engage CCAM users, providers and other stakeholders (i.e. citizens, including vulnerable users, transport operators, public administrations, service providers, researchers, vehicle and technology suppliers) to collect, understand and structure in a manageable and exploitable way their needs, desires, and concerns related to CCAM. SINFONICA will co-create final decision support tools for designers and decision makers to enhance the CCAM seamless and sustainable deployment, to be inclusive and equitable for all citizens.
18	Atlas L4				1		1			1		4	4	4	3,8	MAN Truck & Bus, Knorr-Bremse, LEONI and Bosch are joining forces for greater safety, flexibility and efficiency in logistics. Together with automated logistics provider FERNRIDE, test tool manufacturer BTC Embedded Systems and the research service provider for human factors topics WIVW, they aim to have autonomously driving trucks on the highway for the first time by the middle of this decade in the ATLAS-L4 project.
19	MOBILITIES FOR EU						1	1		1		4	4	4	3,8	MOBILITIES FOR EU aims at demonstrating that innovative passenger mobility and freight transport concepts designed and implemented following participative and user-center principles are cost-effective and feasible solutions to contribute significantly to the cities' transformation towards climate-neutrality, allowing to speed up the process even to reach SCOPE 2 emissions reduction in 2030. Madrid (Spain) and Dresden (Germany) will implement 11 pilots comprising 27 very innovative solutions for mobility of people and freight, exploiting the combined potential of electrification, automation and connectivity, from the design to the implementation and evaluation stages acting as Lead Cities (LC). Both cities also ambition to act as pioneers of this process, taking advantage of multiple already existing initiates of social engagement and empowerment that will be integrated in the idea of Urban Transport Labs (UT-Labs), conceived as Innovation Hubs with the aim of fostering faster upscaling and replicability at EU level, making 5 Replication Cities (Ioaninna–Greece, Trencin–Slovakia, Espoo-Finland, Gdansk-Poland and Sarajevo-Bosnia&Herzegovina) through their own UT-Labs direct participants of the processes and later on main protagonists of their own designs.

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20	Scale up user-Centric and dAta driven soLutions for connEcted Urban Poles				1			1	1	1		3	4	3,5	3,6	The MERIDIAN project will foster digitalisation of the mobility system focussing mainly on the CEF Core Network Corridors Scandinavian-Mediterranean and North Sea-Baltic. This will be achieved by implementing digital systems and services along the busiest European freight corridors.
21	MERIDIAN	1								1		4	4	4	3,6	In SCALE-UP 3 advanced urban nodes Antwerp, Madrid and Turku, team up around 1 main goal: develop data-driven and user centric strategies to accelerate the take-up of smart, clean and inclusive mobility, by means of well-connected and multi-usage urban nodes, to the level needed to meet EU climate and transport objectives. - Develop (inter)connected and multimodal nodes for passengers and freight as a backbone of a resilient mobility system, including network optimisations - Provide access to inclusive clean and safe mobility solutions - Change travel behaviour focussing on clean, active and healthy modes of transport The 5 objectives relate to fields of intervention in which the SCALE-UP urban areas excel and deliver valuable output by implementing 28 mobility measures scaled to the FUA and taking into account the TEN-T dimension. Furthermore a strong framework for thematic policy validation amongst SCALE-UP experts guarantees a meaningful cooperation between the 3 urban areas, internal capacity building and mutual exchange and learning.
22	elligent Transport Systems (C-ITS) hybrid technology on the motorways within the TEN-T backbone	1			1							4	4	4	3,6	Suitability assessment and identification of specific location for installation of hybrid C-ITS stations on the infrastructure and into vehicles and more.
23	Central European cross-border cooperation for ITS	1							1			4	4	4	3,6	In East-Central Europe in particular, where several smaller countries (most of them having different languages) with lots of cross-border traffic, information exchange is a must. Therefore, X4ITS Member States and partners are committed to make data available along the whole corridor which should ultimately lead to high-quality end-user information services.
24	rt Network Operator Platform enabling Shared, Integrated and more Sustainable Urban Freight Logi	1								1		4	4	4	3,6	SENATOR will deliver an innovative “control tower” approach, allowing dynamic planning and ensuring operative optimisation through a fluent relationship between urban planners, urban freight logistics players and citizen engagement. This will be actuated in a platform which balances demand of freight & delivery services with available vehicle load for on-demand city needs. The main concept behind the project idea is to create a new urban logistic model focused on the four urban layers (end-receiver, transport, logistics and infrastructure). This will provide integrated models for urban planning policies. This urban logistics model creates a new role, the smart network operator that boost collaboration among all freight urban logistic agents. Based on a multi-level system model for urban space management promoting sustainability and shared-connected freight and delivery services in cities, SENATOR will optimise the satisfaction of all stakeholders’ needs through empowering their decision-making capacity & prioritising urban mobility by an integrated approach.
25	NAPCORE	1							1			4	4	4	3,6	NAPCORE is established to coordinate and harmonise more than 30 mobility-data platforms throughout Europe. It is the world's largest partnership in the field of mobility-data platforms. It is co-financed by a Programme Support Action under the European Commission's Connecting Europe Facility.

