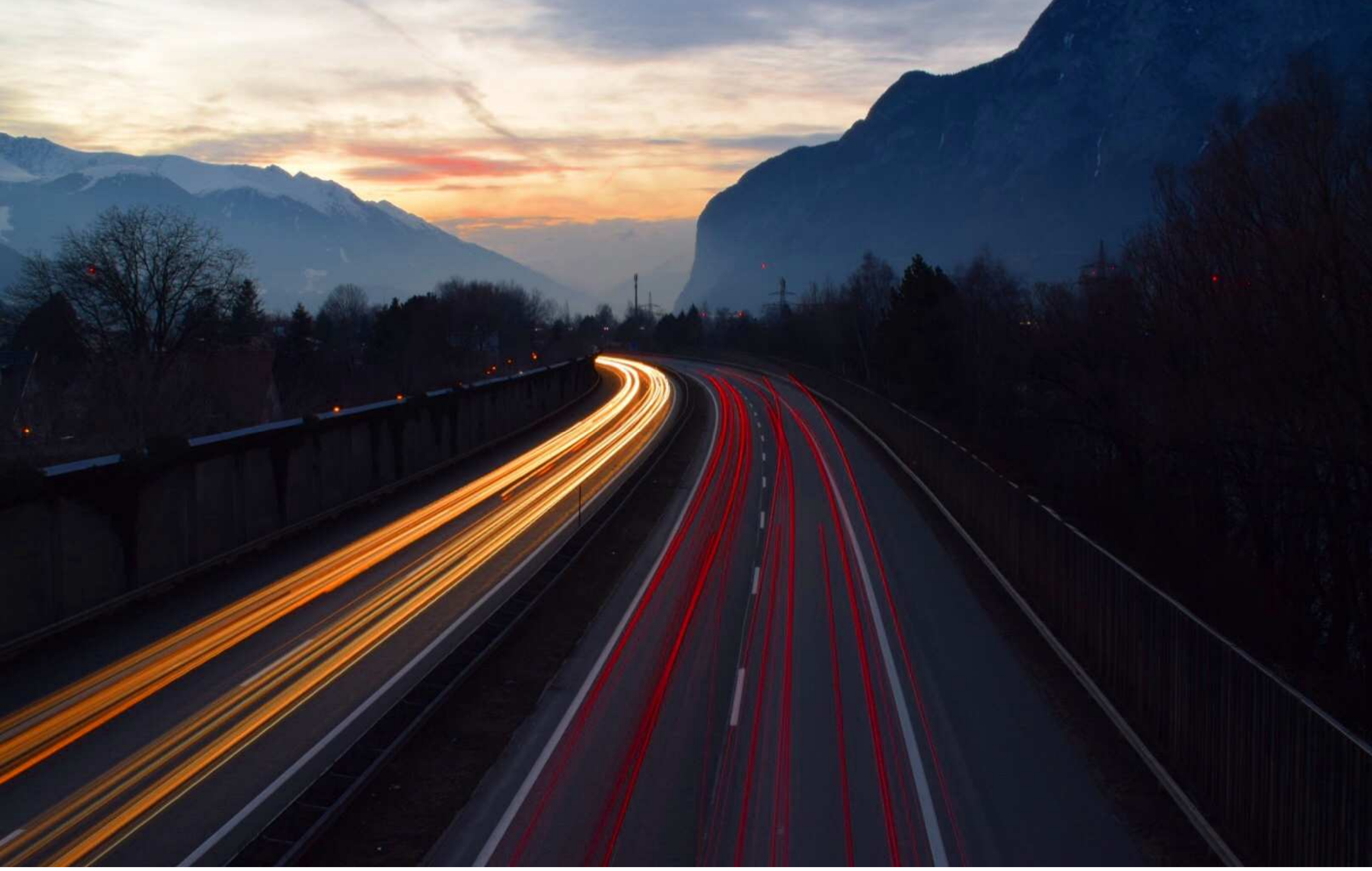

Future trends for transalpine transport

Input paper on the role of innovative technologies and digitalization for the iMONITRAF! strategy

Zurich/Tubingen, 25th September 2018

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Executive summary

The role of technological innovation for the iMONITRAF! strategy

The iMONITRAF! network brings together the Alpine regions along the major freight transit corridors Brenner, Gotthard, Mont Blanc and Fréjus to reduce road freight transport and its negative environmental and social impacts. The iMONITRAF! strategy 2012 is a major milestone for the network, as it defines common targets as well as a set of common measures, including several regulatory measures for the short-term but also incentive systems that support modal shift policies. Since the development of the strategy, however, several developments have gained new momentum and technology has developed at a much higher speed than foreseen.

This paper has the objective to check the role of future technology driven trends for the iMONITRAF! strategy, its target system and common measures. All Alpine regions and countries support an ambitious modal shift approach and it will be crucial to align the specific policies and flanking measures with the new developments.

Five innovation clusters with relevance for iMONITRAF!

With a focus on long-distance transalpine transport and in light of the iMONITRAF! target system, five major innovation clusters can be identified (see figure S-1).

FUTURE TRENDS AND INNOVATION CLUSTERS

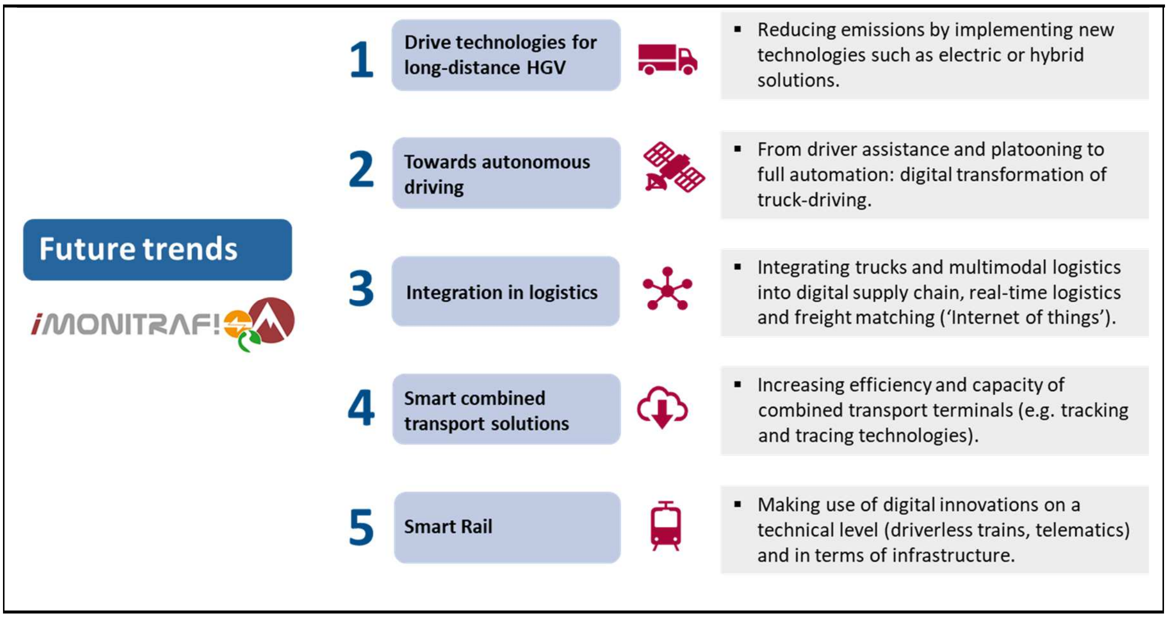

Figure S-1: Source: INFRAS

- **Cluster 1: Innovative drive technologies for long-distance HGV:** Growing public awareness for climate change and air pollution put the automotive industry increasingly under pressure. Several drive technologies offer potential to reduce emissions on a large scale. Among them, electric freight vehicles serve as a promising option.
- **Cluster 2: Towards autonomous truck driving:** Digitalization has great impacts on road transport. Already today, technological advancements, such as driver assistance systems and platooning, symbolize the potential towards fully automated trucks. According to several studies, fully automated trucks will be available on the market by 2030.

- **Cluster 3: Integration in logistics (Logistics 4.0):** Integrating trucks and trains into the logistics process is continuously improving. Digital technologies will enable real-time logistics data across the entire supply chain. In addition, freight matching is getting easier and logistic service providers will depend on automated services to optimise their processes.
- **Cluster 4: Smart Combined Transport solutions:** Sensors, telecommunication technologies and robotics: already today, combined transport (CT) terminals can operate automatically. By further integrating tracking and tracing technologies and on the basis of standardized trailers and handling equipment, terminals will gain in efficiency.
- **Cluster 5: Smart Rail:** The railway sector is increasingly under pressure and needs to ensure a similar level of digital innovations. This may include further progress regarding driverless trains, telematics or the automatization of shunting services.

Depending on policy frameworks and measures, three possible development pathways for trans-alpine pathway seem to be possible:

1) a trend scenario with only moderate uptake of new technologies,
2) a scenario with a technology focus on the road towards electric and automated HGV and with a loss of competitiveness for rail transport and
3) a scenario with a focus on cluster 3, 4 and 5 aiming at integrated, intermodal solutions.

