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Impacts and Value Chains of the Cloud-Edge-IoT Continuum in the Transportation Sector

Why is the CEI continuum important for the Transportation Sector?

By facilitating the smooth exchange of data across multiple IoT devices, the Continuum guarantees the constant tracking and evaluation of transport-related metrics, cultivating proactive and tailored solutions within the transportation sector. It also expedites the rapid transmission of crucial transportation data to cloud servers for in-depth analysis, resulting in more precise assessments and strategic planning. Ultimately, it serves as a catalyst for advanced transport applications and services, from remote vehicle monitoring to efficient logistics management, thus increasing the accessibility of high-quality transportation services.

Cloud computing:

34% Extensive use

38% Limited use

18% Plan to use

Edge:

3% Extensive use

17% Limited use

39% Plan to use

IoT:

10% Extensive use

40% Limited use

21% Plan to use

As part of its efforts to promote the CEI Continuum, the EUCEI initiative has carried out a series of industry focused surveys on current and planned adoptions. The Transportation sector sees a lot of yet-untapped potential for CEI development, though it's comparatively ahead on Edge. Whilst Cloud is already present in over 70% of the surveyed companies, Edge and IoT are projected to grow by almost 40% and over 20% respectively over the next few years, highlighting the transformation that is taking place across the Computing Continuum in Europe (see percentages for usage and plans for uptake by 2025).

What are the main opportunities for CEI in Transportation?

As the functional scope of transportation sector is very divers considering transport modes in passenger and freight transport, the field of IT-solutions and thus conceivable CEI applications is very large. The CEI applications may concern transport networks, vehicles, traffic management, mobility services, data platfoms, logistics applications, fleet management, planning applications etc.

Port and Warehouse Automation. Ports and logistics hubs feature many moving elements (e.g. ships, trains, trucks, cranes, workers and operators). They also include third parties in relation to logistics business. The movement of freight, fleets and other resources must be carefully co-ordinated. IoT systems can monitor and track assets, freight and people to aid port and logistics operations. Autonomously guided vehicles (AGVs), drones and other assets may be integrated to further improve port operations. The use case supports more efficient logistics operations, reduced loss, damage and theft, higher safety and security as well as a better visibility of port operations and integration with other systems.

Fleet Tracking and Freight Monitoring. Freight tracking enables operators to optimise routes, monitor driver safety, schedule maintenance and to reduce theft. Operators can also monitor freight condition to ensure the safety of transported goods. CEI applications in fleet tracking and freight monitoring contribute to more efficient supply chains for all types of goods.

Autonomous Vehicles and Infrastructure. Automotive manufacturers add electronic driver aids to passenger, commercial and public transport vehicles on a path to fully autonomous operation. Using a range of sensors, vehicles can operate autonomously, communicated with nearby vehicles