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26	5G-ROUTES				1		1	1				3	4	3,5	3,4	To conduct advanced field trials of most representative and innovative CAM applications seamlessly functioning across a designated 5G cross-border corridor (‘Via Baltica-North’) spanning across 3 EU member states borders (Latvia-Estonia-Finland) in order to validate the latest 5G features and 3GPP specifications under realistic conditions, so as to accelerate the widespread deployment of 5G E2E interoperable CAM ecosystems and services in digitised motorways, railways and shipways throughout Europe. To achieve the overall project’s objective, the following eight (8) key interdisciplinary implementation objectives have been defined, which are SMART, i.e. Specific, Measurable, Attainable, Realistic and Time bound.
27	Intelligent traffic lights on Kuringersteenweg | Mobilidata				1		1	1	1			2	4	3	3,2	Mobilidata addresses three closely related objectives: To develop a sustainable digital data-infrastructure; which enables The roll-out of Day 1 and Day 1.5 C-ITS applications, as well as other applications which thrive on the availability of high-quality data; which requires A close cooperation between the public authorities and private parties. This implies locations related to the North Sea–Mediterranean Corridor, the North Sea–Baltic Corridor and the Rhine-Alpine Corridor as well as the urban nodes of Antwerp and Brussels. The new network of iTLCs will enable the C-ITS services and provide positive impact on public transport providers, police forces, cyclists, pedestrians, and other road users.
28	ReMuNet						1	1		1		3	3	3	3	AWARD is paving the way for the roll-out of driverless transportation, whatever the weather conditions are. It will deploy safe and efficient connected and automated heavy-duty vehicles in real-life logistics operations.
29	AI-based CCAM: Trustworthy, Explainable, and Accountable						1					3	4	3,5	3	Connected and Cooperative Automotive Mobility (CCAM) solutions have emerged thanks to novel Artificial Intelligence (AI) which can be trained with huge amounts of data to produce driving functions with better-than-human performance under certain conditions. The race on AI keeps on building HW/SW frameworks to manage and process even larger real and synthetic datasets to train increasingly accurate AI models. However, AI remains largely unexplored with respect to explainability (interpretability of model functioning), privacy preservation (exposure of sensitive data), ethics (bias and wanted/unwanted behaviour), and accountability (responsibilities of AI outputs). These features will establish the basis of trustworthy AI, as a novel paradigm to fully understand and trust AI in operation, while using it at its full capabilities for the benefit of society. AITHENA will contribute to build Explainable AI (XAI) in CCAM development and testing frameworks, researching three main AI pillars: data (real/synthetic data management), models (data fusion, hybrid AI approaches), and testing (physical/virtual XiL set-ups with scalable MLOps).

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30	AWARD (All Weather Autonomous Real logistics operations and Demonstrations)						1	1	1			2	4	3	3	This project aims at developing and enabling to deploy a safe autonomous transportation systems in a wide range of real-life use cases in a variety of different scenarios. This encompasses the development of autonomous driving system (ADS) capable of handling adverse environmental conditions such as heavy rain, snowfall, fog. The ADS solution will be based on multiple sensor modalities to address 24/7 availability. The ADS will then be integrated into multiple vehicle types used in low-speed areas. Finally, these vehicles will be deployed, integrated and operated in a variety of real-life use cases to validate their value in the application and identify any limitations: forklift (un)loading in warehouses and industrial plants, hub-to-hub shuttle service on open road, automated baggage dispatching in airports, container transfer operations and vessel loading in ports. Logistics operations will be optimized thanks to a new fleet management system that will act as a control tower, gathering all information from subsystems (vehicles, road sensors, etc.) to coordinate the operations and protect vulnerable road users. This work should then enable commercial exploitation of the technology and policy recommendations for certifications processes.
31	ULTIMO			1				1				3	3	3	2,8	The project aims to validate integrated shared CCAM systems and services for people and goods across Europe. Develop open-source application programming interfaces (APIs) for seamless integration of vehicles and fleet management into MaaS and LaaS systems. Reach large-scale, multivendor deployments in all sites, using the most adapted vehicle for each transport use case. Set the basis for a common and reusable model for High-Definition (HD) maps. Provide automated passenger services for safety and service quality. Develop and validate cross-sectoral business models. Improve interaction with road users and infrastructure for improved safety. Realistic, long-term transition planning design for the deployment of AVs in MaaS and LaaS.
32	Den Digitala Testbanan Digital Proving Ground			1	1		1	1	1	1		2	2	2	2,8	The project provides Drive Sweden and its members with digitalized testing opportunities for new connected, automated, and shared mobility services. Project participants include AstaZero, Telia, and VOI. Telia's innovation network NorthStar enables integration between cloud-based platforms, vehicles, and AstaZero's vehicle-centered testing platform (ATOS), as well as creates conditions for managing the quality of connected services. VOI, as one of the world's largest micromobility companies, contributes by demonstrating applications of selected use cases.
33	Drive Sweden Koordinering Etapp 3									1	1	3	3	3	2,8	The strategic innovation program Drive Sweden drives the development of digitalized, connected and shared mobility solutions for a sustainable transport system. Our vision is for Sweden to take a leading role in using digital technology to create a more sustainable transport system. The coordination project is stage three of the programme.

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34	ROADVIEW											3	4	3,5	2,8	ROADVIEW integrates a complex in-vehicle system-of-systems able to perform advanced environment and traffic recognition and prediction and determine the appropriate course of action of a CAV in a real-world environment, including harsh weather conditions. ROADVIEW develops an embedded in-vehicle perception and decision-making system based on enhanced sensing, localisation, and improved object/person classification (including vulnerable road users). ROADVIEW ground-breaking innovations are grounded on a cost-effective multisensory setup, sensor noise modelling and filtering, collaborative perception, testing by simulation-assisted methods and integration and demonstration under different scenarios and weather conditions, reaching TRL 7 by the end of the project. ROADVIEW implements the co-programmed European Partnership “Connected, Cooperative and Automated Mobility” (CCAM) partnership by contributing to the development of a more powerful, fail-safe, resilient and weather-aware technologies. The consortium is a perfect combination of leading universities in the field and research institutes, high-tech SMEs, and strong industry leaders. Beyond their research excellence, the consortium members bring a unique portfolio of testing sites and testing infrastructure, ranging from hardware-testing facilities and rain and wind tunnels to test tracks north of the Arctic Circle.
35	HCT City: Fallstudie massgods i städer. Piloter och systemanalys.				1				1			3	3	3	2,8	The project's goal is to provide a basis for the development and implementation of the HCT concept on mass transport in cities through field trials in the form of pilots in real environments and to demonstrate a potential to reduce the number of trucks by up to 50% and CO2 emissions by 40%. The hypotheses identified in the feasibility study will be verified. In addition, the project wants to show benefits in terms of accessibility, local emissions, road wear and traffic safety.
36	Integration and Harmonization of Logistics Operations									1		3	3	3	2,6	TRACE targets to the aforementioned integration activities offering a universal platform with functionalities related to planning, scheduling, optimization and events management as well as the use of blockchain technology to facilitate the real time conclusion of smart contracts and financial operations, thus, becoming one of the first attempts to provide an ‘intelligent cover’ upon the current logistics frameworks. TRACE envisions real demonstrators in different European countries with different goals that start from transportations with the use of shared resources, the disruptive events detection and re-scheduling of transfers while concluding with the use of unmanned vehicles to automate the last mile deliveries. TRACE also proposes new transfer corridors, safe areas where unmanned vehicles can collect items towards the final destination and new (virtual) hubs. TRACE will perform studies related to the barriers towards the new logistics era, the new business opportunities, the requirements for the legislation and regulatory frameworks and expose the benefits of the proposed approach in terms of the reduction for energy demand and emissions while limiting the operational costs for logistics stakeholders.

