REPORT SIITS

WORKPACKAGE 1

The future of the Integrated Intelligent Transport System (IITS)

Brief overview

SIITS

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Abstract:

This report provides a brief overview of the future of the transport system, emphasizing the main trends and drivers shaping its development. It explores the rapid adoption of electric vehicles, the integration of autonomous technologies, the rise of shared and connected mobility services, and the imperative of sustainability. The report underscores how urbanization, climate change concerns, and technological advancements are collectively steering the transport sector towards a more efficient, eco-friendly, and interconnected future.

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Abbreviations

Short form	Expanded form
AV	Autonomous Vehicle
AI/ML	Artificial Intelligence/ Machine Learning
C-ITS	Cooperative- Intelligent Transport System
DSRC	Dedicated Short Range Communication
EV	Electric Vehicle
GPS	Global Positioning System
IITS	Integrated Intelligent Transport System
IOT	Internet of Things
ISO	International Organisation for Standardisation
ITS	Intelligent Transport System
OEM	Original Equipment Manufacturer
MaaS	Mobility As A Service
M2M	Machine- to- Machine
SIITS	Sårbarheter i fremtidens integrerte intelligente transportsystemer (Vulnerabilities in the integrated intelligent transport systems of the future)
V2V	Vehicle- to- Vehicle
WBSCD	World Business Council for Sustainable Development

Summary

The future transport system is developing and undergoing transitions. This is essentially a system of several integrated and interconnected technologies (hence the name ‘Integrated Intelligent Transport System’ or IITS). Its main aim is to deliver on the goals of improved safety, sustainability, and value creation for the society. The SIITS project focusses on managing the vulnerabilities of the complex future transport system that has several complexities associated due to the use of advanced technologies. This report provides an overview of the future of the transport system, emphasizing the main trends and drivers shaping its development. It explores some of the social, economic, environmental, and regulatory perspectives. These are rapid adoption of electric vehicles, the integration of autonomous technologies, the rise of sharing based economy, and the imperative of sustainability. The report underscores how urbanization, climate change concerns, and technological advancements are collectively steering the transport sector towards a more efficient, eco-friendly, and interconnected future.

This report establishes a general understanding that an IITS constitutes complex and dynamic interactions (e.g., vehicle-to vehicle, pedestrian-to-vehicle) among various stakeholders. The system interactions rely heavily on reliable information sharing facilitated by a combination of technologies, frameworks, and regulations (e.g., GPS, 4G/5G, DSRC). More importantly, the success of such a complex system will depend on the effectiveness of partnerships among public and private stakeholders. Next, the report sheds some light on the main drivers for ongoing developments, current system capabilities and future developments in this area. While the technology trends can fluctuate over time, this report attempts to visualise future of the transport system in the long-term, based on current status of developments.

1 Introduction

1.1 Background

In the National Transport Plan 2022–2033 by the Norwegian Ministry of Transport, the Government has emphasised on developing a good transport system that provides everyone freedom and opportunities, increases quality of life, contributes to value creation, protects, and saves lives, and helps to improve health, the environment, and the climate. This vision underscores the significance of the future's intelligent transport system as being pivotal in achieving goals such as heightened safety, sustainability with reduced carbon emissions, and the enhancement of value through increased efficiency and comfort.

What is IITS?

The European Commission defines Intelligent Transport System (ITS) as the system(s) that apply information and communication technologies such as automated driving in transport, making mobility safer, more efficient, and more sustainable. ITS has the potential to solve several major social problems such as growing congestion and emission, create new services, generate jobs, and foster growth in the transport sector.

The future will see a shift away from the traditional use of isolated ITS systems. The future transport system would evolve towards systems based on the seamless integration of a wide range of relevant heterogeneous technologies that can collect large amounts of data, process it, and then take appropriate actions based on this real time information (Guerrero-Ibanez et al., 2015). The system integrating various technologies and services to optimize transportation systems and improve overall mobility is referred to as the Integrated Intelligent Transport System (IITS).

A next generation of ITS solutions (as per the European Commission) is paving the way for automaton in this sector. This is called Cooperative-ITS (or C-ITS). C-ITS are systems that allow effective data exchange through wireless technologies so that vehicles can connect with each other, with the road infrastructure and with other road users. C-ITS is a group of ITS technologies where service is enabled using dynamic and present situation related data/information from other entities (ISO 17427-2:2015).