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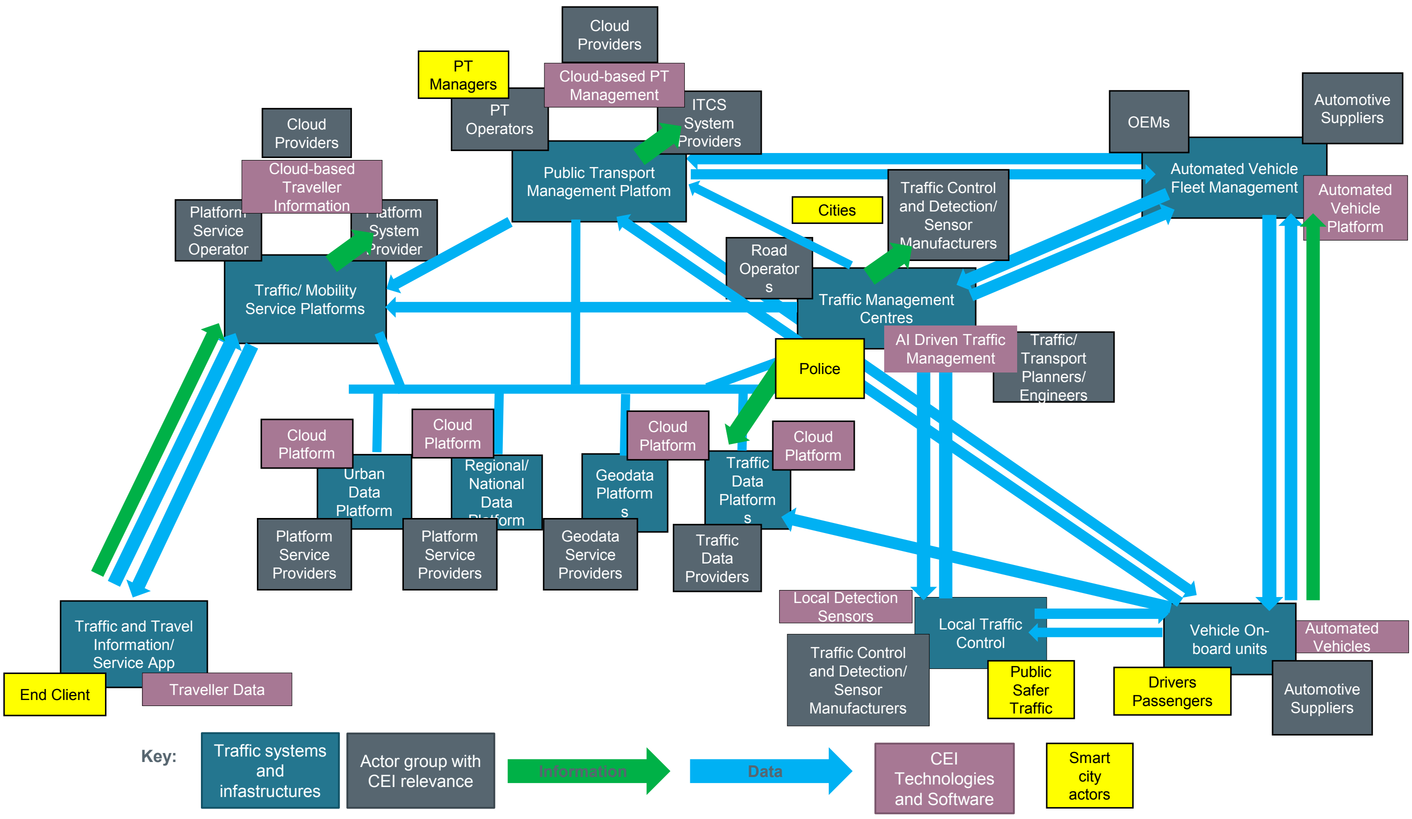
and share dare to and from the infrastructure to enable new safety features and to support traffic management. Autonomous systems increase safety for passengers and other road users. These systems will also lead to an increase in efficiency and reduce labour efforts.

What are the data, value and information flows in Traffic Management?

Urban traffic management is one of the key domains for the adoption CEI technologies. A model of the value network and revenue streams for the whole transport sector involves a variety of applications and functional areas. Transportation in the Smart City context is considered to be a promising area for the adoption and update of CEI solutions.



The graph above shows a simplified, generic model of the data and information streams in the context of transportation in the Smart City. The major investments in the CEI infrastructure are expected from the public sector, e.g. local city governments. A higher quality of life for the citizens would attract more well educated people that would provide work force for industry and international companies.

The emerging data spaces are universally connected to possible players who provide and receive data, sometimes according to the principle of broadcasting which becomes very complex. Therefore the model does not show point to point connections in this respect.

In the figure above, the necessary functions have been marked with purple blocks. They refer to components in the cloud, at the edge and local sensors.

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Who are the essential actors and potential gate keepers?

The essential actors in the context of urban traffic management are road operators, traffic control/management/information system providers, traffic and system planners and engineers, the traffic police, public transport companies and operators of various data spaces for the exchange of the traffic and geo-data. If automated fleets are integrated, the cooperation with OEMs (automotive companies) und their system suppliers will become more and more relevant as cooperation with road operators needs to become closer. Looking at travel information services, respective IT-system providers will be important.