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37	SYNCHROMODE								1			3	3	3	2,6	The project aims to transform traffic management by incorporating a multimodal network-wide perspective. To that end, it will equip traffic managers with the SYNCHROMODE Toolbox, providing predictive and optimisation capabilities to balance network supply and demand and manage the impacts of events. Furthermore, it will execute research activities beyond the current state of the art in transport modelling, traffic prediction, optimisation of multimodal traffic operations, enhanced data quality, use of new multimodal traffic data sources, and new KPIs for improved monitoring and assessment. Project results will be tested and validated in three real-world case studies: Thessaloniki (Greece), the Netherlands, and Madrid (Spain). SYNCHROMODE aims to develop data driven ICT tools for improving the management of transport operations from a multimodal perspective and managing the overall transport network as a whole. SYNCHROMODE will provide to transport managers new predictive and network optimization capabilities for balancing the transport supply and demand, and capable of reacting to different types of events. The project will research in transport network supply& demand modelling, simulation and prediction of future states; optimization techniques for multimodal traffic optimisation, standards for data collection and storage; new governance models in transport management and new approaches for defining KPI for assessing the overall solution.
38	HITS 2			1	1		1	1	1			2	2	2	2,6	The project is led by Scania with agile project management methodology. Planning and prioritization are continuous, based on lessons learned from the project and needs that can support the sustainable agenda that the project has. In order to address the complex challenges, the methodology will be based on the business and service design toolbox. Together with the consortium, consumers and the city, we will develop hypotheses that will be tested through simulations. These simulations are also validated through experiments (using prototypes) to ensure the integrity of the model.
39	Real and synthetic scenarios generated for the development, training, virtual testing and validation of CCAM systems						1	1	1	1		2	2	2	2,4	SYNERGIES furnishes stakeholders with interoperable, federated scenario databases, incorporating data from Safety Pool Scenario Database™, ADScene, StreetWise, VV Methods, L3Pilot, Hi-Drive, and more. This facilitates standardized processes, streamlines development cycles, and ensures regulatory compliance. To accomplish this, SYNERGIES will culminate in a European platform designed to enhance the development, training, virtual testing, and validation of CCAM systems. The SYNERGIES Platform comprises a Scenario Dataspace, aligned with Europe's approach to data sharing and competitiveness, and a Marketplace, ensuring continual updates and Dataspace scalability. Furthermore, SYNERGIES encourages the inclusion of new initiatives into the scenario dataspace by offering the requisite tools and guidance, from data processing and scenario identification to scenario database governance. This presents a unique opportunity to amplify investments in research and development, consolidating Europe's leadership in CCAM development, all while prioritizing safety and data protection.

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40	C-Roads Antwerp-Helmond			1	1		1	1				2	2	2	2,4	The project setup focusses on The deployment of combined Day-1 and Day-1.5 C-ITS services in Antwerp and Helmond, Test and deploy 40 OBUs for ISA and UVAR, Test with 250 professional drivers equipped with the C-ITS truck services, including traffic light priority, 500 private drivers testing the C-ITS services on an application in combination with multi-modal mobility and (temporarily) UVAR information and 350 active users (bicyclist, micro-mobility, and shared bike users) testing the application on UVAR and green light priority
41	ELEVATE - Electric Vehicles for Advanced Transportation Efficiency						1	1	1	1		2	2	2	2,4	Within ELEVATE, an understanding of the entire studied system and its sub-components will be created, i.e. what interacts and which actors have systems that need to be integrated, as their interrelationships affect the utilization of vehicles, charging infrastructure and the project's productivity. Furthermore, the project will study new planning models that can be translated into digital planning tools that in the future can contribute to high resource utilization of electrified construction transport. New connected tools enable information sharing and thus the ability to reduce queues and congestion that would otherwise be caused by transports linked to the construction industry.The project thus contributes to creating conditions for the development of a connected, shared and automated planning tool for electrified construction transport digital services that enable efficient use of the infrastructure, and models and analysis methods for new transport solutions in the construction sector.
42	BEhavioural ReplicaTion of Human drivers for CCAM			1	1		1	1	1	1		2	1	1,5	2,4	The main objective of BERTHA is to develop a scalable and probabilistic DBM based mostly on Bayesian Belief Network (BBN). The DBM will be implemented on an open-source HUB (repository) to validate the technological and practical feasibility of the solution with the industry and become a unique approach for the model's worldwide scalability. The resulting DBM will be translated into a simulating platform, CARLA, using diverse demos, which allows building new driving models on the platform. BERTHA will also include a methodology that, due to the HUB, will share the model with the scientific community to ease its growth.
43	EVENTS				1		1	1	1			2	2	2	2,4	EVENTS project aims to create a robust and resilient perception and decision-making system, able to tackle the abovementioned challenges. In EVENTS, in case the system or some of the subsystems cannot perform with the expected quality and reliability, an improved minimum risk manoeuvre is triggered. Within the scope of EVENTS project, and in order to cover a wide area of scenarios, the various types of “events” are clustered under three main use cases:

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44	Safety assUraNce fRamework for connected, automated mobIlity SystEms			1	1		1	1	1	1		2	1	1,5	2,4	SUNRISE will develop and demonstrate a commonly accepted, extensible Safety Assurance Framework for the test and safety validation of a varied scope of CCAM systems. This will be achieved by: 1) Bringing the needs of heterogeneous CCAM use cases; 2) Defining a scenario-based database framework that will broaden the HEADSTART methodology; 3) Holistically addressing the CCAM test scenario generation; 4) preparing the required tools for comprehensive testing (virtual and physical), taking into account robustness, scalability, interoperability, quality and standardization; 5) integrating functional safety and cybersecurity; 6)involving the use cases from the initial stages, acting as a guiding principle within the project. The project will define, implement and demonstrate the building blocks of this Safety Assurance Framework: harmonized and scalable safety assessment methodologies, procedures and metrics taylored for use cases, a federated European Scenario Database framework and its necessary data interfaces, a commonly agreed simulation framework including tools and interfaces. SUNRISE will work closely with CCAM stakeholders as policy makers, regulators, consumer testing, user associations and all relevant stakeholders.
45	SIVE AND FULLY INTEGRATED SMART SOLUTION FOR RESILIENT, SUSTAINABLE AND OPTI								1	1		3	2	2,5	2,4	The overreaching goal of KEYSTONE is to support the development of a sustainable, efficient, and safe transport system, allowing enforcement authorities to access data for the purpose of checking compliance with rules applied in the transport of goods and passengers. The aim is to tailor standardised digital solutions that can be used from several realities to standardize the transport system. To demonstrate the validity of the solutions proposed, an app will be developed so that two highly diverse pilots can prove the efficiency of the KEYSTONE's innovation. Using the gained experience to develop a seamless, interoperable, and intermodal digital transport ecosystem that can be replicated at European leveThe overreaching goal of KEYSTONE is to support the development of a sustainable, efficient and safe transport system. Allowing enforcement authorities to access data for the purpose of checking compliance with rules applying in the transport of goods and passengers. The aim is to tailor standardised digital solutions that can be used from several realities in order to standardize the transport system. In order to demonstrate the validity of the solutions proposed, an app will be developed so that two highly diverse pilots can prove the efficiency of the KEYSTONE's innovation. Using the gained experience to develop a seamless, interoperable, and intermodal digital transport eco-system that can be replicated at European level. The KEYSTONE digital solutions consists of standardised APIs for data and information sharing between transport enforcement authorities and logistics operators based on a federated approach allowing to reduce the costs of logistics thanks to more efficient operations and interoperability, to reduce the impact on the environment thanks to data sharing, the possibility to consolidate flows and to improve safety thanks to seamless information exchange with enforcement authorities and the possibility to foster the acceptance of the CCAM solutions.

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46	FAME						1			1		2	3	2,5	2,4	The FAME project aims to establish a European framework for CCAM testing activities on public roads comprising taxonomy, the CEM, CCAM TDS, and a legal and ethical framework. It seeks to develop a common evaluation method (CEM) that provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect (wider socio-economic) impacts directed at different user groups. The project also focuses on developing a CCAM test data space (TDS) to establish trusted data sharing between different types of stakeholders within the CCAM community. Additionally, it aims to engage the stakeholder network of the CCAM partnership and enrich it with the broader European and international CCAM stakeholder community for the further development, alignment, and exploitation of the content of the Knowledge Base and the development of a common methodology and testing framework. Finally, the project seeks to enhance the EU-wide Knowledge Base with an efficient governance mechanism, ensuring continuous contribution from CCAM stakeholders to serve their needs and the CCAM partnership (SRIA).
47	Urban logistics and plaNning: AntiCipating urban freigHt generAtion and demand including dIgitalisation of urbaN freight						1			1		2	3	2,5	2,4	UNCHAIN project aims to contribute to more sustainable urban logistics and help the transition towards climate-neutral and smart cities. To achieve this, it will boost the cooperation between public authorities and logistics stakeholders by implementing a standardised and reliable data exchange ecosystem and an innovative set of urban logistics services. With the UNCHAIN project, public authorities and transport operators will enjoy mutual benefits via cooperation schemes for sustainable urban freight transport policies and operations. UNCHAIN will “break the chains”, boosting the cooperation between public authorities and logistics stakeholders. It will create a set of services for optimal and flexible urban logistics operation, management, planning and policymaking, unleashing the potential that technology and digitalisation can bring to the sustainable urban logistics and moving towards climate-neutral and smart cities. UNCHAIN will implement a standardised and reliable data exchange ecosystem supported by a public-private collaborative framework that will allow the establishment of reliable data sharing agreements, break data silos and make the urban freight data more available and accessible. Driven by the unlocked data, an innovative set of 12 urban logistics services will be implemented to optimise the allocation of urban space, improve the policy-making capacity of local authorities and optimise network management and logistics operation. With UNCHAIN, public authorities will improve their data collection capabilities and have the right tools to achieve sustainability goals. Meanwhile, for operators, having services aligned with their own and society's objectives will unlock mutually beneficial cooperation schemes, a key factor for long-term collaboration and the establishment of sustainable urban freight transport policies and operations.