Relevance for iMONITRAF! targets and objectives

A SWOT(strengths-weaknesses-opportunities-threats) analysis shows that the five innovation clusters have the potential for disruptive changes in the transport system. They will also affect the iMONITRAF! objectives and target system as formulated in the common strategy:

TECHNOLOGICAL INNOVATIONS – RELEVANCE FOR IMONITRAF! OBJECTIVES

	Relevance for Alpine Space	**Air im-provm.**	**CO_2 emis-sions**	Noise improv.	**Modal shift**	Effi-ciency	Safe ty
Cluster 1: Electric solutions freight transport	Reduces environmental pressures of road transport.	++	++	+	--	0	0
Cluster 2: To-wards autono-mous driving	Optimisation of traffic flow & significant reduc-tion of road transport costs.	+	+	0	--	0	++
Cluster 3: Integra-tion in logistic pro-cess	Competitiveness road-rail, need for action for regional transport sec-tor.	Depends on specific implementation, especially if rail transport is integrated in automated lo-gistic processes.				++	0
Cluster 4: Smart CT (especially ter-minals)	Improvement of CT ter-minals with respect to capacity, quality and handling time.	+ (indi-rect)	+ (indirect)	++	++	++	0
Cluster 5: Smart Rail	Reduces costs of rail transport and improves inter-operability.	+ (indir.)	+ (indir.)	0	++	+	++

Table S-1: ++ = very positive impact, + = positive impact, 0 = no impact, - = negative impact, -- = very negative impact.

The table indicates chances to improve the environmental performance of transalpine freight transport, mainly for air pollutants and greenhouse gas emissions. However, depending on the development of the different clusters, there might be risks for the modal shift policy. Efficiency increases will have two effects: On the one hand increased load factors reduce the level of vehicle kilometers, on the other hand, reduced costs might induce higher freight transport volumes.

Overall strategic implementation

The different technology-driven trends might lead to considerable impacts on the competitive situation between road and rail – regarding their environmental but also economic performance. The Alpine regions, with their high share of transit traffic and their long-term policy based on the modal-shift rationale, need to steer the development in a strategic way:

- Developments on the road will be strongly market driven: automated vehicles will ease social problems in the road transport sector (especially regarding working times) and will reduce the pressure on the labour market. Electric solutions will be driven through climate change policy, based on EU and national policies.
  → **In order to maintain and further strengthen the competitiveness of rail transport and to make full use of the new rail basetunnels, iMONITRAF! should put a strong focus on innovation clusters 4 and 5** – supporting the automation and integration of CT and thus guaranteeing its compatibility with fully automated logistic solutions.
- Fully automated HGV will be available by 2030, but their market deployment will depend on political frameworks. It needs to be ensured that these frameworks consider the characteristics of the Alpine regions (safety needs, capacity constraints).
  → **iMONITRAF! needs to develop a common approach towards regulation of automated HGV to shape national and EU frameworks.**
- Electric solutions and other alternative technologies have a strong potential to improve air quality in the Alpine regions, thus incentive systems need to be developed to set strong incentives for their deployment in the sensitive Alpine environment.
  → **iMONITRAF! needs to review its common measures to improve incentives for low-emission vehicles and should support a common approach towards vehicle charging.**

Integration in iMONITRAF! common measures and strategy

Making full use of the chances of technological innovations and digitalisation will require strong cooperation and a common voice of the Alpine regions. If the Alpine regions with the major transit corridors work together and develop common harmonised solutions, they can profit from the different innovation clusters to strengthen their modal shift policy:

- **Regulatory measures and standardisation***:* Further dynamic adjustment of driving bans for low-emission vehicles, regulations on automated driving as well as regulations for standardisation of charging infrastructures for electric truck systems, based on a commonly agreed system.
- **Modal shift policy:** Further optimisation of road charging systems (Toll Plus) to set incentives for clean vehicles through strong modulation of tolls as well as integrated incentives for combined transport. With the construction of the rail base tunnels Brenner and Mont Cenis the highest level of connectivity and automation to integrate rail transport in automated logistic processes needs to be ensured. Also, the financial support mechanisms for CT need to be reviewed, with a focus on unaccompanied CT solutions which build on smart CT and rail.
- **Steering instruments:** An Alpine Crossing Exchange might still be interesting to steer capacities on the Alpine motorways, but an undifferentiated approach might have adverse effects on the modernisation of vehicle fleet.
- **Standardisation of CT and rail:** To support the automation of CT and rail services and to maintain the competitiveness of rail transport in a Logistics 4.0 framework, a stronger standardisation of frameworks and technologies is necessary (fully automated terminals, standardisation of trailers and handling equipment).

1 Background and objectives

iMONITRAF! strategy 2012 and modal shift rationale

Since 2005, the Alpine regions join their forces to work towards a reduction of road freight transport and its negative environmental and social impacts. In 2012, political representatives from all regions along the four major transit corridors Brenner, Gotthard, Mont Blanc and Fréjus have signed a common transport strategy which defines modal-shift targets for each corridor as well as short-term targets regarding air quality improvement and CO_2-reductions. Overall, the iMONITRAF! strategy is guided by the modal shift rationale which is also implemented at national level and is a crucial element of the European framework.

The common strategy of 2012 also includes a set of common measures to implement the target system, including several regulatory measures for the short-term (such as driving bans, speed limits) but also incentive systems that support modal shift policies. Over the last years, the network has specifically focused on the development of a Toll Plus System, to integrate the needs, characteristics and specific externalities of Alpine regions into national road pricing systems.[1] For the long-term, the strategy further foresees the implementation of a cap-and-trade instrument to directly steer road freight volumes and to ensure a full utilisation of the new base tunnels.

Transformation of the transport sector

iMONITRAF! has already investigated the role of innovative technologies and approaches in a dedicated report in 2011 (Lückge et al. 2011) as a basis for preparing the iMONITRAF! strategy. Since the signature of the strategy in 2012, several developments have however become a new dynamic and technology has developed at a much higher speed than foreseen. These effects will lead to major transformations in the transport sector, affecting both passenger and freight transport and with considerable effect on the competitiveness of road and rail.

- Fight against air pollution and noise: pressures to reduce transport-related air pollution have considerably increased over the last years and the issue has received high media attention. Especially, the environmental problems of Diesel technology have received high public awareness (recent urban problems but also on Alpine corridors) and strong regulatory measures are currently tested (including driving bans for all Diesel vehicles except EURO VI in urban areas).
- Decarbonisation challenge: To reach the ambitious targets as defined in the Paris Agreement, a decarbonization of the transport sector will be necessary. Thus, research and development as well as support systems have focused on the development of alternative low-emission technologies. Especially, electric solutions are strongly supported and several vehicle and charging technologies are recently tested.
- Digitalisation and automation: the digital transformation has accelerated considerably over the last years and many operations and services in the transport sector already have high degrees of connectivity and automation. New IT solutions offer a broad variety of options to optimize (intermodal) transport and logistic chains and to reduce the environmental footprint of freight transport.
- Consumption trends: On the other hand, transport volumes are projected to increase even further – due to changing consumption patterns and a growing role of e-commerce

[1] Rapp Trans: Regional transport in the frame of a Toll Plus System, Indepth analysis to further develop the iMONITRAF! proposal, 2017
INFRAS/Climonomics: Specifying the regional proposal on Toll Plus: An in-depth analysis of the iMONITRAF! network on design elements, impacts and legal issues of a Toll Plus System, 2015

(increasing trend towards individualized products and services, home deliveries with very short delivery time) which have led to an increase of Light Duty Vehicles in the freight transport fleet as well as, more recently a discussion on the role of unmanned aerial vehicle (drones).

- Changing mobility patterns: At the same time, mobility patterns are changing rapidly and have effects on freight transport capacities on the Alpine motorways: on the one hand, work becomes more flexible with a growing role of teleworking and flexible working times – leading to a better distribution of traffic flows. On the other hand, leisure-time mobility is increasing with a trend towards shorter but more frequent holidays and thus an increase of traffic flows in the Alps.
- Increasing awareness on safety: Recent incidents with road and rail infrastructures brought the issue of transport safety back to the political scene: while, for example, the accident related to the construction of a new rail tunnel in the German part of the Rhine Valley (main freight rail track between Rastatt and Baden-Baden) led to severe economic consequences for the European north-south rail freight transport system, the collapse of the Morandi bridge in Genua illustrated the need to constantly modernize and maintain transport infrastructures.

Objectives of this paper

This input paper has the objective to check the role of future technology driven trends for the iMONITRAF! strategy, its target system and common measures. All Alpine regions and countries support an ambitious modal shift approach and it will be crucial to align the specific policies and flanking measures with the new developments. Some technological developments will be strongly driven by the transport market itself as they offer large economic savings, others will require political support to be competitive as they have larger upfront investment costs or involve higher risks for operators. Thus, the Alpine regions need to find a common approach to integrate the new technological developments into their policies and measures and to make use of their advantages for strengthening the modal shift approach.

Based on an overview on the major innovation clusters with relevance for the Alpine regions, the paper analyses their role and impact for the iMONITRAF! strategy (targets and measures). Three potential scenarios are then developed to illustrate the potential pathways for the Alpine regions and to support a political discussion on the role of technological innovations. Finally, the paper provides some first recommendations regarding the need for appropriate framework conditions to steer the uptake of innovations with the different technological trends and illustrates the need for further analysis and action in the frame of iMONITRAF!. Specifically, the recommendations highlight the need for action to strengthen the modal shift approach in an increasingly automated transport system and specific measures to maintain the competitiveness of road freight transport.

2 Description of innovation clusters

Economic and social trends as well as the need to decarbonize freight transport have triggered several innovative approaches, relating to the overall transport system:

- Vehicle innovations, to improve the environmental and safety performance of vehicles. Also, this includes the different stages of vehicle automatization.
- Infrastructure innovation, related to the construction and operation of road and rail infrastructures, including the automatization of terminals.
- Process innovations, related to the overall logistic and transport processes.
- System innovations, which lead to disruptive changes in the overall transport system, e.g. triggered by a full digitalisation and automation of vehicles and logistic processes.