While IITS focuses on optimizing the entire transportation system to address the social issues mentioned earlier, C-ITS specifically emphasizes on enhancing safety and traffic efficiency through, communication (real-time data exchange) and coordination among vehicles and infrastructure. In essence, IITS encompasses a more extensive array of components and services under its umbrella, with C-ITS being an integral element contributing to its success.

Integration among ITSs is dependent on the interactions among technologies, vehicles, infrastructure, and network. Integration can be achieved by establishing standard communication protocols, data sharing platforms, centralised control centres, collaborative partnerships among agencies, private sector entities, research institutions, etc., and many other ways. Cooperation, for example, through communication can enable multiple ITS services being delivered through efficient sharing of data/information among them. However, implementing such a system requires a complex yet systematic design, utilizing different technologies and communication protocols (or common data format and procedures).

Figure 1 depicts a high-level view of such interactions among different ITS elements, such as:

- Vehicle – to – vehicle
- Roadside unit – to – vehicle
- Vehicle – to – central entity
- Central entity – to – roadside unit
- Pedestrian – to – vehicle

- Roadside – to – roadside unit, etc.

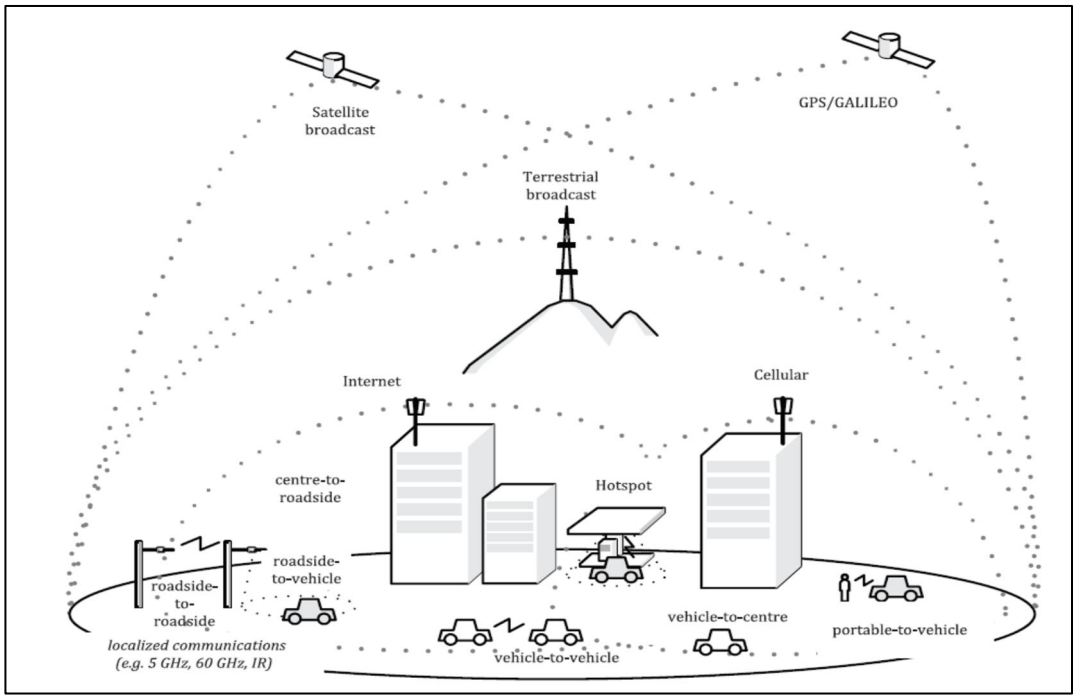

Figure 1 (Source: ISO 21217) ITS Communication representation

Communication technologies (wired and wireless) facilitating these interactions can be:

- Global Positioning System (GPS)
- Internet
- Cellular network (4G/5G)
- Hotspot
- Dedicated Short Range Communication (DSRC)
- Bluetooth
- Wi-fi, etc.