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48	Project: REDO2, Remote automated vehicle operation 2							1	1			2	3	2,5	2,4	Project aims will be prerequisites, tools, methods, and demonstrations of remote operation of automated vehicles. Furthermore, the project includes comprehensive studies on operational requirements of remote operation, as well as advice and overview on regulation and laws. Lastly, the project aims to disseminate the findings through implementation and demonstration of remote operation systems to the public. This will enhance the competitiveness of Swedish industry and academia with knowledge on creating remote operation of automated vehicles.
49	Hi-Drive								1	1		2	3	2,5	2,4	The objectives are to further extend the "Code of Practice for development of Automated Driving Functions." Develop a "Code of Practice for road tests" on EU-wide harmonized admission procedures for CAD testing on public roads. Support European global transport governance for high-level automated driving. Arrange a systematic stakeholder engagement process and community building to enhance the exploitability of the project results and ensure the interoperability of the CAD systems. Liaise with projects relevant to the Hi-Drive project and coordinate the international cooperation in agreement with the European Commission as well as the third country partner organisations.
50	SPINE			1					1	1		2	2	2	2,2	SPINE aims to accelerate progress towards climate neutrality by integrating public transport systems with new mobility services, sharing schemes, active transport modes, and micromobility. The SPINE consortium consists of experienced professionals, including transport engineers, public transport operators, computer scientists, data analysts, transport modelers, social scientists, urban planners, policy analysts, and software providers, who will provide a comprehensive approach to the challenges, scope, and expected impact of the project.
51	DISCO			1	1				1			2	2	2	2,2	it aims to support cities in undertaking the digital transformation of urban logistics and sustainable planning and to optimally and strategically manage urban space, in order to accelerate the achievement of EU mission cities goals by 2030.
52	i4Driving			1	1		1	1	1			2	1	1,5	2,2	Deliver a new library of credible models of heterogeneous human driver behaviors which provides a human road safety baseline for CCAM virtual assessment. A new library doesn't mean new models. It means a combination of models, suitable and valid for both scenario-based and traffic-based safety assessment, which bring the heterogeneity and complexity of the road traffic system into simulation. Adding sufficient heterogeneity does justice to the diversity of human driving behaviors and drives the occurrence of both "uncritical" and safety critical situations in daily traffic. Sufficient system complexity is needed to make a robust and meaningful analysis of road safety.
53	MAIA				1		1	1				2	2	2	2,2	The MAIA project aims to act as an impact multiplier for climate research projects funded under the Horizon Europe and Horizon 2020 programs. Its goal is to make the currently dispersed knowledge more interoperable, accessible, and usable while rendering economically sustainable outcomes. The project focuses on connecting knowledge and promoting climate action through the activation of a pan-European community, the coordination of the Climate Resilience Projects Cluster, and the creation of technological structures like the MAIA Portal and Connectivity H

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54	KEYSTONE									1		2	3	2,5	2,2	The overarching goal of KEYSTONE is the development and conceptualisation of a sustainable, efficient and safe transport system, which allows enforcement authorities to access data for compliance checks. To achieve this ambitious goal, the following milestones and objectives are met: Tailor standardised digital solutions from several existing use cases to the transport system, demonstrate the validity of a proposed web app solution via 2 real-world pilots, develop a seamless, interoperable and intermodal digital transport ecosystem for replication, define API standard for data and information sharing between operators and authorities and respect & integrate reduction of costs and CO2 footprint, increase the consolidation of data and safety conditions and foster the acceptance of CCAM technologies further.
55	GREEN-LOG			1	1		1	1	1	1		1	1	1	2	he GREEN-LOG project aims to accelerate systemic changes to create last-mile delivery ecosystems that are economically, ecologically, and socially sustainable. It establishes platforms comprising inclusive stakeholder Urban Living Labs to foster social innovation and design and implement cutting-edge delivery solutions. The project integrates advanced simulation environments for scenario building to optimize last-mile delivery interventions, ensuring maximum environmental sustainability, traffic reduction, and financial viability. Additionally, GREEN-LOG offers Logistics-as-a-Service platforms that include interconnected city logistics, autonomous vehicles, cargo-bike-based solutions, and multimodal parcel deliveries integrated with public transportation. These solutions rely on networked city logistics data spaces for proactive ecosystem optimization, balancing the interests of stakeholders such as consumers, businesses, and the city.
56	CHARM			1	1		1	1	1	1		1	1	1	2	The CHARM ECSEL JU project aims to develop industrial IoT (Internet of Things) solutions with an improved tolerance towards harsh industrial surroundings. Digitalisation of the European manufacturing industries is the key to their continuous renewal and competitiveness. Harsh environmental conditions in manufacturing processes and end user environment may slow down the opportunities brought by IoT and AI (Artificial Intelligence). The CHARM (Challenging environments tolerant Smart systems for IoT and AI) project is set to solve this challenge.
57	A leap towards SAE L4 automated driving features			1			1	1		1		1	2	1,5	2	The project comprises five different use cases, each describing a part of the logistics chain. It identifies what is already possible on SAE L4, and what is not possible yet. For the public roads, the project will focus on understanding and overcoming the regulatory barriers and PDI shortcomings on the motorway corridor with road authorities and OEMs of the project involved. In cocreation with all stakeholders the project will search for an optimal combination of physical, digital infrastructure and OEM equipment, easy to implement and low in costs for all parties. In addition to the demonstrations, the project provides detailed business models for the logistics sector, demonstrating that the use of CCAM can lead to greater profits, especially when vehicles drive on a coordinated way.