A broad literature survey has been conducted to identify major innovation clusters (related to all four types of innovation) which have a specific relevance for the Alpine freight transport system. The literature survey shows that some innovation clusters need to be evaluated with a specific view to Alpine characteristics:

- Implementation in sensitive environment: some innovation clusters face specific challenges in the sensitive Alpine environment. E.g. the development of overhead infrastructures for e-mobility would be much more expensive than in flat areas and would lead to considerable visual intrusion, autonomous vehicles will have to fulfil specific safety requirements when passing Alpine tunnels or high-risk passages.
- Capacity constraints: Road capacities in the narrow Alpine valleys are limited and cannot be further developed. In combination with peaks in tourism and passenger traffic, some road stretches are already used at the limit of their capacities (e.g. the total break-down of traffic on the Lower Inn Valley motorway and the Brenner motorway during several occasions in 2016 has led to the implementation of the dosing system in Tyrol).[2] These challenges have to be considered discussing the different steps towards fully autonomous driving.
- Safety: One-tube tunnels in the Alps, but also high-risk motorway stretches with steep slopes, bridges or difficult curves, require specific safety considerations. It needs to be discussed if autonomous vehicles and vehicles with new drivetrain solutions can fulfil these safety standards. In addition, new technologies have potentials for better monitoring and maintaining the quality of transport infrastructures.
- Standardisation potential: Also, the literature survey shows a high need to find harmonised and standardized approaches to avoid unwanted parallel development of different technologies that lead to inefficiencies or even incompatibilities.

With a focus on long-distance transalpine transport and with a view to the iMONITRAF! target system, five major innovation clusters can be identified which will have a high impact on the future Alpine freight transport system (see figure 1). The following sections provide a short description of each innovation cluster, more detailed information is provided in the factsheets in the Annex.

[2] For more information see iMONITRAF! Annual Report 2017.

FUTURE TRENDS AND INNOVATION CLUSTERS

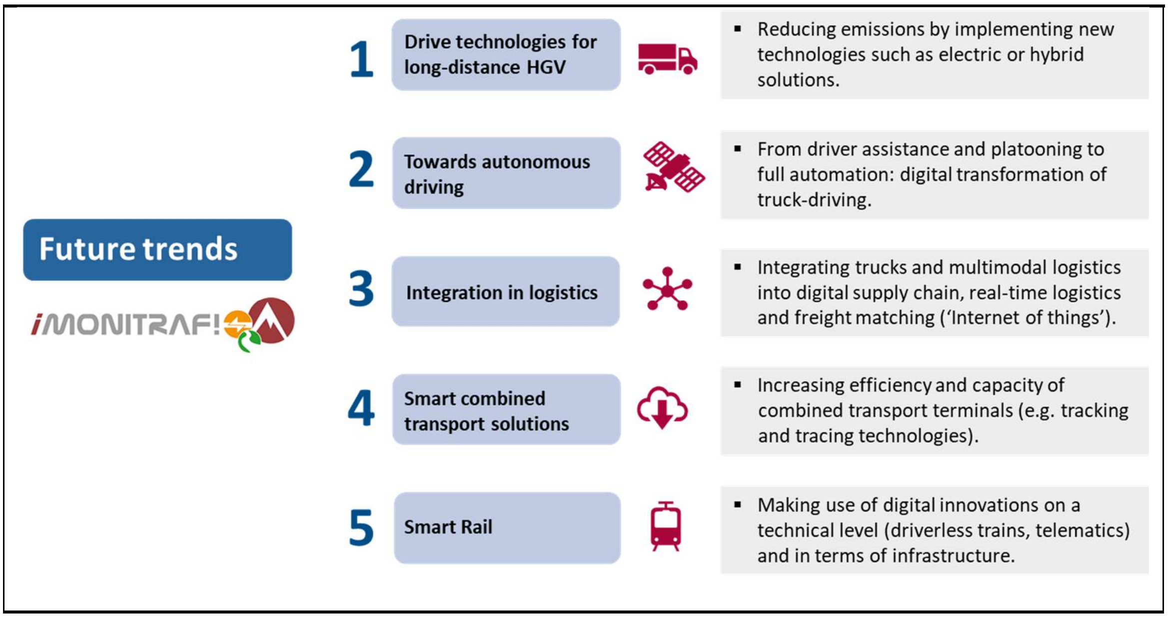

Figure 1: Source: INFRAS

Innovation cluster 1: Innovative drive technologies for long-distance HGV

Growing public awareness for climate change and air pollution and recent scandals such as the "Dieselgate" put the automotive industry increasingly under pressure. Several drive technologies offer potential to reduce emissions on a large scale. Among them, electric freight vehicles serve as a promising option. In road transport, there has been gradual progress so far.

The need to decarbonise the freight transport sector as well as growing problems with air quality in urban and mountain areas have led to the development and demonstration of new technological solutions for heavy good vehicles (HGV). For passenger vehicles, the transition to alternative drive-trains is already beginning with millions of electric cars or cars fuelled by natural gas on the roads. Also, for light commercial vehicles, several electric or gas-based vehicles are commercially available. However, progress with HGV has been more limited, but first vehicles are becoming commercially competitive. In addition, new technologies are tested in dozens of demonstration projects and a vast variety of prototypes is available (ICCT 2017). In general, the following technologies offer a potential for large-scale emission reductions (International Energy Agency 2017):

- Electric solutions: While the technical principles for the electrification of trucks are similar to those available for passenger cars, the greater size and weight of trucks substantially increase the barriers to batteries serving as a substitute for diesel. Thus, several infrastructure-based solutions for charging of electric trucks have been developed and tested around the world: overhead transmission lines (eHighway), charging infrastructures integrated in the road (conductive or inductive) or fast battery-swapping solutions.
- Natural gas solutions: Medium heavy-duty compression ignition engines can be designed to run on a blend of diesel fuel and methane, where methane is typically mixed with small volumes of diesel to provoke ignition. Vehicles using such engines are called dual-fuel vehicles. Alternatively, engines can be manufactured to run solely on methane, using positive ignition systems. Natural gas is the main source of methane currently available and used in dual fuel and dedicated engines. Biomethane is also suitable for this purpose.

Methane needs to be in the form of compressed natural gas (CNG) or liquefied natural gas (LNG) to make it a suitable transport fuel.

- A range of biofuel options is also available to replace petroleum product consumption. Biofuels have the potential for reducing greenhouse gas emissions, but must fulfil rigorous sustainability criteria to avoid adverse environmental or social effects.[3]
- Hydrogen fuel cell vehicles : Trucks using fuel cells and hydrogen are essentially electric vehicles using hydrogen stored in a pressurised tank and equipped with a fuel cell for on-board power generation. High-pressure tanks allow for higher ranges per unit volume than tanks with lower pressures, so that the development of such high-pressure tanks seems crucial for the deployment of hydrogen technology for HGV.

With respect to transalpine freight transport, a transition towards electric freight vehicles brings along the largest disruptive potential as they are (local) zero-emission vehicles and would remove local air emissions and reduce noise problems.[4] As battery range will be the crucial factor for the deployment of electric HGV, specific infrastructures for reliable and fast charging will be essential to make electric trucks competitive (ICCT 2017). Several options are already tested, including new infrastructures systems with overhead transmission lines (eHighway, Siemens 2018) or conductive systems integrated in the road but also supercharger stations which can be integrated in the existing service station system.[5]

Especially, if new electric trucks are equipped with automation technologies (see innovation cluster "autonomous driving" below), several recent studies and demonstration projects estimate considerable cost savings that could come along with a large-scale deployment of electric freight transport systems for the road. ICCT (2018) estimates that overhead catenary electric heavy-duty vehicles would cost approximately 25%–30% less, and hydrogen fuel cells at least 5%–30% less, than diesel vehicles to own, operate, and fuel in the 2030 timeframe.

ELECTRIC SOLUTIONS FOR LONG-DISTANCE FREIGHT TRANSPORT

Figure 2: Lefthand: eHighway, Source: Siemens (2018); Righthand: Tesla E-Truck, Source: Reuters.

[3] https://ec.europa.eu/energy/en/topics/renewable-energy/biofuels
[4] It has to be considered, that e-Vehicles reduce engine related noise, however not noise produced by tyres.
[5] https://www.tesla.com/supercharger?redirect=no

Innovation cluster 2: Towards autonomous truck driving

Digitalization has great impacts on road transport. Already today, technological advancements, such as driver assistance systems and platooning, symbolize the potential towards fully automated trucks. According to several studies, fully automated trucks will be available on the market by 2030.

The digital transformation brings along several technological advancements leading to a stepwise automation of HGV. Like cars, trucks are changing rapidly. New sensor and connectivity technologies link the truck to its surroundings – to other vehicles as well as to the infrastructure – and further technological improvement will bring along several steps towards full automation of freight transport on the road. The first steps of this automatization process is already taking place: driver assistance systems allow for a communication between vehicles and enable “Platooning” (several trucks building a convoy to improve safety and to reduce fuel consumption). The second stage with additional driver support systems is pending and will enable additional safety features and will improve comfort for drivers of trucks in a Platoon. The future stages of the automatization process depend on several technological break-throughs and require a discussion on acceptance as well as the regulatory and legal framework for automated vehicles, but several studies project a high or even full automation of vehicles 2030 – with their market-shares depending on regulatory frameworks and incentives (PWC 2017, IEA 2017, Roland Berger 2018).

The first stages of the automation process mostly bring along safety and environmental advantages (with slight additional comfort for drivers). Fuel savings in these two stages are estimated at 6-8% due to platooning of trucks. Stages 3 to 5 mostly affect the role of drivers and thus labour costs in the road transport sector. Economic savings from autonomous driving are considerable, especially starting from stage 3 where drivers can take up other responsibilities. Labour cost savings are estimated to be around 30% in stage 4 and up to 90% in stage 5 (Roland Berger 2018).

