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Next generation connectivity for enhanced, safe & efficient transport & logistics

Whitepaper on governance and business models

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The 5G-Blueprint project's main objective consisted in exploring and overcoming technical challenges related to 5G-enabled and cross-border teleoperated transport, both over land and water.
In parallel, extensive research has been undertaken on the business and governance-related aspects of teleoperation and on the options for optimisation of the 5G network required to run it.
Work on governance and business models started by defining and validating a series of ***5G-enabled CAM business cases***, providing the basis for exploring and detailing options for sustainable deployment of 'teleoperated' logistics operations and related adequate Business Models. Once validated, all findings furthermore were translated into clear recommendations for sound cooperation and Governance.
The main outcomes of this part of the project encompass a better understanding of a 'teleoperation' business case from a logistics perspective (D3.1) and related potential business models (D3.2), that subsequently were complemented by a techno-economic assessment of the 5G network investments required (D3.3), the validation of a thorough value network analysis and most promising business models (D3.4) and, finally, a roadmap including considerations and detailed guidance on both required action and governance (D3.5).
The scheme below clarifies the logic of the workflow realized, along with the corresponding tasks:

Figure 1: Overview of tasks on governance and business models in the 5G-Blueprint project

All deliverables are published here on the 5G-Blueprint website, whereas the present white paper bundles the main joint learnings.

First analysis and learnings:

The main insight from **D3.1 "Business cases and initial value network"** is that the market for teleoperation (TO) transport services strongly depends on the specific characteristics of the segment of the logistics industry considered. Market segments with short rides and relatively long waiting or loading/unloading times will benefit most from teleoperation as non-driving activities take a significant share of the driver's time. On the contrary, for longer haul transport operations fully autonomous vehicles rather may be preferable - considering the stringent connectivity requirements imposed by teleoperated driving/ sailing, which may not yet be covered along the complete trajectory.

Furthermore, the deployment of 5G-based teleoperation in logistics may introduce additional challenges caused by the absence of a 'driver-in vehicle' – which may call for new/ additional roles or services and eventually contractual arrangements between the actors in the supply chain. For example, as drivers today are the prime responsible for vehicle and cargo safety, transport service providers may need support from logistics facilities to guarantee that the right cargo is loaded safely and securely. Such new arrangements introduce an amended way of working and contracts across the logistics industry. Therefore, partners concluded that initial deployment of 5G teleoperated transport will likely start in geographically limited areas, with a limited number of supply chain partners willing to co-operate.

The 'market analysis' provided in deliverable **D3.2 "Delineation of business models"** identified (at the time of writing, February 2022) in total 13 different companies that were offering teleoperation solutions. The reported details shed light on the strong and weaker points of actual service offerings and pinpoint some key challenges to address. The main conclusion of this preliminary assessment was that most development of teleoperated transport still was strongly technology-driven (start-ups and companies with a relatively small scale of operations). In contrast, the number of practical use cases in the first time remained limited. This deliverable furthermore outlines and elaborates on the (preliminary) business models and the value network for 5G-based teleoperation services.

At this stage, the project identified **7 applications ('scenarios')** to correctly position the *potential use cases* and *related business models* as schematically depicted in the diagram below.

These applications *differ*

- in the geographic scope of their deployment (on private premises, in a local area with a mix of private and public roads, over an extended geographic area, or cross-border), and
- in whether they involve transport over land or over water.