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58	SELF assessment, protection & healing tools for a trustworthY and resilient CCAM				1				1	1		1	2	1,5	1,8	SELFY will increase CCAM ecosystem's safety, security, robustness, and resilience by researching and developing a toolbox made of collaborative tools which main pillars are: (i) situational awareness, through collaborative perception and monitoring; (ii) data sharing, advanced processing for detection of malicious events and decision-making; (iii) resilience, increased ability to adapt and respond to cyber-threats and cyber-attacks; and (iv) trust, including guarantees regarding privacy, confidentiality, integrity and immutability of data in a collaborative CCAM environment. SELFY tools can operate individually and/or cooperatively with other tools, generating a distributed global solution, where SELF-protection, SELF-response and SELF-recovery decisions will be managed locally or globally as appropriate for any given cyber-attack, malicious activity or hazard, extending the Operational Design Domain (ODD)
59	EvoRoads						1	1		1		2	1	1,5	1,8	EvoRoads aims to accelerate the attainment of the Vision Zero EU goal through a holistic framework of innovative models, tools and services that enable data-driven evolution of safety assessment frameworks, facilitate dynamic monitoring of cyber-physical infrastructures and promote the proactive warning for safety risks in complex environments. At the operational level, EvoRoads defines safety criteria and KPIs quantification methodologies covering the entire spectrum of the "Safe System" approach and develops a connectivity platform where transport infrastructure assets are digitalised and safety assessment services are functioning in a harmonious way. Advanced AI-driven analytics for fusing infrastructure monitoring data at different geospatial resolutions, on-the-edge sensory and communication technologies for local infrastructure monitoring, a dynamic evaluation of infrastructure readiness solution in supporting the operation of CCAM, a road maintenance diagnosis and prognosis tool, and low-cost smart signs with integrated electronics and embedded components for elicting desirable user behaviours are developed. The approach is validated at 7 locations in Spain, Italy, Latvia and Romania, addressing different types of infrastructure settings and road users in urban and rural environments. Interaction with existing programmes on roadmapping and recommendations at national, EU and global level will be promoted, allowing a multiplication effect of project's results.

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60	Holistic and adaptivE Interface Design for human-technology Interactions			1	1	1	1	1				1	1	1	1,8	The HEIDI project aims to develop a fluid, cooperative HMI that integrates internal and external adaptive HMI solutions in a holistic manner. This cooperative HMI effectively synchronises driver data and data from other road users to facilitate an optimal joint action between the actors, following the foresight safety1 concept. With this, the HEIDI HMI solutions guarantee that all road users share the same understanding of the situation with a view to ensuring a safe interaction. To realise this overall aim several technical innovation modules will be developed. These new HMI solutions will be prototyped and validated in a multi-user simulation environment and in real vehicle prototypes. For this purpose, the HEIDI project brings together key industry and academic partners that provide a unique infrastructure for developing, testing, and validating the proposed HMI concepts, such as the co-simulation environment provided by VTI, where pedestrians and drivers can interact in the same experiment in two interconnected simulators, and the facilities provided by RUAS, where real vehicles can interact with real pedestrians in a safe environment. Additionally, the HEIDI project will develop recommendations for regulation and standardisation guidelines to EuroNCAP and to IEEE, especially focusing on external HMIs, as this area is still characterised by high uncertainty for manufacturers.
61	ReliablE in-Vehicle pErception and decisioN-making in complex environmenTal conditionS									1		2	2	2	1,8	In the context of this project, these unexpected situations where the normal operation of the CAV is close to be disrupted (e.g. ODD limit is reached due to traffic changes, harsh weather/light conditions, imperfect data, sensor/communication failures, etc.), are called “events”. EVENTS is also the acronym of this project. Today, CAVs are facing several challenges (e.g. perception in complex urban environments, Vulnerable Road Users (VRUs) detection, perception in adverse weather and low visibility conditions) that should be overcome in order to be able to drive through these events in a safe and reliable way. Within our scope, and in order to cover a wide area of scenarios, these kinds of events are clustered under three main use cases: a) Interaction with VRUs, b) Non-Standard and Unstructured Road Conditions and c) Low Visibility and Adverse Weather Conditions. Our vision in EVENTS is to create a robust and self-resilient perception and decision-making system for AVs to manage different kind of “events” on the horizon. These events result in reaching the AV ODD limitations due to the dynamic changing road environment (VRUs, obstacles) and/or due to imperfect data (e.g. sensor and communication failures). The AV should continue and operate safely no matter what. When the system cannot handle the situation, an improved minimum risk manoeuvre should be put in place.
62	CCAM Sweden									1		3	1	2	1,8	CCAM Sweden aims to gather and engage Swedish and Nordic stakeholders in the field of connected, cooperative and automated mobility (CCAM). The goal is to better understand the needs for service development through stakeholder engagement in various networks, increase knowledge in the area, and contribute to roadmaps and other strategic documents.

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63	Zero Emission flexible vehicle platforms with modular powertrains serving the long-haul Freight Eco System										1	2	2	2	1,8	ZEFES major outcomes: Executing of real-world demonstrations of long-haul BEVs and FCEVs across Europe to take zero-emission long-haul goods transport in Europe to the next level. Pathway for long-haul BEVs and FCEVs to become more affordable and reliable, more energy efficient, with a longer range per single charge and reduced charging times able to meet the user's needs. Technologies which can deliver promised benefits (easy handling, similar driving hours & charging/fueling, high speeds and ability to operate in complex transport supply chains). Mapping of flexible and abundant charging/fueling points and novel charging concepts. Novel tools for fleet management to support the rising number of long-haul BEVs and FCEVs vehicles in the logistics supply chains.
64	Nya förutsättningar för optimerade godstransportlösningar								1			3	1	2	1,8	This project aims to explore the new conditions for optimized freight transport solutions by studying the interaction between open and closed systems in the transport industry to increase the understanding of business conditions for efficient freight transport. This involves questions both how different variants of the transport assignment problem can be formulated or should be modeled, and when solutions require context-based qualitative answers.
65	HCT-program 2020-2022 - förlängt t. o. m. 2024									1		2	2	2	1,8	The project aims to maximise the utilisation of multimodal freight transport capacity, achieve competitive sustainability with higher levels of efficiency, and reduce the average cost of freight transport through the development of novel solutions and their integration with legacy logistics systems.
66	UNCHAIN						1					2	2	2	1,8	The UNCHAIN project, with 10 European cities on board, aims to transform the way cities manage logistics and space. By integrating data from various sources, UNCHAIN will develop 12 data-driven city services, validated by these cities, to tackle congestion, safety, and environmental challenges.
67	FOR-FREIGHT							1		1		2	1	1,5	1,6	The aim of the FOR-FREIGHT project is to design and develop novel, interoperable transport and logistics (T&L) solutions to enhance operational capacity, efficiency, and sustainability in multimodal and transshipment services. It seeks to establish three advanced T&L experimentation facilities in real operational, multi-stakeholder environments to support these logistics. The project also aims to validate its solutions in real-life scenarios, demonstrating their maturity and business-readiness, with a focus on superior performance in integrated multi-stakeholder logistics chain management. Additionally, it strives to foster the development of effective business models and collaborative approaches for interoperable and cooperative T&L services, supported by a comprehensive data governance framework. Finally, it ensures compatibility with existing and emerging EU logistics standards while contributing to the standardization of end-to-end multimodal, multi-stakeholder management solutions.