TECHNOLOGICAL DEVELOPMENT TOWARDS FULLY AUTOMATED TRUCKS

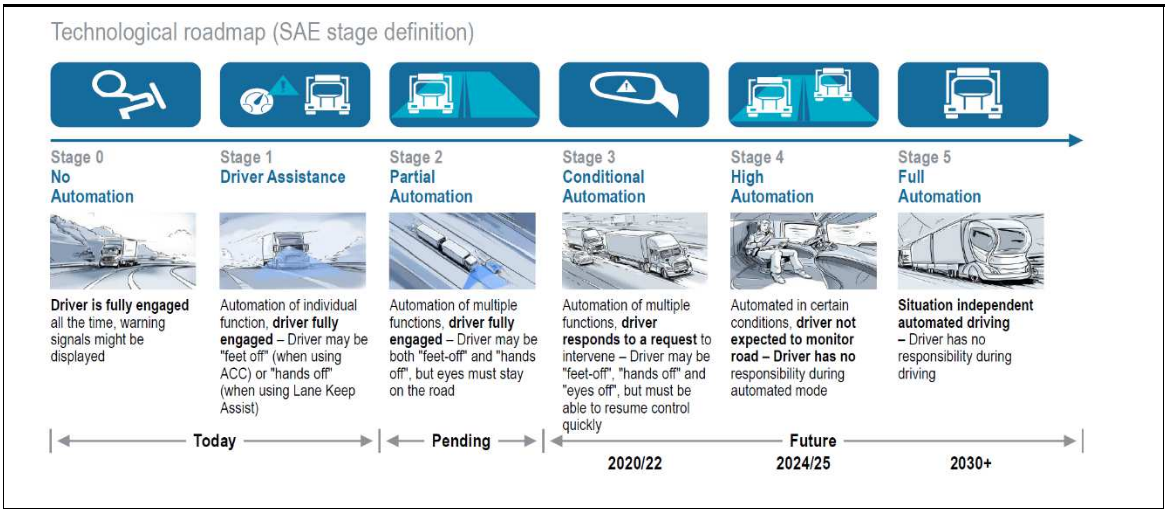

Figure 3: Source: Roland Berger (2018).

Innovation cluster 3: Integration in logistics (Logistics 4.0)

Integrating trucks and trains into the logistics process is continuously improving. Digital technologies will enable real-time logistics data across the entire supply chain. In addition, freight matching is getting easier. Thanks to further technical advancements, trucks might soon be able to *determine whether they can take additional freight or not and logistic service providers will depend on automated services to optimise their processes.*

Fully connected trucks, trailers and trains do not only allow automated driving but also enable a much stronger integration in the overall logistics process. A full integration of trucks into the logistic process will enable mainly two key elements (PWC 2017):

- Integration in the digital supply chain: It will soon be possible to integrate the truck into real-time logistics data across the entire supply chain, from parts and materials suppliers to manufacturers to warehouses and distributors and finally to the end customer. This will further improve just-in-time production processes and will reduce stock-keeping and warehousing costs.
- Freight matching: Thanks to their ability to communicate with fleet management and with shippers of goods - and in the future with cloud-based solutions for freight matching (e.g. Uber Freight) - trucks will eventually be able to determine whether they can take on additional freight. The truck trailer itself will be able to determine through sensors its available space and weight, as well as scheduled route, and other relevant information, and communicate this data to a digital freight-matching platform. This will lead to a better utilisation of HGV capacities.

Similarly, fully connected trailers and trains can be integrated in the logistics process to enable fully integrated combined transport services. All in all, these development have the potential to trigger systemic changes in the logistic process, with a full automation of the logistics system toward the concept of "physical internet" (Simmer et al. 2016).

From a strategical viewpoint, it needs to be ensured that the resulting optimised logistic system does not only integrate road transport solutions but that it also links to rail freight. This however requires a similar automation of rail freight transport to maintain a level-playing-field between road and rail.

Innovation cluster 4: Smart Combined Transport solutions

Sensors, telecommunication technologies and robotics: already today, combined transport terminals can operate automatically. By further integrating tracking and tracing technologies and on the basis of standardized trailers and handling equipment, terminals will gain in efficiency – and will be able to optimize their capacity use.

Digital solutions but also technological improvements in the field of robotics will also enable a stronger automation of combined transport services, especially regarding the operation of CT terminals. This includes fully automated trans-shipment of trailers with high-tech vertical trans-shipment technologies.

Sensor and telecommunication technologies as well as robotics are already available to allow for a full automation of CT terminals. Similar to already ongoing development at large ports, CT terminals should be further developed towards "smart terminals" where all devices and equipment are connected via the Internet of Things and where intelligent containers and trailers – linked via tracking and tracing technologies – are trans-shipped in a fully automated way (see e.g. AlpInnoCT 2018, Vision for Alpine CT after 2030). This will lead to considerable efficiency gains for CT but also enables an optimized capacity use of terminals which, especially in the Alpine Space, often have limited space availability.

This automation will however require a rather strong standardisation of trailers and of transhipment technologies to enable efficient and fully integrated solutions. In the long term, the consolidation and improvement of CT terminals has the potential to lead to systemic changes, e.g. a further development of the European core freight network in which standardized CT solutions can become an important backbone.

In the long term, the automation of rail freight transport might not only take place aboveground: new intermodal underground systems could have a transforming effect on the combined transport system. In this context, cargo sous terrain, hyperloops, cargo tube serve as important keywords. In Switzerland, there are plans for setting up test tracks (Cargo sous terrain 2018; Petry et al. 2018: 37; SRF 2018).

Innovation cluster 5: Smart Rail

Against the backdrop of digital transformations in the road transport sector, the railway sector is increasingly under pressure. By making use of digital innovations several companies aim at profiting from future potentials ("smart rail"). This may include further progress regarding driverless trains, telematics or the automatization of shunting services.

By using a similar term – "SmartRail 4.0" – several rail companies in Switzerland have started a programme that deals with future potentials of the digitization and automatization in the rail sector (SBB 2017). There are numerous innovations that might significantly influence the future development – on a technical as well as on an organisational level. Regarding technical innovations, automated processes could be of great importance (Petry et al. 2018, EURAC Research 2018).

- Telematics: Methods such as tracking and tracing information of the current position of the waggons and gathering data on material conditions through sensors, enable clients to get information on the location and status of the freight. In addition, it allows operators to optimize their processes (Bruckmann, D., Fumasoli, T & Mancera, A. 2014: 27).
- European Signalling system: In order to reduce different signalling systems, the European Commission aims at implementing a European signalling system (ERTMS, European Rail Traffic Management system). One of its components is the European Train Control System (ETCS). The so-called ETCS-Level 3, which provides "continuous train supervision with continuous communication between the train and trackside" is currently being developed (European Commission 2018, DB Netze 2017, European Court of Auditors 2016).
- Driverless trains: In 2017 Swiss Federal Railways has tested automated driving tools. According to the SBB an automatic train traffic system has the potential to reduce distances between trains and increase the passenger and freight capacity. Already today several metro lines in Europe – such as in Lausanne for instance – are operating driverless (Swissinfo 2017, Allianz pro Schiene 2016).
- Assistance systems for engine drivers: From a short-term perspective, driver assistance systems might support train drivers in operating energy efficient. Besides, such systems might allow for a higher interval between trains (BMVI 2017: 21).
- (Partial) automatization of shunting services and last mile transportation: By implementing the automatization of services on shunting stations – for instance shunting locomotives, coupling or the inspection of the waggon order – the supply chain could gain in efficiency (BMVI 2017: 22).

3 Role of innovation clusters for iMONITRAF! strategy

All innovations in the transport sector will affect the competitive situation between road and rail transport, with respect to economic but also environmental aspects. As iMONITRAF! has defined specific objectives and targets within its transport strategy (Lyon, 2012), it will be crucial to assess the impact of the five identified innovation clusters on these objectives and targets. Also, the set of common measures needs to be reviewed to consider new harmonization and regulation needs but also to develop an integrated incentive and pricing system which enables a fair competition between road and rail transport.

Today, the implementation status of the five innovation clusters differs considerably, but all clusters are projected to develop dynamically until 2030. This means that framework conditions need to be shaped today to steer their development. Until 2050, a full update of all innovation clusters can be foreseen and the overall logistic process will develop more and more towards a "physical internet" (see figure below).