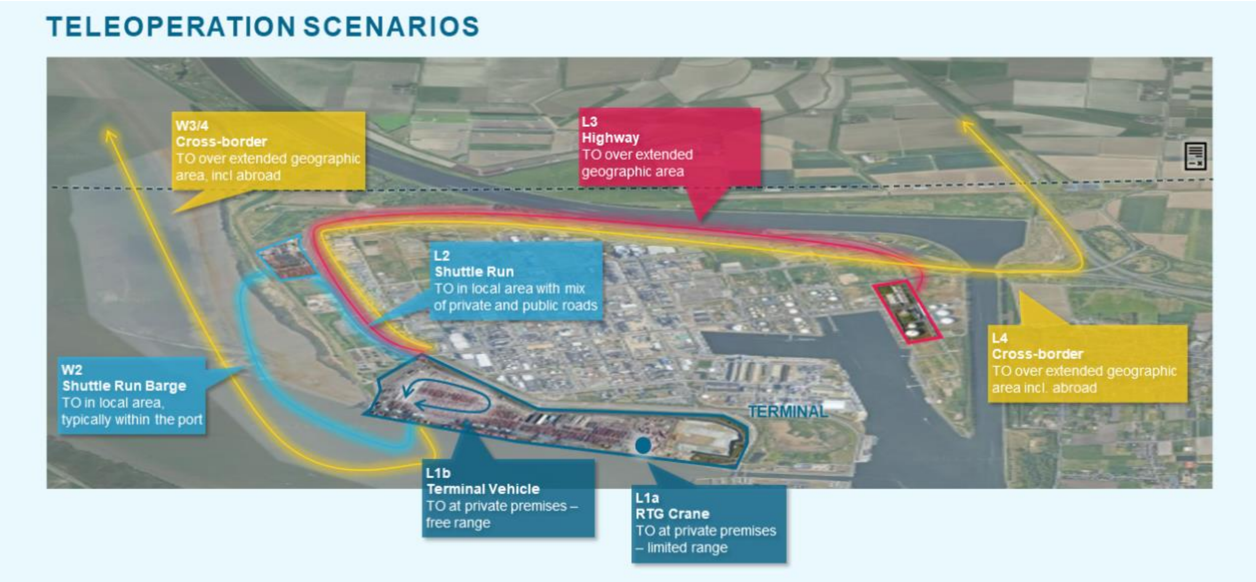

Figure 2: Overview of application (scenarios) considered in the 5G-Blueprint project

The title of each scenario refers to a typical application of teleoperated transport within that scenario:

- *L1a RTG Crane – teleoperated fixed-range rubber-tired gantry cranes (used to pick-up containers);*
- *L1b Terminal Vehicle – teleoperated free-range terminal vehicles such as terminal tractors or reach stackers;*
- *L2 Shuttle Run – teleoperation of frequent runs between the warehouse nearby and the port terminal;*
- *L3 Highway – teleoperated transport over the highway*
- *L4 Cross-border – teleoperation of cross-border transport over the highway;*
- *W2 Shuttle Run Barge – teleoperated barges within the port;*
- *W3/4 Cross-border – teleoperated barges over longer trajectories, potentially cross-border.*

Main findings – regarding feasibility and deployment (cost), business models:

Results from the project's initial analysis were complemented by an in-depth analysis from both a techno-economic perspective on required 5G networks, and the business opportunities:

Techno-economic analysis (TEA) is a method of evaluating the technical and economic feasibility of a project or technology. In the context of teleoperated (TO) transport, this analysis involves an examination of the costs and benefits of using teleoperated vehicles for transportation in a 5G scenario, as well as the technical requirements and recommendations for this approach. The TEA performed builds on the outcome of the previous Tasks (and corresponding deliverables) and considers factors such as the cost of implementing teleoperation technology, and the potential for cost savings along different deployment options for both 5G network and teleoperation center.
Deliverable **D3.3 "Techno-economic analysis"** concludes on following main findings from a techno-economic analysis point of view:

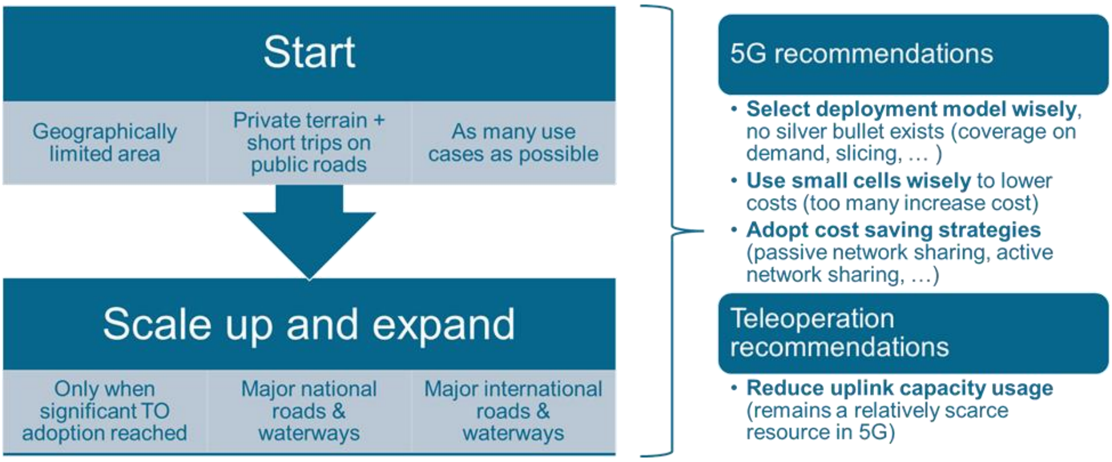

Figure 3: Summary of findings and recommendations of the Techno-Economic Analysis