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68	URBANE								1	1		1	2	1,5	1,6	The objectives are to analyze the physical, digital, social, and business dimensions of complex last-mile logistics delivery systems. To define target strategic innovations and develop a new framework to facilitate the co-creation of innovative and green last-mile delivery solutions. To set up, prototype, test, and demonstrate last-mile innovative solutions in four Lighthouse Living Labs (Wave 1), leveraging green automated and connected mobility. To provide the infrastructural enablers for innovation transferability, including consensus protocols to support collaborative services in local logistics networks governed by smart contracts, digital twinning capabilities, and data-driven decision-making tools to enable replicability of the most effective practices. To model, deploy, and demonstrate smart solutions in two Twinning Living Labs (Wave 2), clearly evidencing the level of adaptation of models and efficient replicability of solutions demonstrated in Wave 1 Living Labs. To develop business plans and design a commercialization path for key project outcomes. To disseminate, promote scale-up, enable effective policymaking, and support relevant Living Lab initiatives at the EU level.
69	SAFEROAD2PORT Improvements on the road access to the maritime port of Bilbao and its connectivity with other critical infrastructures in the Biscay region						1	1	1	1		1	1	1	1,6	The SAFEROAD2PORT is part of a global project, which aims to improve the road in the N-637 (TXORIERRI corridor) and its connection to the core port of Bilbao, Spain. The port has 2 terminals for civil use (a freight terminal and a passengers' terminal), which currently face a very high road traffic from/to the TEN-T core network (around 1.4 million trucks/year). At the same time Bilbao's maritime port is a strategic infrastructure for military use, as it has been used as departing/reception point for the military supply to ports in north of Europe (Atlantic and North/Baltic Seas). The improvement of the road accesses to the maritime port of Bilbao is considered as a prioririty for the Biscay region, as it will reduce congestion, minimise the impact of heavy traffic flows in the metropolitan area of Bilbao and improve the connectivity with other critical infrastructures (portroad-airport). The SAFEROAD2PORT project will contribute to the upgrade of the road access to the Bilbao port, along the N-637 road, in the section between Cruces junction and Rontegi bridge, which is one of the most congested road sections in Biscay's road network, affecting not only long distance transport services to the maritime port, but also private and public transport services (estimation of at least 15,000 vehicles/h and >35,000 people affected each day at peak hours). In particular, the project will improve the weaving segments by the reconfiguration of road accesses.
70	Cross-border TAF TSI Telematics investment Action								1	1		1	2	1,5	1,6	The aim of this project is to ensure the integration and effective use of telematics devices in freight wagons to facilitate data delivery to the TAF TSI platform. This includes equipping freight wagons with telematics devices, providing data access through various solutions (web-based, machine-to-machine, and common interface), and meeting specific milestones to ensure compliance with European standards and regulations for rail freight operations.

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71	Ökad trafiksäkerhet genom automatiserad trafikinformation	1								1		2	1	1,5	1,6	The sub-programme Vehicle and Road Safety aims to contribute to the development of so-called Vision Zero vehicles. Vision Zero vehicles are vehicles with systems that reduce the number of accidents, and reduce the consequences of the accidents that do occur. Here we list all the opportunities to apply for funding within the initiative.
72	TTR Railway Undertakings lighthouse – Study to promote TTR implementation for RUs to facilitate efficient, interconnected rail cross-border transportation						1			1		2	1	1,5	1,6	The aim of the project is, in the passenger section, to respond promptly to the needs of applicants, to plan services in advance each year (comparable to air competitors) and, for the goods business, to achieved greater flexibility and quality for requests during the current timetable period (Rolling Planning). In the first instance, the Infrastructure Manager is called upon to define, in agreement with all stakeholders through medium-long term models (Capacity strategy and Capacity Model), the methods for allocating overall capacity. Moreover, the Temporary Capacity Restrictions (TCR) are considered, for which international coordination mechanisms and publication at predefined time intervals are also taken into consideration. In order to coordinate activities to facilitate the implementation of the project and the new processes at national level, each Manager has appointed a National TTR Manager.
73	GreenRoute – Optimizing freight transport for a sustainable future				1		1			1		1	1	1	1,4	The project will develop and introduce a prototype that contributes to planning and reporting linked to climate impact. The prototype will visualise and analyse the climate impact of freight transport in the form of a heatmap. The tool will provide a good understanding of which areas and routes in the city are exposed to a high climate impact. The prototype enables: Improved planning and optimisation of routes, detailed reporting on the climate impact of e.g. vehicles, shipments and customers and ecision support for freight buyers by visualising the possible climate impact of different transport alternatives.
74	Innovation and cooperation for a sustainable future - A German & Swedish partnership for innovation						1		1	1		1	1	1	1,4	The aim of this project is to foster innovation and cooperation between Germany and Sweden as a means to achieve sustainable economic development and long-term inclusive job creation. It focuses on areas such as mobility, test beds for industrial digitalization (Industrie 4.0 and Smart Industry), SME digitalization, and eHealth. Through bilateral studies, partnerships, and knowledge exchanges, the project seeks to enhance technological advancements, standardization, and the implementation of innovative solutions in these areas, while promoting cross-border collaboration and the sharing of best practices