EXPECTED TIMELINE

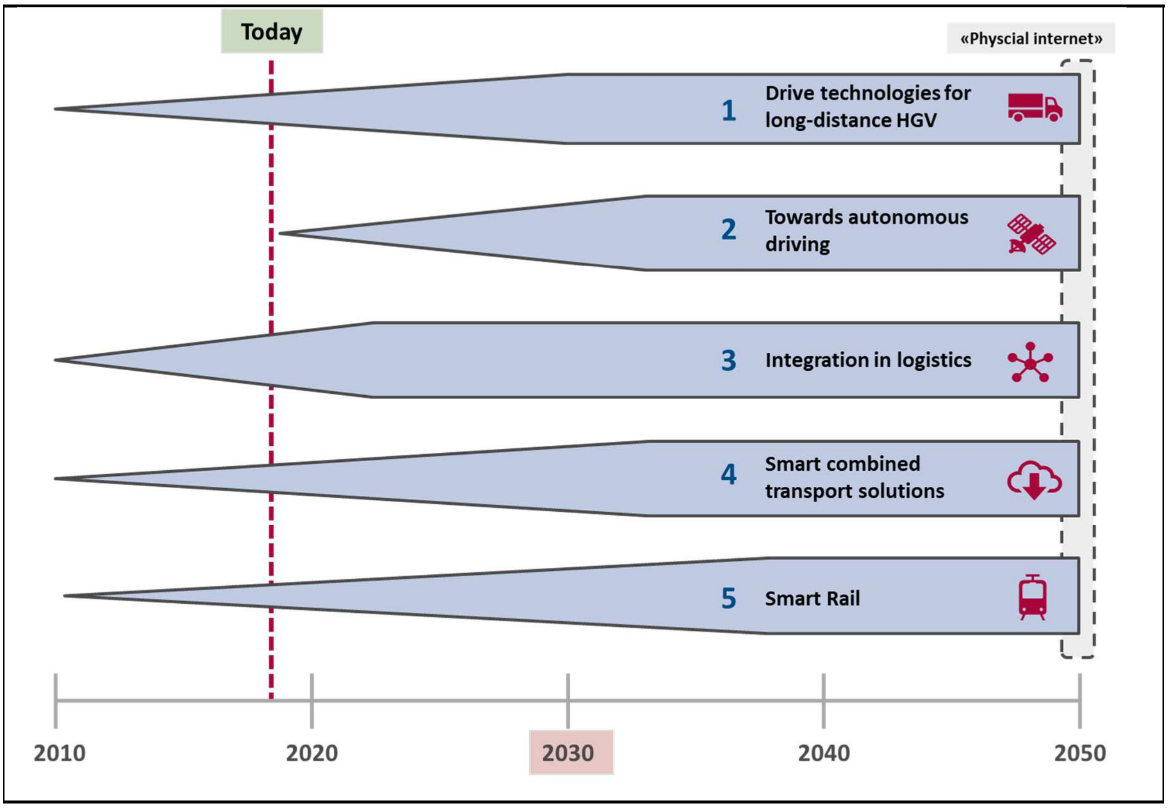

Figure 4: Source: INFRAS

Innovation clusters – Strengths, weaknesses, opportunities, threats for iMONITRAF!

The following table includes an analysis of strengths, weaknesses, opportunities and threats (SWOT) to show the impacts of each innovation cluster for the iMONITRAF! strategy and its major modal shift rationale. The evaluation is based on the information as included in the factsheets in the Annex.

Summarizing the SWOT analysis, the following major impacts with respect to the transalpine freight transport system can be identified:

- Cluster 1 (Drive technologies for long-distance HGV) and cluster 2 (towards autonomous driving) have a disruptive potential to improve environmental and economic competitiveness of road transport. Especially if these two clusters are combined (electric and fully automated trucks), road transport can be operated with nearly zero emissions (air and noise) and has the potential to improve road safety and to optimize capacity use.
- Impacts of cluster 3 (integration in logistics) depend on the automation level of road and rail. Only if combined transport services are developed at the same level of connectivity and automation as road transport, they will be integrated in an automated logistic chain (Logistics 4.0).
- Cluster 4 (Smart CT) and Cluster 5 (Smart Rail) will affect the competitive situation of rail transport and are crucial to ensure that CT and rail will play a role in the digital era.

The innovation clusters will however not only affect transalpine transport but will also have impacts on the transport sector within the Alpine regions:

- Especially cluster 3 will have impacts for both shippers and carriers in the Alpine regions. Shippers will have the opportunity to reduce their transport costs and carriers have the potential to improve their income due to improved capacity use of vehicles and reduction of empty runs (with the help of automated freight matching). This however requires, that regional transport operators improve their vehicle fleet and equipment at the same speed than large-scale companies operating at international level.
- Cluster 4 affects the operators of CT terminals in the Alps. Fully automated terminals will help operators to optimize their processes and to increase their capacity within their limited spatial constraints. However, this requires considerable upfront investments which might require public support.

STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS (SWOT) OF INNOVATION CLUSTERS

	Strengths	Weaknesses	Opportunities	Threats
Cluster 1: Electric solutions freight transport	• High potential to reduce negative environmental impacts of road freight transport, regarding local as well as global pollutants.	• Depends on complete renewal of vehicle and the provision of new charging infrastructures (either stationary charging or transmission system) • Very high upfront costs, especially for charging infrastructures. • Different charging systems available, need for standardisation.	• Accomplish a breakthrough in air quality policy, reach air quality targets. Impact on noise rather low. • Use synergies with the shift towards e-mobility in the passenger transport sector to create economies-of-scale.	• Reduce political pressure to shift freight from road to rail with the risk to reduce competitiveness of rail.
Cluster 2: Towards autonomous driving	• Slight potential for energy savings (6-8% due to Platooning). • Safety improvements due to vehicle-2-vehicle communication. • High potential for labour cost savings (not specific to Alpine region).	• Requires further improvements in telecommunication technologies, sensors, etc. • Acceptance and shift of mindset: high automation levels require discussion on acceptance (shift from objective to rational decisions).	• Optimisation of traffic flow on Alpine motorways and improvement of safety. • Slight improvement of air quality (as long as automated trucks are based on internal combustion engines).	• Automated vehicles reduce costs of road transport and will thus lead to further growth of traffic volumes (incl. induced transport) → effect on modal split but also on capacity of road infrastructures).
Cluster 3: Integration in logistics	• Optimisation of overall logistic processes, improvement of efficiency. • Better efficiency leads to lower environmental impacts.	• Further improvements in telecommunication technologies, sensors, etc.	• Optimisation of traffic flows due to better efficiency of the overall transport system. • Slight reduction of environmental pressures due to improved efficiency (but “rebound” seems possible). • Positive effects for transport sector in the Alpine regions.	• If technological improvements first affect road transport, this will reduce costs of road transport significantly with negative effects for modal split.
Cluster 4: Smart CT (especially terminals)	• Improve reliability and quality of CT • Reduce handling times in CT terminals and thus overall transport time.	• Requires large upfront investments in CT terminals for equipment.	• Improve competitiveness of combined transport • Support standardisation process of trailers (based on vertical transhipment technologies).	• Land-use of terminals • High financial risks for operators due to large investment needs
Cluster 5: Smart Rail	• Improve reliability and quality of rail services • Reduce costs and transport time on rail.	• Requires large upfront investments in rolling stock and infrastructure	• Improve competitiveness of rail	• Interoperability needs to be ensured. • High financial risks due to large investment needs.

Table 1:

Relevance for iMONITRAF! targets and objectives

The SWOT analysis shows that the four innovation clusters have the potential for disruptive changes in the transport system. They will also considerably affect the iMONITRAF! objectives and target system as formulated in the common strategy (Lyon, 2012). The following table gives an overview. The mid-term emission targets of the iMONITRAF! strategy (reach air quality targets by 2020, 20% reduction of CO2-emissions by 2020) as well as the long-term modal shift targets (with specific absolute targets per corridor) are highlighted in bold.

TECHNOLOGICAL INNOVATIONS – RELEVANCE FOR IMONITRAF! OBJECTIVES

	Relevance for Alpine Space	**Air improvm.**	**CO_2 emissions**	Noise impr.	**Modal shift**	Efficiency	Safe ty
Cluster 1: Electric solutions freight transport	Reduces environmental pressures of road transport (zero-emission vehicles)	++	++	+	--	0	0
Cluster 2: Towards autonomous driving	Optimisation of traffic flow and significant reduction of road transport costs.	+	+	0	--	0	++
Cluster 3: Integration in logistic process	Competitiveness road-rail, need for action for regional transport sector.	Depends on specific implementation, especially if rail transport is integrated in automated logistic processes.				++	
Cluster 4: Smart CT (especially terminals)	Improvement of CT terminals with respect to capacity, quality and handling time.	+ (indirect)	+ (indirect)	++	++	++	0
Cluster 5: Smart Rail	Reduces costs of rail transport and improves inter-operability.	+ (indir.)	+ (indir.)	0 (depends on noise measures)	++	+	++

Table 2: ++ = very positive impact, + = positive impact, 0 = no impact, - = negative impact, -- = very negative impact.

The table indicates clearly that there are chances to improve the environmental performance of transalpine freight transport, mainly for air pollutant and greenhouse gas emissions. However, depending on the development of the different clusters, there might be risks for the modal shift policy. The efficiency increases will have two effects: On the one hand the increased load factors reduce the level of vehicle kilometers, one to other hand, reduced costs might induce new transalpine freight volumes.

4 Development pathways for transalpine transport

Three development pathways

The development (and also breakthrough of new technologies) is depending on different factors, mainly

- global economy: the speed of economic development and related to this the growth rates of freight and its structure
- technology: the speed of development in automatization and digitalisation, certainly based on global economy and technology trends
- policy: the acceptance of new technologies and their admission in real transport situation, mainly autonomous driving and platooning. Related to that the relevance of modal shift policy and the influence of national and European policies to support break throughs in the rail sector.

Two dimensions are most important for freight transport developments:

- breakthrough of new technologies and related disruptive developments: low – high
- importance of intermodality: low (road scenario) – high (combined transport scenario)

Based on that it is possible to draw three possible development pathways for transalpine transport:

- **Trend with moderate uptake of new technologies**: There is no strong technological change, either due to low economic development and/or due to low acceptance for the admission of new technologies. Thus freight transport growth rates, modal shift and related environmental performance will follow existing forecasts.
- **Electric and automatic HGV**: The focus is on clusters 1, 2 and 3: The breakthrough of new technologies, especially electrification and automatization (platooning, driverless truck) will mainly happen in road transport. Road transport thus will face lower costs[6], more flexibility and lower emissions. The cost reduction and the better acceptance of environmentally friendly HGV will lead to significant modal shifts from combined to road transport. Rail transport loses market shares.
- **Integrated intermodal solutions:** The focus is on clusters 3, 4 and 5: Digital logistics, automatic terminals, smart rail and automatic driving will penetrate strongly the rail market, will lead to lower rail costs and will lead to a strong competitiveness of combined transport road-rail especially on long distance transalpine transport. The new base tunnels (Brenner, Mont Cenis) support this C.T. revolution. Modal shift changes towards rail transport trough the Alps.