- Recommended initial deployment of TO services in a limited geographical area, with only short trips on public roads; integrated as many as possible use cases to maximize the number of connected vehicles. Such an approach allows for cost sharing, best use of TO operators and for gradually extending access to each service. Once significant TO adoption is achieved, deployment can expand by involving more stakeholders or by covering major national and even international transport routes.
- The TEA results revealed that there's no one-size-fits-all approach for network deployment cost-effectiveness. In specific scenarios, for example a limited port area, on-demand 5G coverage proves to be most cost-effective, especially when considering UL capacity requirements. However, for areas including major national transport axes, 5G network slicing with regular traffic emerges as the most economical option.
- Adjusting use case requirements for uplink capacity can significantly reduce connectivity costs. Implementing technologies like video compression and network status prediction algorithms can cut TCO by 26%-40% compared to worst-case scenarios. Additionally, smart deployment of small cells alongside macro cells can enhance uplink capacity at a reasonable cost, but excessive small cell deployment may trigger higher costs.
- Lastly, adopting cost-saving strategies such as passive and active network sharing can substantially reduce overall deployment costs and allows for optimization of network deployment efficiency.

Building on the insights achieved under previous Tasks, **D3.4 "Validated business models"** extends and validates the value network analysis and business models already identified in D3.2. The results of the analysis can be summarised in the following points:

- The business impact of teleoperation depends on the scale and type of operations. Large, uncertain (communication) infrastructure investments are required, therefore the business case is more evident in smaller scenarios where little infrastructure upgrades are needed and current inefficiencies are substantial, as well as in larger cross-border scenarios along highways or canals, where having remote driver supervise multiple (semi-autonomous) vehicles at once would strongly enhance cost-efficiency.
- It is suggested to start land-based deployments in smaller areas within logistics sites (remotely operating cranes, skid steers, reach stackers, inventories of passenger cars, etc.). For sites that can rely on an existing and satisfying network infrastructure, the most realistic short-term business models involve the site owner managing its own TO center and operating 'site-internal' services, employment of existing staff to perform the remote operations and retrofitting of vehicles. When new 5G networks need to be deployed, approaches involving a joint venture of site owners or local transport companies become more feasible since this allows for the sharing of tele-operating costs across vehicles whereas economies of scale can be realized by reusing infrastructure.
- Once the technology and commercial aspects of teleoperated transport are validated, gradual scaling up towards larger-scale scenarios becomes realistic, for example with the teleoperation of trucks for repetitive shuttle runs around logistics sites. The business case of this scenario depends on the extent of time inefficiencies for logistics operations present in the area (e.g. waiting times to enter a port or to pick up a container). Additionally, in such a scenario there is a potential to considerably alleviate the problem of unfilled job vacancies by reducing workforce needs. In a scenario where large infrastructure investments are needed, the involvement of external parties such as port authorities or public agencies should be considered to help finance such investments.
- When scaling up to highway scenarios**,** the large CAPEX needs for 5G network infrastructure deployments make the business case only positive for a large volume of operations. In national scenarios, this likely requires adoption by multiple local transport companies. Cross-border highway corridors offer the highest prospects in terms of potential profitability, but technical challenges remain. For instance, safety concerns (from the potential inability of the vehicle's system to safely respond in case of a connectivity delay or 5G signal loss), which imply that TO of trucks only becomes feasible when combined with automation technology. Assuming the truck would rely on its autonomous systems to drive during most of the highway trip, the derived increase in uptime and cost-efficiency generates substantial profitability prospects for long-haul transport. In terms of business models, involving an internationally-minded, specialised TO service provider is seen as an easier model to implement and to scale up to larger deployment scenarios.
- Regarding waterway transport, the business model and business case are clearer. The model of an entrepreneurial service provider that specialises in TO but does not own the vessels appears to be the most realistic one for the short term. Waterway transport offers a more immediate business case from the fact that automation technology is safer to use in canals compared to roads (as there is limited interaction with other users) and that deployment of Connected and Automated technologies (aka CCAM) allows to reduce the size of the on-board crew without the need to make the ship navigate entirely unmanned.