1.2 Purpose

The purpose of this study is to explore and understand the significant factors (drivers and trends) shaping the mobility of the future. It aims to examine the opportunities (and challenges) within the mobility sector, considering the impact of technological advancements, and societal shifts. By analysing these elements, the study seeks to envision potential future scenarios for urban mobility. Through this exploration, it aims to provide valuable insights that can guide policymakers, urban planners, and stakeholders in making informed decisions to create sustainable and efficient transportation systems that enhances the quality of life for residents and visitors alike.

1.3 Scope

The scope of this report encompasses a brief overview of the future of the IITS. IITS is undergoing a paradigm shift and the transitions behind it can be sudden (short-term trends) or gradual (long-term trends). The study undertaken in this report tries to focus more on the longer-term trends and drivers such as changing societal needs and technological advancements as being the key variables. The study does not account for short term aspects so as not be influenced by temporary

factors or noises that may not be reflective of the broader trajectory of developments in this sector. Often, longer term trends and drivers provide a clearer picture by smoothing out these variations. For this reason, this report does not cover details of any particular technological innovation, reactive adaptations to events, or specific MaaS solutions. The study delves into areas such as the system interactions, underpinning technologies, frameworks and nature of partnerships among public and private stakeholders as being pillars supporting the future of mobility sector. It then goes on to discussing the ongoing developments in Norway, current system capabilities and possible future developments.

During the study, it is identified that limitations can arise from inability to apprehend unforeseen black swan events in the long term, lacking historical precedents to make assumptions (given the rapid pace of changes), uncertainties and complexity characterising interactions of various factors. This makes it challenging to accurately predict the future. While these factors may affect the breadth and depth of the findings, these are common challenges faced while conducting such studies. Thus, this report aims to provide valuable insights into the main drivers and trends that could shape the future of mobility, while acknowledging its defined boundaries.

2 Method

The insights presented in this report are an outcome of a combination of research methodologies investigating the topic from different angles. The research is backed by carefully reviewed relevant scientific articles to build a strong foundation of knowledge. Further, lectures prepared by the skilled SIITS project partners have been extremely important in highlighting the current trends, developments and sharing new and different ideas. Particularly, an internal lecture delivered by Jan Olaf Willums (from Inspire Invest) highlights key trends and drivers that are behind the mobility sector's growth, both internationally and in Norway. Additionally, personal reflections and internal discussions about the topic have helped to formulate a vision. Using all these methods together, this research report is an attempt at providing a well-rounded look at the topic.

3 Discussion

3.1 Developments in the mobility sector

To track the developments in the mobility sector, several drivers and trends have been identified. In addition to this, progress in the technological landscape and stakeholders and their emerging needs have also been discussed in the following sections.

3.1.1 Drivers and trends

(From Jan-Olaf Willums lecture on 'Fremtidens mobilitet visjoner, trender og drivere')

Jan-Olaf Willums, the chair and founder of a Scandinavian early-stage capital firm called Inspire Invest, based on his extensive research and knowledge lists some of the main drivers behind the developments in the future transport system. The main drivers and their trends are listed below:

1. *EV*– Electric vehicles (EV) are already on an upward trend in Norway, given their continuously falling costs and longer driving range.
2. *Autonomy*– Autonomous vehicles (AV) will only fuel an increase in the utilization of a typical car.
3. *Mobile data accessibility*– this supports and underpins the behaviour of 'ride on demand'. This refers to passengers being able to book their journey at a suitable time and from an agreed upon and mutually convenient location.
4. *Legislations and politics*– authorities are frequently coming up with policies that make driving and parking more expensive to limit congestion, especially in major cities.
5. *Sharing based economy*– A trend towards decreasing asset ownership and pay-per-use is emerging.
6. *Sustainability* – A trend towards increasing the use of newer technologies to achieve higher economic efficiency, fulfilment of climate and environmental goals and preservation of ecosystems.

These drivers point towards a future of mobility that is sustainable, individualised, and cost effective (resulting from cheaper cost of driving EVs, availability of a greater variety of modes of public transportation, etc.). Yet, some of these drivers also appear to be conflicting in nature. For instance, a sharing-based economy fuelling a reduced asset ownership while falling costs of EV ownership/operations encouraging it. The actual level of private ownership vs. public transport usage in the future will eventually depend on several social-economic variables (status, income level, age groups), infrastructure availability (distance to nearest metro stations, ride sharing hubs, parking spot availability, etc.), regulations (car-free zones, road tolls and parking fees) and other behavioural factors (value or social status associated with owning a car).