The following figure illustrates the logic:

[6] Truck driver costs amount today to 30-50% of total costs

THREE DEVELOPMENT PATHWAYS

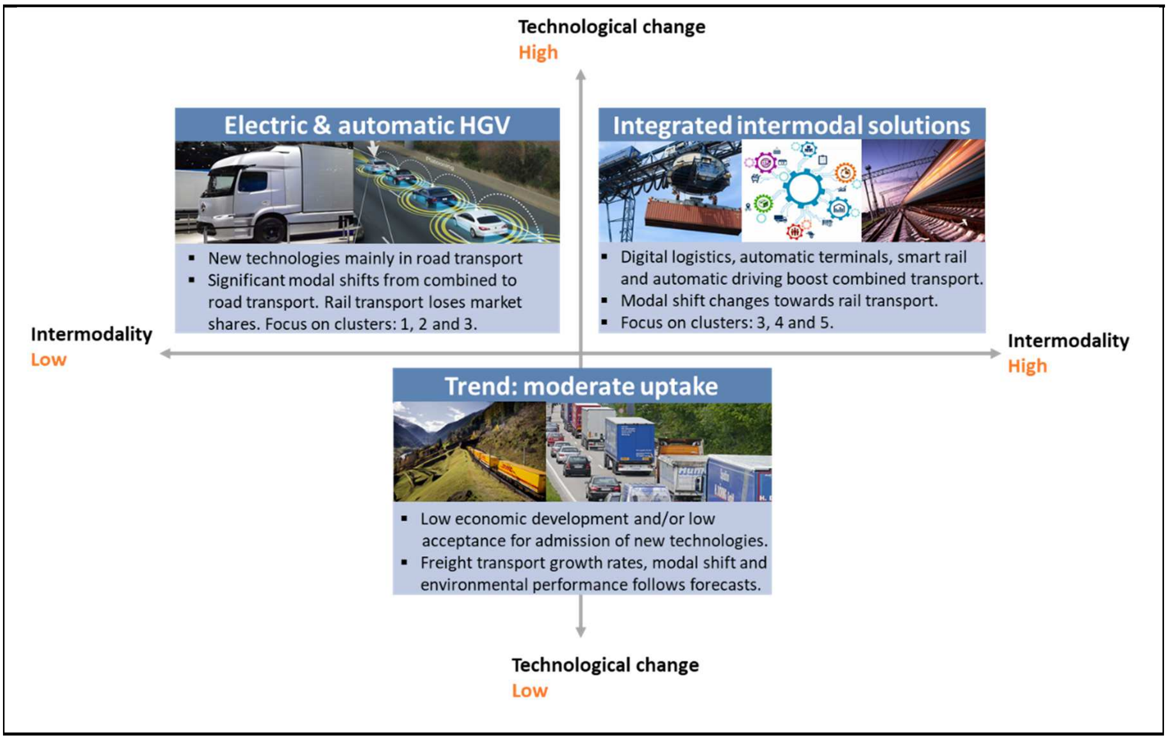

Figure 5: Source: INFRAS. Pictures: Wikipedia, Pixabay.

Thesis on the relevance of the development paths and their influence factors

The following thesis underline the relevance and the framework conditions of the development paths.

- The probability for technological breakthroughs and increased productivity and related environmental performance are bigger for road than for rail. Two reasons are important: Firstly the level of competition and the pressure to find drivers, to reduce drivers costs at the same time will increase incentives to remove drivers and thus push road automatization technology. Secondly one has to consider that the truck market is global. Economies of scale of production are much higher than for rail transport, where rolling stock markets are much more segmented.
- The probability of technological breakthroughs strongly relates to the political acceptance and the (harmonized) admission of new technologies.
- Electric and automatic HGV might improve safety and road transport emissions. Many related problems are however not solved, such as capacities and noise. Furthermore the electrification would lead to new energy topics (such as loading stations, landscape, general problems of new electricity production capacities).
- The construction of the basetunnels (CH, A, F) leads to a strong pressure for transalpine policy to adapt new technological potentials for rail infrastructure (cluster 5 smart rail).
- The main potentials for rail transport are related to intermodal transport (intelligent, automatic and standardized systems). Pure wagon trains are much less relevant and will anyway lose market shares.

- Nevertheless the improvement of the safety and environmental performance of transalpine HGV must be an important agenda point.

→ It is important to use the potentials of all innovation clusters with a focus on the development path 'integrated intermodal solutions' and support modal shift.

→ Looking at the timeline of the development of new technologies, 2030 might be an important point of time to make specific decisions for the admission of new technologies. This time coincides with the time of operation of new rail base tunnels. Before it is important to support intermodal technology development.

5 Need for political action

Overall strategic implementation

The different technology-driven trends might lead to considerable impacts on the competitive situation between road and rail – regarding their environmental but also economic performance. The Alpine regions, with their high share of transit traffic and their long-term policy based on the modal-shift rationale, need to steer the development in a strategic way:

- In order to maintain and further strengthen the competitiveness of rail transport and to make full use of the new rail basetunnels, a strong focus should be put on innovation clusters 4 and 5 – supporting the automation and integration of CT and thus guaranteeing their compatibility with fully automated logistic solutions. Developments on the road will be strongly market driven: automated vehicles will ease social problems in the road transport sector and will solve the shortage on the labour market. Electric solutions will be driven through climate change policy, based on EU and national policies.
  → The network of the Alpine regions should thus focus its further activities on supporting automation of CT and rail services and their integration in logistic services.
- Fully automated HGV will be available by 2030, but their market deployment will depend on political frameworks and regulations. It needs to be ensured that these frameworks consider the specific characteristics of the Alpine regions (specific safety needs, capacity constraints).
  → The network of the Alpine regions needs to develop a common approach towards regulation of automated HGV to shape national and EU frameworks (also including minimum requirements with respect to the degree of automation for HGV on the transalpine network). Specifically, the link to existing measures like the dosing system at the Gotthard Road Tunnel or the dosing system on the lower Inn valley motorway at the Bavarian-Tyrolean border need to be analysed.
- Electric solutions and other alternative technologies have a strong potential to improve air quality in the Alpine regions, thus incentive systems need to be developed to set strong incentives for their deployment in the sensitive Alpine environment. Also, corridor-based approaches should be developed towards the use of the different charging options (superchargers, battery-swap options, road-based systems).
  → The network of the Alpine regions needs to review its set of common measures to improve incentives for low-emission vehicles and should support a common approach towards vehicle charging.

Adjustment of the set of iMONITRAF! common measures

Considering the set of common measures of the iMONITRAF! strategy, the following adjustments will be necessary:

Regulatory measures and standardisation:

- Further dynamic adjustment of driving bans for low-emission vehicles (e.g. exemptions for night-driving ban in Tyrol only for electric HGV)
- Regulations on automated driving are needed:
    - Short-term: rules for platooning: number of trucks to build a convoy, specific rules for safety distances within and between convoys in Alpine area
    - Mid-term: rules for (partly) autonomous vehicles and role of driver on high-risk Alpine sections/tunnels
- Regulations for standardisation of charging infrastructures got electric truck systems, based on a commonly agreed system (superchargers, road-based, battery-swap, eHigh-way).

Modal shift policy:

- Toll Plus: further optimisation of road charging systems to set incentives for clean vehicles through strong modulation of tolls. Also, Toll Plus should be used to set stronger incentives for combined transport (e.g. through reimbursement mechanisms as already implemented in Switzerland).
- Construction of rail base tunnels Brenner and Mont Cenis: ensure highest level of connectivity and automation to integrate rail transport in automated logistic processes. With the help of automated solutions, capacity use of rail base tunnels can be optimised.
- Financial support of combined transport: In the mid-term, with automated HGV driving in convoys, the rolling motorway (Rola) will become even less competitive compared to road transport. Thus, the focus should be put on unaccompanied combined transport which builds on smart CT and smart rail solutions. Subsidy systems should be adjusted to strengthen these modes.

Steering instruments:

The iMONITRAF! strategy foresees the implementation of a cap-and-trade instrument in the long-term (2030), especially an Alpine Crossing Exchange or an Alpine Emissions Trading System. The need for and impacts of such a steering instrument need to be re-evaluated in the light of new technological developments:

- An Alpine Crossing Exchange might still be interesting to steer capacities on the Alpine motorways, but an undifferentiated approach might have adverse effects on the modernisation of vehicle fleet.
- The development of an Alpine Emissions Trading System seems even less realistic in a scenario with a strong shift to clean road transport solutions. A strongly differentiated Toll Plus system sets more transparent incentives for road transport operators and has the advantage to build on accepted approaches.

Stronger need for harmonisation and standardisation

Making full use of the chances of technological innovations and digitalisation will require a strong cooperation and a common voice of the Alpine regions. In an unguided trend scenario, different technologies will develop next to each other and the optimisation potential will be low. If the Alpine regions with the major transit corridors however work together and develop common harmonised solutions, they can profit from the different innovation clusters to strengthen modal shift policy and to reduce environmental pressures of road freight transport. To support the automation of CT and rail services and to maintain the competitiveness of rail transport in a Logistics 4.0 framework, a stronger standardisation of frameworks and technologies seems necessary:

- International smart rail initiative, in particular Interoperability for new automatic systems for rolling stock/locomotives and automatic infrastructure.
- Strong cooperation between terminal operators and CT operators to strengthen standardisation of C.T. systems and handling equipment and to develop common solutions for automated logistics. Therefore support for the development of integrated freight platforms is needed (spatial planning and financial support for automatic freight terminals).
- Specifically, a European process on the standardisation of trailer technologies seems necessary and could be supported by the Alpine regions. The full automation and integration of CT in logistic process will depend on a standardized trailer to enable economies of scale (similarly to standardized containers in maritime transport).