Deployment path, Governance, and Roadmap:

As reported above, partners in the 5G-Blueprint realised extensive research on the business-related aspects of teleoperation and the 5G network required to run it.

At conclusion of the project, however, one crucial question remains: how can we build on the technical achievements of the project to realize a healthy ecosystem in which teleoperation (TO) is deployed at scale in a societally acceptable and economically viable manner?

Deliverable **D3.5 "Governance models and recommendations"** aims to provide concrete answers to that question and more specifically *translates* the technical outcomes and business model analyses into a **deployment roadmap** with an associated governance structure.

The deliverable summarizes challenges, conclusions and recommendations

- along the 7 application scenarios - *cfr. Fig. 2 depicted above*, and
- along 4 main themes (and underlying issues) that in our opinion shape the deployment path of TO: 'Operations', 'Legal', '5G-Network', and 'Business'.

As explained below, each of these 4 themes bundles a series of topics that have been analyzed in-depth, resulting in concerns or key limitations characterized as either *short-term challenges* or *long-term hard constraints.*

Before diving in the details, it finally is important to understand that within all scenarios considered, teleoperation can be applied in either

- ***direct control***, meaning that the teleoperator takes on all crucial driving tasks, or
- ***hybrid***, where the teleoperator oversees an automated driving system and takes over only when the vehicle ventures beyond the operational domain of the automated system.

As a **main conclusion** from our investigations and analysis it appears

teleoperated transport is already commercially viable and up and running in applications with a limited geographic scope, as notably:

- the business case is clear: low complexity with a limited number of stakeholders involved;
- the regulatory and safety concerns remain limited: teleoperation in a controlled environment on private or semi-public roads;
- the connectivity provision is relatively straightforward: typically a private network operated by a single private network operator, over a small geographic area where connectivity weaknesses can be easily identified and addressed.

Whereas these first commercial deployments happen to focus on **small-scale, niche deployments** our analysis suggests, considering the regulatory and connectivity-related complexity increases with the scale of deployment, that more ambitious teleoperation deployments may emerge only through *gradual innovations* and *maturation of the business and technology*.

In the longer term, it furthermore is **unlikely** that **teleoperation in its most ambitious application,** meaning **'direct control, anytime and anywhere' will materialize**. Teleoperated transport indeed faces ***two main inherent challenges*** which, considering the concurrent timeline for truly automated driving systems, imply that by the time these challenges are cleared (if ever they will be cleared) the maturity of automated driving systems most probably will be such that deployment of truly Connected and Automated Mobility services will present the preferred option over set ambitious application of direct control teleoperation:

1. **Roll-out of high-quality 5G will take time and may not be realized everywhere:** The

roll-out of 5G expected in the next 10 years is unlikely to meet the stringent coverage and quality requirements implied by a 'Direct Teleoperation Anytime Anywhere' form of teleoperated transport. The considerable investments in 5G infrastructure indeed may not be realized in low-activity areas where the business case for MNOs is questionable; and even if so, MNOs may not be able to fully meet the stringent quality requirements in terms of uplink capacity everywhere. Direct teleoperation therefore may remain limited to areas where it makes sense for MNOs to invest in the required infrastructure.

2. **Type-approval of teleoperated vehicles is a strict prerequisite** for the roll-out of mass-produced 'direct control teleoperation' enabled vehicles on public roads. Considering it is not yet on the agenda of the relevant regulatory bodies it is highly unlikely that these types of teleoperated vehicles will be available on the EU market within the next 10-15 years. From our assessment, we foresee that it could easily take a decade before the full regulatory process can be finalized, once properly kicked off.

These challenges suggest two important consequences:

- **Direct control teleoperation may be reserved for niche applications** – at least in a first instance, with teleoperated vehicles produced on a smaller scale and targeting dedicated use cases. However – as pointed out below – our assessment suggests that teleoperation functionalities may also find their way also in type-approved and mass-produced fully automated vehicles in light of providing a potential fall-back solution when automation fails.
- **Teleoperation at a larger scale most probably will be hybrid**, where a human teleoperator supervises a fully automated vehicle and intervenes in case the vehicle strays beyond the operational design domain of the automated driving system – for either providing waypoints to the system (indirect support) or for taking over direct control.