3.1.2 Technology

The above discussion looks at the future mobility from a lens of changing social, economic, environmental, and regulatory perspectives. One cannot ignore the role of rapidly changing technology underpinning these. It is being observed that the technology cost, whether it be in terms of computing power, data storage, data processing capabilities, digital imaging, network capacity or Li-ion batteries, are all reducing over time. Companies such as NVIDIA have already developed software and hardware with sufficient processing infrastructure required for level 5 autonomously driving vehicles. For example, their NVIDIA DRIVE Hyperion is a platform and reference architecture that enables designing AVs.

This, combined with public acceptance and favourable economics are important predictors of whether technology is going to disrupt the future. As per the thinktank, RethinkX, the future mobility is expected to boost productivity and disposable income in the USA.

Tony Seba, the founder of RethinkX, listed several technological changes as important enablers of the future transportation system. The top enablers among these being AI/ML, robotics, batteries, sensors/IoT, etc. To comprehend the future of mobility, the fundamental principles behind the relevant technologies and how they affect each other must be clear. Once the role of these technologies is clear, technological risk profiles can be produced to test out the consequences of selected future scenarios. Several organizations have produced such models that may be used as an inspiration to understand future mobility in the SIITS project:

- World Business Council for Sustainable Development (WBSCD) has produced a model on future transportation scenarios.
- Deloitte has developed mobility scenarios post-COVID 19. These include public transportation being provided increasingly by private sector & large tech-based providers, active mobility management to address system-wide challenges through robust governmental data collection & analytics, increased government oversight for data privacy and cybersecurity, etc.
- KPMG sees the model of future mobility being driven by three technological trends or factors: electrification of vehicles, connected & autonomous vehicles and, Mobility-as-a-Service (MaaS).

3.1.3 Stakeholders

The future mobility landscape is expected to have several players (both old and new), will witness new partnerships and lead to the emergence of new business models. For the SIITS project, it is important to look at these stakeholders and their changing business models.

New and evolving stakeholders

The increasing rate of urbanisation places higher demand on the transport sector, especially in the cities. A typical urban user of the transport system has emerging needs for on-demand, personalised experience, safe, affordable, and speedy transport services. It can be expected that the future's integrated mobility being a seamless system delivered by a complex inter-modality among stakeholders. While new stakeholders are becoming a part of this landscape, the older stakeholders are also evolving. We can expect this landscape to constitute stakeholders such as OEMs, micro-mobility services, car sharing platforms, e-mobility developers, ride sharing enablers, and integrated mobility platform developers and many more. It is evident that private sector, including tech firms, will continue to drive innovation. The government will continue to place strict focus on implementing clean and safe transport solutions.

Dynamic business models

A lot of the developments in future IITS will depend on emergence of newer business models. For example, in the current transition phase, a gradual shift from product-centric business model (such as traditional car renting companies) to a service-centric business model (such as ride-sharing services) is becoming increasingly visible. This trend can be expected to continue such that the focus will be on developing service platforms rather than individual products.

The listed drivers (in 3.1.1 and 3.1.2) and risks (whether emerging or traditional) will drive transformation of business models. Global emerging risks (de-globalisation, cybersecurity threats, supply chain vulnerabilities, operation disruptions), local risks (such as entry of disruptive technological development) or environmental threats and possibility of black swan events (such as COVID-19, Ukraine war) will continue to raise new concerns for them and encourage businesses to be resilient and robust. One approach businesses are taking is to minimize their reliance on physical assets. It's important to recognize that this strategy doesn't universally apply to all

situations, as there is no one-size-fits-all solution. Stakeholders are coming to understand that they are confronting more challenging and significant questions. What are the legal, economic, and regulatory implications of these risks for them as stakeholders (government, operators, integrators, users)? What is the risk of innovating (or not innovating)? Are the existing regulations around innovation sufficient (strict or lenient)? What are the demands on safety measures (insurance, cybersecurity measures, compliance, data protection, etc.) to safeguard against above-mentioned risks? Where should these safety barriers/measures be placed? Stakeholders will have to be proactively aware of these issues.