Update of iMONITRAF! strategy and further networking needs

A common approach to deal with these dynamic technological developments of the iMONITRAF! regions is crucial for making full use of their respective advantages. The common need for action remains high and many challenges could be investigated in a continued cooperation beyond 2018. Especially, it seems important to update the iMONITRAF! strategy with its target system and the set of common measures – based on an in-depth investigation on potential pathways/scenarios and the role of common measures for steering the development.

Also, there will be strong need to continue iMONITRAF! as moderator between different ongoing processes and networks and to build on its experience regarding policy capitalisation.

- EUSALP AG4 is not specifically dealing with innovative technologies in the recent mandate. Here, iMONITRAF! can feed its results and recommendations into the EUSALP process (e.g. regarding the further development of the AG4 target system but also the activities on integrated pricing systems).
- AlpInnoCT is running until Oct 2019 and networking activities could be strengthened to streamline policy recommendations and strategic activities with a focus towards standardisation of trailer and unaccompanied combined transport.
- The Working Group Transport of the Alpine Convention is also dealing with the role of innovative technologies and iMONITRAF! can bring the regional perspective into this discussion.
- The Suivi de Zurich Process is still working on recommendations regarding Toll Plus and iMONITRAF! could feed new insights and finetuning needs into this discussion.

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ANNEX – Innovation factsheets

<table>
<tr><th colspan="2">Factsheet 1: Drive technologies for long-distance HGV</th></tr>
<tr><th colspan="2">Main information on innovation cluster</th></tr>
<tr><td>Specific focus of innovation cluster</td><td>Increasing air quality problems in urban areas but also sensitive mountain regions and the recent “Dieselgate” scandal put pressure on vehicle manufactures as well as operators to produce and operate low-emission vehicles. In addition, a decarbonisation of freight transport will be necessary to achieve ambitious climate change targets. Several technological options are currently developed:
• Further improvement of vehicle efficiency and environmental performance with diesel engines (including the use of biofuels as blend)
• Solutions based on natural gas
• Electric solutions
• Hybrid vehicles
→ Further improvements of traditional HGV (internal combustion engine) are seen as “bottom-line”, all potential improvements will be implemented by manufacturers to meet air quality and upcoming CO2-standards.
→ In line with developments in the passenger vehicle fleet, the highest disruptive potential is seen with a transformation towards electric mobility solutions.</td></tr>
<tr><td>Short description</td><td>Electric mobility in the field of long-distance transport: electric-drive vehicles, including battery electric, plug-in hybrid, and hydrogen fuelcell vehicles, have the potential for dramatic emission reductions that are needed to achieve long-term air quality and climate change goals. Compared to passenger vehicles, progress with heavy-duty commercial vehicles has been more limited. Recent demonstration projects as well as first commercial applications illustrate the potential applications. Due to limited battery range of long-distance HGV, several infrastructure-based solutions are possible to support electric freight transport on the road:
• Overhead catenary lines for direct electricity transmission (see e.g. the Siemens eHighway system (Siemens 2018).
• Electricity transmission via an e-road system (inductive or conductive charging).
• Battery swapping systems where complete batteries can be changed at battery exchange stations.[7]
• Charging stations equipped with super-chargers for fast charging of vehicles.</td></tr>
<tr><td>Main stakeholders in innovation process</td><td>Vehicle manufacturers for development of vehicles
In addition, different stakeholders are necessary for different charging options:
• Electricity providers to install and operate charging stations (incl. super-chargers for fast charging).
• Electricity providers plus developers of system solutions to install and operate charging options integrated in infrastructure (overhead, inductive or conductive).</td></tr>
</table>

[7] This option has been taken forward by the company “Better Place” which has not been economically successful but is recently taken up again by China’s electric car start-up Nio: https://www.electrive.com/2017/12/19/nio-launches-ev-battery-swap-mobile-charging-option/

	• Vehicle manufacturers, battery manufacturers or new stakeholders: battery swap-stations.
Type of innovation	The transformation towards electric mobility for freight transport requires vehicle innovations but also infrastructure innovations for charging.
Innovation impact	
Ecological impact	Electric solutions offer great potential to reduce local pollutants (air and noise). Also, they offer a potential for decarbonising the transport sector, however only if the consumed electricity is produced from renewable sources. As solutions for long-distance freight transport require infrastructure-based charging systems, the ecological impacts of these charging systems also need to be considered: • In the sensitive Alpine environment, overhead transmission lines need to be seen in a critical way as they lead to new sources of visual intrusion as well as new risk potential for climate change impacts. • Charging solutions integrated in the road system are less critical from an ecological viewpoint. • Battery swap stations as well as super-charger stations need to be integrated in existing service or control stations to avoid additional land-take.
Economic impact	Although road electrification has high upfront costs from the required energy infrastructure, these costs are compensated in the long term by cheaper energy supply costs compared to alternative liquid fuels. Several studies indicate that the cost of energy infrastructure is relatively small compared to the high cost of energy supply and vehicle costs over the long-term, leading to the result that electrification is the most cost-effective technology for freight transport in the long-term. According to a whitepaper by the ICCT, zero-emission vehicle technologies might have the greatest cost reductions from 2015 to 2030. The study estimates that the costs for vehicle components such as batteries or electric motors will decrease between 2015 and 2030 (ICCT 2017).
Social impact	A reduction of environmental impacts will also affect living conditions and health.
Implementation	
Status of implementation	A vast range of demonstration projects is underway all around the world (see ICCT 2017 for an overview). In Germany, a test section for the eHighway system has recently been launched in Schleswig-Holstein, additional test sections are developed in Hessen and Baden-Württemberg.
Regulatory and financial requirements	• To reach a strong market-share of electric HGV, it seems necessary to take a standardized approach towards the relevant technology (i.e. overhead transmission lines, charging systems integrated in the road, battery swap technologies) as all technologies require a slightly different equipment of vehicles. • Financial incentives: road pricing systems should clearly support the use of low-emission vehicles through a maximum modulation of charges (see Toll Plus proposal). • To make sure that modal shift is further supported in a world with electric vehicles, specific incentive systems need to be developed, e.g. reimbursement of road charges for electric HGV which are part of an intermodal transport chain.

	• Scrappage systems to accelerate the shift to electric vehicles. • Financial support for the development of necessary infrastructures.
Chances and risks for the iMONITRAF! strategy	
Chances	Environmental targets: • Electric HGV offer a high potential to reduce both, air quality and noise. They are (local) zero-emission vehicles with nearly no engine noise. • CO_2 emissions are reduced far beyond the iMONITRAF! targets.
Risks	Modal shift: • Electric vehicles offer a great disruptive potential to reduce local environmental problems in the Alpine transit corridors (air and noise). If they are also equipped with automated technologies, they also offer great potential for economic savings. If this is the case, the competitiveness of rail transport will be further reduced – with resulting impacts on modal split. → Here, it seems especially relevant to ensure that road freight transport based on electric vehicles further supports intermodal transport solutions.

Literature

International Energy Agency (2017)
McKinsey & Company (2016)
PWC (2017)
ICCT (2017)
Siemens (2018)

Factsheet 2: Towards autonomous driving	
Main information on innovation cluster	
Specific focus of innovation cluster	Technological advancements related to the overall digital transformation bring along several disruptive potentials for long-distance freight transport. Like cars, trucks are changing rapidly. New sensor and connectivity technologies link the truck to its surroundings – to other vehicles as well as to the infrastructure – and further technological improvement will bring along several steps towards **full automatization** of freight transport on the road.
Short description	The technological development towards automated trucks takes place in several stages. While the first stage is driven by safety considerations, further steps enable improvements of safety, environmental performance but also savings with respect to labour costs, as the role of drivers is changed over the transformation process (Roland Berger 2018, PWC 2018): • Stage 1 (today): Driver Assistance: Automation of individual function, driver fully engaged – Driver may be "feet off" (when using ACC) or "hands off" (when using Lane Keep Assist). • Stage 2 (pending): Partial Automation: Automation of multiple functions, driver fully engaged – Driver may be both "feet-off" and "hands off", but eyes must stay on the road. • Stage 3 (2020/22): Conditional automation: Automation of multiple functions, driver responds to a request to intervene – Driver may be "feet-off", "hands off" and "eyes off", but must be able to resume control quickly. • Stage 4 (2024/25): High automation: Automated in certain conditions, driver not expected to monitor road – Driver has no responsibility during automated mode.. • Stage 5 (2030+): Full automation: Situation independent automated driving – Driver has no responsibility during driving.
Main stakeholders in innovation process	• Vehicle manufacturers: further develop their understanding of autonomous vehicles, gain knowledge to design trucks which require only limited driver assistance. • New stakeholders in the system: Sensors & communication technologies, telematics, steering systems. • Fleet operators to take up technologies and to integrate (partially) automated trucks in the logistic process.
Type of innovation	System innovation
Innovation impact	
Ecological impact	• Depends on drivetrain of automated truck. For traditional HGV with combustion engines, stages 1 and 2 offer options for efficiency improvements (“Platooning”).
Economic impact	• Economic savings from autonomous driving are considerable, especially starting from stage 3 where driver can take up other responsibilities. • Labour cost savings: 30% in stage 4, 90% in stage 5. • Fuel savings: 6% in stage 1, 8% in stage 2 (no further fuel savings from additional stages). • However, higher equipment costs which partly compensate the saving potential (stages 1 and 2: higher equipment cost lies below fuel savings).
Social impact	• Considerable improvements for drivers (stages 4 and 5 will lead to completely new job profiles).