This conclusion reveals an **interesting interplay between teleoperation and automated driving** as **both technologies are complementary in that they provide solutions to each other's shortcomings**:

- Automated driving systems do not require a high-bandwidth low-latency connectivity but may require human intervention when the vehicle moves outside the system's operational design domain.
- On the other hand, direct control teleoperation systems have the benefit of human control in situations that may be difficult to navigate for an automated driving system but do require a high-quality 5G network.

Combining all findings, the project's outcome in terms of Business, Governance, and Deployment path can be summarized as follows:

ROADMAP

A healthy teleoperated transport ecosystem, the 'dot on the horizon', will not emerge without coordinated action. The roll-out of teleoperated transport beyond 'niche applications' faces challenges that, if unresolved, will block the evolution toward a truly mature and widespread ecosystem.
These challenges can be broken down into two groups:
Stringent 5G connectivity requirements from teleoperation: Teleoperated transport demands a lot from the communications network and the latter may not always be able to deliver the performance required. This makes network saturation issues likely (i.e. when demand for network resources exceeds supply) which could hamper the potential of teleoperated transport. Teleoperation service providers may be reluctant to roll-out their service in the face of degraded network quality and spotty coverage.
The resolution of this challenge involves making 5G networks smarter for teleoperation. Besides the expansion and densification of the 5G network, work needs to be undertaken towards a smart interaction between connectivity supply and connectivity demand from teleoperation. We also need a governance framework that can provide transparency on the quality of the 5G network in a spatiotemporal context, so that teleoperation service providers and regulators can assess where and when teleoperated transport can be safely deployed. Finally, new customer-focused business models are needed for sophisticated customers of 5G services. Service level agreements between customers and MNOs could help manage expectations and handle liability for adverse effects of network saturation issues.

Concerns for operational safety of the teleoperation setup (vehicle, control center, and operators): On the vehicle side, it is difficult today to commercially deploy or even pilot teleoperated vehicles on public roads as regulation is lagging behind. At the same time, oversight of teleoperation service providers is needed to keep them accountable for safety and to ultimately ensure that teleoperation is as safe, if not safer, than on-board operation.
The resolution of this challenge involves the introduction of a standardized and harmonized teleoperation licensing system, a procedure that certifies that a prospective teleoperation service provider meets all the requirements for safe teleoperation. These requirements are related to the vehicle used, the control room setup, the operator, and the connectivity. In that system, teleoperation service providers will be given a license to operate a particular trajectory or bounded area, with a particular vehicle type and with a particular control room setup. In addition, any adjustments to the current logistic process to accommodate teleoperated transport should be kept to a minimum, in particular with respect to cargo handover points (i.e. points at which the responsibility over the cargo and/or the vehicle shifts from one actor to another). This ensures that challenges related to liability and governance are limited and clear, therefore strengthening the business case and willingness to deploy.
A more comprehensive overview of the challenges and solutions resulting from our analysis is provided in the table below. This table also lists the recommended first steps on the roadmap – actions that should be undertaken sooner rather than later to gain and keep momentum towards commercial deployment of teleoperated transport.