Important gate keepers or CEI applications:

- Regulators and especially data protection officers must create the respective framework. A problem is sometimes the storage of public traffic data of international servers in the cloud.
- AI and machine learning application which require strong and continuous data streams are most likely promoting the implementation of CEI applications as they minimise the data flows into the cloud.
- For the implementation of automated driving a closer co-operation between road operators and OEMs must be developed.

Vendor lock-in Urban traffic management systems are supplied by competing private companies and the systems are usually not open. It will be important that at least open and harmonised interfaces are agreed upon. One solution would be to exchange data via open data spaces.

On European level, there are different architectures for traffic control systems, depending on the country.

In the field of automated driving, OEMs also need to support an agreed architecture and interfaces. Initiatives are needed in the context of the development of the software-defined vehicle.

Value Streams (Money Flows)Traffic management to a large extent is in the hand of the public sector. This entails that a significant part of data exchange is not charged. Mutual information exchange between parties without charging is possible.

Nevertheless, following value streams were identified:

The flow of traffic data from private data providers (INRIX, Google, TomTom) to public traffic managers and planners: The paradigm shift has already become obvious several years ago, when the private companies received more and more relevant data from navigation systems and mobile phones. So they come into the position to have – depending on the purpose – partly better traffic data than the public authorities. Nowadays, data is regularly bought by road operators.

- Road operators also have to pay a service fee if their traffic management software is located in the Cloud.
- Road operators buy systems and services from private supplier companies of traffic control systems.
- Traveller information services (e.g. Mobility-as-a-Service) are partly not free of charge for the end user. In this case the service provider receives a service fee.
- There will be most likely a commercial relationship between the OEM and the Cloud services provider for the operator of vehicle edge platforms in automated driving. The concrete solutions, however, need to be defined.

Furthermore the money flows may change over time depending on the success of the applications and when new applications are introduced. For example, new demand management functions in urban traffic management (e.g. city tolls, new forms of road user charging, demand management/access control of robotaxis) could change money flows considerably. New business models will create new money flows.

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Limitations of the depicted value network

- The model can only be a snapshot of the situation in relation to a certain development stage. New developments must be integrated over time and one must be aware of the point in time for which the model was made. Does it depict the state of the art or a particular stage of R&D?
- The model can only cut out a specific functional area of interest. Depicting the whole transport sector would either become very complex or so high-level that conclusions are hardly possible.
- The model does not distinguish between static, semi-static and dynamic data.

What are the key requirements for the uptake of CEI in urban road traffic management?

- The further digitalisation of traffic detection, control, management and information systems in European cities.
- The further integration of connected and automated driving into the urban transportation systems.
- The integration of intelligent, data-driven and AI-based technologies in traffic and transport-related applications.
- The adoption of CEI technologies by the leading industry which provides traffic control and management as well as systems for automated and connected driving.

The most enabling factor for the practical application of the use cases is the further automation of traffic detection, the introduction of connected and automated driving, improved and more powerful traffic management services (e.g. based in Digital Twins of the road infrastructure) through the use of Artificial Intelligence and Machine Learning. These kind of application require data collection in real-time based on a comprehensive sensor system and an intelligent data processing. Edge computing would allow a data analysis near the sensors.

What are the main challenges hindering the practical application of traffic management use cases?

- Cities must define their transport policy framework in which the traffic management goals are defined. Only then the suitable technological approach can be chosen.
- The regulatory framework data, especially concerning AI, data use in cloud services, data protection and privacy, need to be encrypted.
- The reluctance to use cloud services due to data protection issues.
- Making sure that road safety is guaranteed in highly automated AI systems.
- The data quality must be increased.
- Ethical question: Would a AI-based traffic control system be fair to all road users?
- AI must not be a black box: It must be transparent and trustworthy with defined rules.
- Type approval for automated AI systems – technologies must be harmonised before vehicles appear on urban streets. Certification and standardisation are the basis for acceptance.