As per World Economic Forum's mobility report, the upcoming innovations in the mobility sector, if deployed in a coordinated and collaborative manner, can optimize the entire transport system. However, this is not an easy task as it requires joint efforts from government, private sector, and the public. The integrated, interconnected, and cross-disciplinary nature of technologies introduces many (new) complexities in the overall system. It is important that the technologies underpinning the future mobility thrive together by upholding shared common values such in the system (such as trust, integrity, and transparency).

WBSCD, the global organization that brings together businesses and other stakeholders to accelerate the transition to a sustainable world, defines some of these shared values as:

- Cost, efficiency, and minimum emissions are values followed for the transitions in global fleet industry.
- Smart charging infrastructure being developed are focusing on maximizing user experience, improved access, and energy efficiency.

3.2 Current system capabilities and future developments

This section details the technological development taking place in the current mobility systems. This forms a basis to anticipate the sector's future status.

3.2.1 Technological developments

The current developments can be indicative of where the future of mobility is headed. As per Valerann (2022), Oladimeji et al., (2023), technological developments are:

- *Autonomous vehicles*: Stavanger has already adopted Level 4 autonomous e-buses in regular public transport service (Electrive, 2022). Kongsberg Maritime's autonomous ship recently completed a complex 160-mile autonomous journeys at sea carried out over 13 hours and involved a range of remote and autonomous technologies on a cargo vessel operating off the coast of Norway, reported by The Maritime Executive (2023).

- *Sensor systems*- passive infrared and active radar systems have been developed for improving traffic conditions and alert traffic operators for a richer information environment.

- *Sustainability and pollution monitoring*- ITS control systems can control and optimise traffic flow to reduce large-scale emissions. In the major cities this can reduce congestion and fuel consumption through shorter idle vehicle time.

- *Connected vehicles*- V2V communication is becoming more widespread and allows sharing information related to traffic flow and safety. It is also pushing development to the next-level AV such that vehicles can 'talk' to each other. This will feed into AI algorithms to minimise human driving error.

- *Accident detection*: Using IOT cloud platform for traffic visualisation and applying ML to accident-prone locations can give early alerts about unexpected slowdowns. Some of the

suggested solutions, such as Celesti et al., (2017), can transmit an alert over a distance of 1 km in a little under 120 ms.

- *Infrastructure*: The capabilities of ITS is greatly increasing through changing the required infrastructure. For instance, using hardware and software to facilitate bus fleet monitoring, fusing social networks with IOT to speed up communication.

In the future, one can expect the system of autonomous vehicles (ferry, taxis, long-haul freight trucks, buses, shuttles, ships, etc.) as a generally acceptable mode of transportation. This will cater to an extremely personalised mobility experience with more innovative last-mile solutions coming up. All this will be supported by building and implementing smart infrastructure (i.e., infrastructure with integrated technologies for connectivity, data analytics, automation, safety and security). Of course, it is important to recognize that these advancements won't happen on their own. They will be driven by a comprehensive transformation of urban areas, encompassing initiatives such as smart cities, smart grids, and smart buildings.

4 Conclusion and recommendations

The future of mobility will be influenced by strong social, economic, and environmental factors driving its development. There has never been a more pressing demand for humans to evolve their means of transport to be safer, more sustainability, and efficient. The future of mobility will be an interplay of drivers, trends, technology, and evolving stakeholders outlined in this report. Electrification, automation, smart infrastructure, and emerging stakeholder partnerships seem to form the cornerstone for an integrated intelligent transport system of the future. The degree and effectiveness of integration achieved are yet to be seen and will ultimately determine the success of collaborations among stakeholders.

A push from regulators and urban planners (to be sustainable), users (to be efficient) and private players (to be innovative) is already shaping the system. We expect that the authorities play a significant role in influencing the future of IITS because they directly contribute to establishing an environment conducive to innovation and determining the level of regulatory compliance expected from parties engaged in development of technology.

Comprehending the future is not an easy task. However, a systems approach combined with scenario thinking is one possible way recommended for thinking ahead about strategic planning, risk management and policy development.

Finally, considering the integrated and interconnected nature of this system, our recommendation for stakeholders is to approach risk and vulnerability management in a systemic manner. This involves addressing the system as a whole, rather than focusing on isolated parts or components, especially in the context of this rapidly evolving landscape.

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