Theme	Roadblocks to Deployment of Teleoperation	L1 TO @ Terminal	L2 Shuttle Run	L3 Highway	L4 Cross-border	W2 Shuttle Barge	W3/4 A to B Barge	Solution	First steps
Teleoperation	Reduced **situational awareness** could undermine safety of teleoperation	☺	😐	😐	😐	😐	😐	Define set of mitigating requirements (under the umbrella of a licensing system)	(TO Service Providers) Devise a set of best practices on how to deal with reduced situational awareness
	Specialised **fuelling** or charging infrastructure is needed [for long-haul transport]	☺	☺	😐	😐	☺	☺	Fuelling or charging stations operated by third parties along main transport corridors, with fuelling protocol in place	Involve potential providers of services at an early stage to resolve chicken-egg problem
	Insurers are reluctant to provide **insurance** for teleoperated vehicles as they cannot assess the risks involved	☺	😐	😐	😐	☺	☺	Mandate a Vehicle Data Recorder which would make it easier to attribute fault and assess risk; deploy novel insurance schemes	(Insurance companies) Explore innovative insurance schemes for teleoperation service providers
	Teleoperators may lack the **legal certainty** (in particular when operating in support of automated driving systems)	☺	😐	😐	😐	😐	😐	Change jurisprudence to better protect the teleoperator from adverse effects beyond his control	(Lawmakers) Consider how criminal and civil liability should be adjusted in the wake of unmanned, automated and/or teleoperated transport
Legal	**Exemption process** is tedious, untransparent and costly	☺	😐	😐	😐	😐	😐	Standardization and Harmonization of Exemption process.	(TO Service Providers) Push exemption granting bodies to harmonize and standardize procedures
	Creation of **type approval process** for teleoperated vehicles has not started yet in the EU [only for large-scale deployments]	☺	☹	☹	☹	☺	☺	Regulatory change to enable type approval of teleoperated vehicles	(TO Vehicle Providers) Push to put direct control teleoperated vehicles on the UNECE agenda
	Lack of accountability by service providers could have detrimental effects on safety of teleoperation	☺	😐	😐	😐	😐	😐	Introduction of licensing system for teleoperation, harmonized at EU level	(Regulatory Agencies) Create a roadmap towards a teleoperated transport licensing framework
5G	**Network saturation** and **coverage** issues may hamper potential of Teleoperation	😐	😐	☹	☹	😐	☹	Expand network infrastructure; develop network awareness; create governance framework; introduce novel business models	(Telecom Regulators) Investigate how transparency on 5G coverage should be adjusted to the needs of teleoperation
	The MNO has limited control over quality of service provided by **roaming** MNOs	☺	☺	☺	☹	☺	☹	Optimized Steering of Roaming; Automated Driving fallback; Coverage on Demand; Agreements between Roaming partners	(MNOs) Investigate: Optimized Steering of Roaming, scalability of Inter-PLMN handover, Dual SIM, Service Level Agreements between MNOs
	The solutions enabling seamless **handover** need to mature before large-scale deployment can take place	☺	☺	☺	☹	☺	☹	Hybrid control teleoperation at border crossings Maturation of inter-PLMN handover.	(TO Service providers) Use dual-sim for first cross-border deployments at limited scale and investigate the need for seamless handover at scale.

LEGEND

☺	No issues related to the topic and the scenario
😐	Either issues are minor or easy to solve
☹	Issue is both major and hard to solve

GUIDELINES

When executing the Teleoperation Roadmap, a number of overall guiding principles do apply.

Avoid a Teleoperation disruption. The introduction of teleoperation functionalities in the existing logistics ecosystem should be gradual. Drastic changes to how this ecosystem functions from an operational, regulatory, and business perspective have in our view limited chance of success. Instead, we recommend a gradual evolution towards more ambitious forms of teleoperation, focusing first on applications where the benefits from teleoperated transport are clear without disrupting the logistics chain.

Involve all relevant stakeholders. The impact of the introduction of teleoperated transport goes beyond those people and organizations that are directly involved with setting it up (such as TO service providers, fleet providers, or logistics companies). In order to avoid an investment bottleneck and a coordination problem later down the road, it is best to involve all stakeholders from an early stage during the piloting or deployment phase. For a comprehensive list of stakeholders and their roles, we refer to Deliverables 3.2 and 3.4.

Teleoperation follows connectivity. While teleoperated transport presents an interesting business opportunity for connectivity providers, it is unlikely that individual teleoperated transport deployments will trigger significant investments in the 5G network infrastructure. When considering a deployment at a particular time, teleoperation service providers should therefore assess the potential of the deployment with the (5G) network at that time as a given – or at least with the projected evolution in connectivity absent the deployment. In other words, a teleoperation service provider should look at the connectivity that is currently being provided (or that is projected to be provided) to assess whether the service offering is viable and safe, rather than count on MNOs to make the necessary investments to fill in any gaps in connectivity.

That being said, it should be emphasized that 5G is the most suitable communication network for teleoperation. While some forms of teleoperation can today be deployed without requiring 5G network connectivity, a 5G-focused deployment strategy when considering the provision of direct teleoperation services is recommended.

Tag along with Automated Driving. Automated driving faces many challenges that also count for teleoperated transport, in particular those linked to unmanned transport. For example, issues related to liability (who is in control), type approval and pilot exemptions are similar for teleoperation and automated driving. The latter however has the advantage that many regulatory initiatives already have been kickstarted. We therefore recommend to duly consider and integrate teleoperation technologies in relevant analyses and decision-making processing on automated driving, and applaud recent initiatives to that effect. This has the additional benefit that solutions for both technologies will be immediately aligned, which minimizes coordination issues later on.