The dialogue with industry experts revealed that there are already CEI applications in operation (e.g. the operation of V2X roadside units) and CEI applications which are in development and near implementation (e.g. the improvement of camera data concerning vehicle classification). Nevertheless, there is a considerable potential e.g. concerning the establishment of Digital Twins, which depict the real-time traffic situation in real-time, for all road users and provide this data to traffic control algorithms.

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What are the Key service requirements for traffic management?

Design

- Solutions should be customised to on-site processes, offering tangible benefits.

Installation

- Cost-effectiveness is key, with system integration and customisation being major cost factors. Standardising data formats and interfaces can reduce these costs.
- For future solutions providing post-sales consumer data, the value derived from the data should justify the service cost.

Operation

- The system must operate in near-real-time, even with internet disruptions, relegating only offline processes like AI-model-learning to the cloud.
- A user-friendly interface is essential for non-engineers, ensuring seamless integration with end-user workflows.

Value-added Supplements

- Data can enable external monetization strategies, like enhancing OEM customer service or aiding compliance with regulations like the Supply Chain Act.

Maintenance

- The system should require minimal maintenance, considering SMEs' limited on-site staff.
- Non-engineers should handle basic maintenance tasks, and customer service should be reliable with a dedicated contact.

Disposal/Upgrade

The system should be long-lasting, with upgrades causing no interruptions.

Major upgrades should come with staff training options.

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What are the value chain catalysts for CEI adoption?

1. Collaborate with Expert Providers

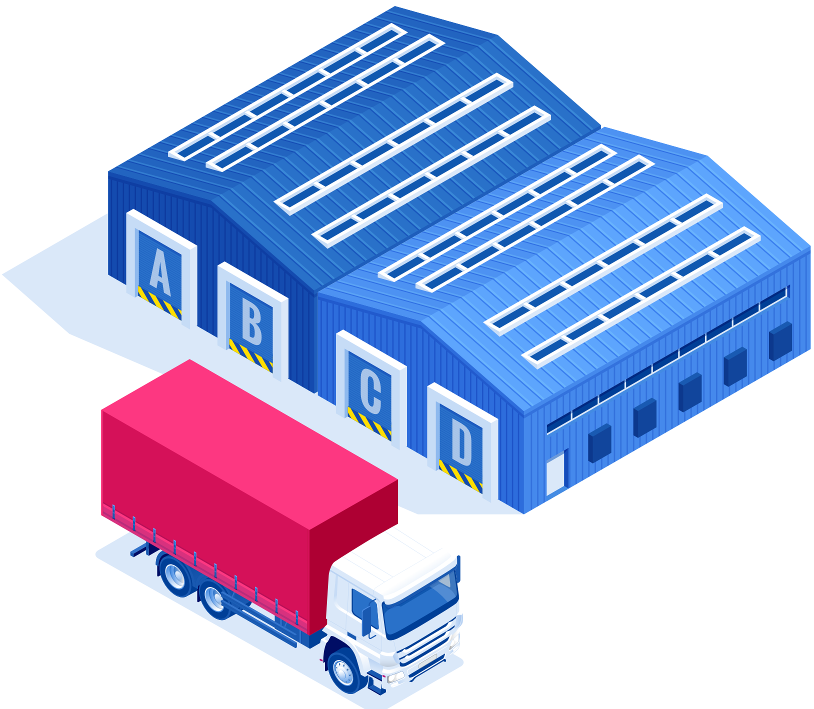
Partner with CEI service providers, R&D, and technology experts to bridge expertise gaps and facilitate communication with other technology providers, leveraging their knowledge to streamline CEI customization and integration efforts.

2. Empower Domain Experts

Involve domain experts whose workflows are affected by CEI systems as key decision makers. Design CEI solutions to support and assist domain experts, capturing their valuable knowledge and addressing skill gaps.

3. Innovate for Future Readiness

Exploit CEI solutions as drivers of innovation and competitive advantage, helping the sector prepare for upcoming market changes. Explore collaborative data-sharing applications along the supply chain to unlock additional value and partnerships.



If you're interested in growth opportunities in this sector or want to learn more, contact us at: info@eucloudedgeiot.eu