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75	Steg 1 och 2 åtgärder med fokus på ITS och digitalisering	1							1	1		1	1	1	1,4	The project is expected to be able to provide a clear picture of the benefits that ITS and digitalization solutions can bring alternatives to or as a complement to more traditional measures. The project also intends to create an understanding of when in time these should and can be available, as well as what and what efforts will be required in the short, medium and long term. By looking at the knowledge base that exists regionally and the basis and results from previously implemented ÅVSs, concrete proposals can also be produced based on the prevailing traffic situation. Consequently, the project can, based on the project's results and in accordance with the ÅVS methodology, develop relevant shortcomings, measures and packages of measures with estimated effects for input to the national level for previously studied stretches (primary study area is E6/Greater Gothenburg). A significant and important work that will take place within the framework of the project with contributions from experts from industry and academia as well as competencies within the Swedish Transport Administration's regions. The project also aims to increase the level of knowledge about ITS and digitalization within and outside the Swedish Transport Administration. This is a work that consists of disseminating knowledge in the area, but above all to ensure that relevant expertise is widely available within the organizations concerned. Especially within the knowledge companies that work for and with the Swedish Transport Administration, but also organizations that contribute in various ways to the development of society. A further goal of the project is toa to bring together competences at different levels in the Swedish Transport Administration's organisation and to identify and involve critical resources outside the organisation.
76	EPA - Enhanced Perception Ashore	1							1	1		1	1	1	1,4	Maritime transport is undergoing a revolutionary change, with an increasing degree of digital decision support being implemented in the industry, both on board ships, in fairways and in ports. Previous projects such as Reeds (Reeds, 2023) and New Sensors (New Sensors, 2021) have identified several types of sensors for perception with strong potential to improve maritime safety and promote more sustainable maritime transport. The new sensors can complement established sensors in shipping for short distances, and this requires the development of cost-effective perception systems to enable data collection to higher automated systems, both on board and on land. The project's goal is to adapt these sensors for maritime purposes when placed on land.
77	electronic Freight Transport Information 4 ALL					1	1	1				1	1	1	1,4	The goals are to encourage digitalisation in freight transport and logistics, reduce administrative expenses while enhancing the control capabilities of competent authorities, and enhance the efficiency and sustainability of transport.
78	Move2CCAM							1	1			1	1	1	1,2	MOVE2CCAM encourages further research and uptake activities for CCAM, facilitates public acceptance and adoption of CCAM solutions, enhances capacity for governance and innovation in the transport and logistic sector, and ensures economic benefits for CCAM users.

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79	DT4GS							1				1	1	1	1	The strategic sector main impact objectives of the DT4GS project are to support shipping companies in achieving up to a 20% reduction in CO2e emissions by 2026. This will be accomplished by developing and deploying real-time configurable digital twins (DTs) for ship and fleet operational performance optimization in four Living Labs (LLs) involving different types of shipping companies. The project also aims to establish fully validated industry services for Green Shipping Operational Optimization DTs, expected to be adopted by more than 1,000 ships by 2030. Additionally, it seeks to establish a comprehensive zero-emission shipping methodology, supporting Virtual Testbed and Decision Support Systems for new buildings, retrofits, and the shipping-port interface.
80	BERTHA											1	1	1	0,8	The work packages of this project are structured as follows: WP1 focuses on developing a robust and scalable probabilistic Driver Behavioural Model (DBM) to comprehensively analyze driver behavior. WP2 aims to define and collect human driving performance data, including indicators for modeling, realization, and validation. WP3 involves creating a working prototype for an open, decentralized, and cloud-scalable Human Behaviour Data HUB to enable collaborative workflows. WP4 evaluates the usefulness of Driver Behavioural Models (DBMs) in simulating downstream driving tasks. WP5 assesses the acceptance and safety performance of Cooperative, Connected, and Automated Mobility (CCAM) solutions through standardized tests. WP6 enhances the project's impact by focusing on dissemination, exploitation, and communication activities. WP7 manages the overall project efficiently, ensuring the provision of resources and streamlined processes for its execution.
81	MOBINET											1	1	1	0,8	MOBiNET will develop, deploy and operate the technical foundations of an open, multi-vendor platform for Europe-wide mobility services. Key MOBiNET innovations address the barriers to cooperative system-enabled service deployment, including the lack of harmonised services; availability of communication means; inaccessibility and incompatibility of transport-related data; fragmentation of end-user subscription; proprietary technologies in user devices; etc.MOBiNET will develop solutions for both business (B2B) users and end (B2C) users (drivers and travellers):- a comprehensive directory of Europe-wide mobility and transport-related data and services;- an e-Marketplace as an e-commerce network linking end users, content- and service-providers;- single sign-on MOBiNET membership;- membership of the MOBiNET B2B Provider Community enables providers to add third-party content and services contract-free to their own products;- a platform-independent agent on end-user devices, including access to a MOBiNET Service Directory and an intelligent communication & connectivity manager that hosts end-user services;- the project will develop both a Service Development Kit to enable easy creation of MOBiNET user services and a set of uniform Reference Services suitable for Europe-wide deployment, including "eco-traffic management-as-a-service" and a multimodal traveller assistant.The MOBiNET platform facilities will be hosted as cloud services available to the provider community, and will be operational early during the project.
		11	0	22	30	3	45	44	45	53	3					