	• Acceptance issues need to be considered → ethical considerations (fair vs. rational decisions).
Implementation	
Status of implementation	Stage 1 of the automatization process is already implemented and enables the possibility of "Platooning". Stage 2 technologies are already available. For stages 3,4 and 5, the development timeframe depends on further technological developments. However, many sources see a full automatization realistic for the timeframe 2030.
Regulatory and financial requirements	Regulatory requirements: • Should autonomous HGV be allowed on high-risk Alpine roads? Under which conditions? → Develop relevant regulatory framework, e.g. the need to engage a driver on Alpine roads, in tunnels, etc. • Regulations for Platooning: regulation on number of HGV to form a Platoon on different motorway stretches. Financial incentives: • No additional incentive systems need to be given, development is purely market-driven.
Chances and risks for the iMONITRAF! strategy	
Chances	Emission targets: • Limited potential for emission reductions in stages 1 and 2 of automatization process ("Platooning"). However, this comes along with capacity issues if large platoons are formed on Alpine motorways with limited capacities.
Risks	Modal shift targets: • Autonomous driving will reduce the costs of road freight transport considerably with resulting risks for the Alpine modal shift strategies.

Literature

Roland Berger (2018)
PWC (2017)
International Energy Agency (2017)
IRU (2017)

Factsheet 3: Integration in logistic processes	
Main information on innovation cluster	
Specific focus of innovation cluster	The connectivity of trucks (with all technologies required for autonomous driving) will enable their **full integration into the entire logistics effort**.
Short description	A full integration of trucks into the logistic process will enable to key elements: • Integration in the digital supply chain: It will soon be possible to integrate the truck into real-time logistics data across the entire supply chain, from parts and materials suppliers to manufacturers to warehouses and distributors and finally to the end customer. This will further improve just-in-time production processes and will reduce stock-keeping and warehousing costs. • Freight matching: Thanks to their ability to communicate with fleet management and with shippers of goods – h and in the future with cloud-based solutions for freight matching – trucks will eventually be able to determine whether they can take on additional freight. The truck trailer itself will be able to determine through sensors its available space and weight, as well as scheduled route, and other relevant information, and communicate this data to a digital freight-matching platform. All in all, these development have the potential to trigger systemic changes in the logistic process, e.g. with a stronger role of hub-and-spoke systems.
Main stakeholders in innovation process	• All stakeholders in the logistic process. • Producers of enabling technologies, especially for providing platform solutions.
Type of innovation	Process innovation with the potential for systems innovation.
Innovation impact	
Ecological impact	• Indirect ecological impact as efficiency of overall transport system will be improved (better capacity use, route optimization, etc.).
Economic impact	• The optimisation of the logistics process will bring along cost savings for all relevant stakeholders and will lead to reduced transport costs.
Social impact	• Less pressure on drivers with respect to ecological and economic impacts.
Implementation	
Status of implementation	• First elements are already implemented, especially regarding the development of smart trucks.
Regulatory and financial requirements	• This innovation cluster requires few framework conditions as it is fully driven by the logistics market. However, it needs to be ensured that rail transport develops at the same level as road transport to remain competitive in an automated logistic world.
Chances and risks for the iMONITRAF! strategy	
Chances	• Overall, there are no specific chances with respect to transalpine freight transport. Efficiency improvements will lead to a slight reduction of environmental pressures and in transport costs. • Positive effects for regional shippers and carriers, but also if they innovate at the same speed as large-scale international operators.

Risks	• Innovations in this cluster have a closer connection to road transport and have a strong potential to further reduce costs of road transport. It thus needs to be ensured that rail transport and CT solutions are developed at the same level of automation to ensure their integration in future logistic processes.

Literature

PWC (2017)

International Energy Agency (2017)

Factsheet 4:Smart combined transport solutions	
Main information on innovation cluster	
Specific focus of innovation cluster	Automation and technological innovations will also improve the operation of combined transport services, especially regarding the **full automation of CT terminals.**
Short description	Digital solutions as well as robotics are already available to allow for a full automation of CT terminals. Similar to already ongoing development at large ports, CT terminals should be further developed towards “smart terminals” where all devices and equipment are connected via the Internet of Things and where intelligent containers and trailers – linked via tracking and tracing technologies – are shipped in a fully automated way (see e.g. AlpInnoCT 2018, Vision for Alpine CT after 2030). This automation will however require a rather strong standardisation of trailers and of transhipment technologies to enable efficient solutions. In the long term, the consolidation and improvement of CT terminals has the potential to lead to systemic changes, e.g. a further development of the European core freight network in which standardized CT solutions can become an important backbone.
Main stakeholders in innovation process	• Operators of CT terminals (regarding equipment of CT terminals with robotics and connectivity). • Logistic service providers which make use of CT (regarding standardisation of trailers and their ability for tracking and tracing).
Type of innovation	Infrastructure and process innovation, vehicle innovation with potential for systemic innovation.
Ecological impact	• Indirect through the modal-shift impact of smart terminals. • Smart terminals based on vertical transhipment technologies (making use of robotics) can also operate with limited space availability.
Economic impact	• Cost savings through efficient terminal operation and time-savings during the transhipment process
Social impact	• The increasing automation of combined transport services challenges the specific role of individuals within the process of smart combined transport solutions.
Status of implementation	• Most technologies are already available and are used in large ports. However, CT terminals face the challenge of renewing their equipment and of fully connecting all devices with each other.
Regulatory and financial requirements	• Regulatory framework: Further automation of CT is only possible with a stronger standardisation of trailer technologies. • Financial support: Subsidies for modernisation of CT terminals seems highly critical to enable a full automation of CT services. • Steering instruments: Indirect support is possible to strengthen the capacity utilization of CT terminals, e.g. via exempting pre-and onward carriage from road charging (Toll Plus).

Chances	• Systemic changes possible thanks to the consolidation and improvement of CT terminals (e.g. further development of the European core freight network).
Risks	• As the automation process will require a rather strong standardisation of trailers and of transhipment technologies to enable efficient and fully integrated solutions, the success of combined transport solutions depends on common efforts.

Literature

Alpine Convention – Working Group Transport (2016)

AlpInnoCT & Interreg Alpine Space (2018a)

AlpInnoCT & Interreg Alpine Space (2018b)

Factsheet 5: Smart Rail – Automation of rail freight transport	
Main information on innovation cluster	
Specific focus of innovation cluster	As Industry 4.0 and the Internet of Things promise to connect everything with everything, it will be crucial for a successful modal shift policy to also ensure a **high connectivity of rail transport services and a high level of automation**.
Short description	“**Smart Rail**” includes several major elements in which a high degree of automation has the potential to increase competitiveness of rail freight transport. There are numerous innovations that might significantly influence the future development – on a technical as well as on an organisational level. Regarding technical innovations, automated processes could be of great importance – for instance with respect to train coupling or train disposition (Petry, Maibach, Gandenberger, Doll et al. 2018: 37). • Telematics: Methods such as tracking and tracing information of the current position of the waggons and gathering data on material conditions through sensors, enable clients to get information on the location and status of the freight. In addition, it allows operators to optimize their processes (Bruckmann, D., Fumasoli, T & Mancera, A. 2014: 27). • European Signalling system: In order to reduce different signalling systems, the European Commission aims at implementing a European signalling system (ERTMS, European Rail Traffic Management system). One of its components is the European Train Control System (ETCS). The so-called ETCS-Level 3, which provides “continuous train supervision with continuous communication between the train and trackside” is currently being developed (European Commission 2018, DB Netze 2017, European Court of Auditors 2016). • Driverless trains: In 2017 Swiss Federal Railways has tested automated driving tools. According to the SBB an automatic train traffic system has the potential to reduce distances between trains and increase the passenger and freight capacity. Already today several metro lines in Europe – such as in Lausanne for instance – are operating driverless. (Swissinfo 2017, Allianz pro Schiene 2016). • Assistance systems for engine drivers: From a short-term perspective, driver assistance systems might support train drivers in operating energy efficient. Besides, such systems might allow for a higher interval between trains (BMVI 2017: 21). • (Partly) automatization of shunting services and last mile transportation: By implementing the automatization of services on shunting stations – for instance shunting locomotives, coupling or the inspection of the waggon order – the supply chain could gain in efficiency (BMVI 2017: 22).
Main stakeholders in innovation process	• Operators of rail infrastructures and rolling stock • Providers of system services (e.g. for provision of train control systems).
Type of innovation	• Mainly infrastructure innovation (technological and organizational level).
Ecological impact	• Thanks to driver assistance systems, a more energy-efficient driving style – resulting in less CO_2 emissions and energy consumption – might be possible (BMVI 2017: 21).

Economic impact	• As last mile transports and shunting services are amongst the most significant cost factors, the (partial) automatization may result in productivity gains and reduced costs. Besides, more frequent intervals may have a positive effect (BMVI 2017: 20-21). • Improved conditions in cross-border transport due to standardization of signalling system.
Social impact	• New job profiles due to (partial) automatization of specific processes.
Status of implementation	• In several European cities there already exist driverless metros. With respect to the rail transport sector in general, however, this development is still at its beginning. • Signalling systems: According to a report by the European Court of Auditors from 2016, "ERTMS is being implement slowly and is experiencing interoperability problems" (European Court of Auditors 2016: 42).
Regulatory and financial requirements	• According to the Rail Freight Masterplan by the German Federal Ministry of Transport and Digital Infrastructure automatic operations in the long-distance rail sector require an analysis of necessary adaption with respect to national and international regulations (BMVI 2017: 21).
Chances	• Productivity and efficiency gains as well as more energy-efficient driving styles.
Risks	• Rail freight companies may lack behind their competitive companies in road transport sector.

Literature

Allianz pro Schiene (2016)
Bruckmann, D., Fumasoli, T & Mancera, A. (2014)
Bundesministerium für Verkehr und digitale Infrastruktur BMVI (2017)
DB Netze (2017)
European Commission (2018)
European Court of Auditors (2016)
Petry, C. et al. (2018)
SBB (2018)
SRF (2018)
Swissinfo (2017)