Rail Baltica Global Project Corridor Synergies Study

Final Report

ANNEX 1: INTERNATIONAL BEST PRACTICE AND OPPORTUNITIES

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Co-financed by the Connecting Europe Facility of the European Union

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ANNEX1: WP2 INTERNATIONAL BEST PRACTICE AND OPPORTUNITIES

1 INTRODUCTION

Table 1 draws on the European and global best practices for the maximisation of the commercial and selected synergy opportunities.

Table 1: International Best Practice and Opportunities

Work Packages	Scope / Overview of Synergies and Potential Impacts
Wayleaves	• The Rail Baltica Global Project (RGBP) could set the general conditions for service providers to access dark fibre optic as well as 5G mobile infrastructure
Digital Infrastructure	• Deployment of 5G mobile networks • Deployment of fibre optic high-speed backbone networks • Smart Stations, deployment of communications and advanced services • Deployment of edge computing centres / nodes
Energy Infrastructure[1]	• Installation of renewable energy generation sources • Utilisation of the energy subsystem to transfer electrical energy generated by the infrastructure manager(s) (IM) or third parties • Development of battery electrical vehicle charging infrastructure charging infrastructure (BEV) • Development of fuel cell electrical vehicle charging (FCEV) infrastructure
Local Connections for Industrial Areas	• Construction of private railway branches in order to facilitate accessibility for relevant industrial, defence and/or logistics areas - European experience and North American experience

Source: RB Global Project Synergies Study (2021)

[1] This synergies study focuses on analysing and providing policy recommendations for the maximization of benefits of the Rail Baltica (RB) corridor from the “Dig Once” perspective and provide insights to national governments and EU on opportunities to co-synchronise relevant infrastructure developments with the delivery of RB through a single backbone perspective, in other words, the study will assess the value of a seamless connection approach to infrastructure developments between the three Baltic States.

The following paragraphs introduce the relevant international best practice case studies in such a corridor, as well as emerging opportunities stemming from innovation and digitalization:

1.1 LEASE OR GRANT ACCESS RIGHTS TO DARK FIBRE OPTIC, 5G MOBILE INFRASTRUCTURE, FACILITIES OR EQUIPMENT BUILDINGS (DIGITAL BACKBONE NETWORKS IN THE EU)

Rail administrators could set out the general conditions for service providers to access dark fibre optic as well as 5G mobile infrastructure. The rail administrator can play an important role as a Neutral Host in cities and densely populated areas and boost the introduction of broadband communication networks in rural and less populated areas. In the railway industry it is very common to lease or grant access rights to buildings, passenger station facilities and land areas to the extent that traffic or infrastructure management is not compromised.

Traditionally, and based on general international practice, a wayleave is an agreement between the owner or land user (the grantor) and a third party (the grantee, typically a utility company) permitting the grantee to access privately-owned land to carry out works (for example electricity or telephone service providers) in return for compensation.

There are regulations which require the railway incumbent to be the one who holds the ownership of the land and the railway assets, mainly for safety and security reasons, and to be the one who grants access to third parties (such as telecom providers) offering them the infrastructure in conditions of reliability, availability, maintenance, and safety. The usual practice in this context is to grant access to the service providers if the traffic or the railway management itself is not compromised. This is in line with European regulations which aims to guarantee open access. Although market conditions differ from one country to another, in the context of free competition, the regulations regarding this matter are limited.

Based on the foregoing, dark optic fibre additional-auxiliary service may be embedded in the context of lease agreements or right-of-way/use for its installation and maintenance. Thus, Rail Baltica could, at a Global Project level, set out the general conditions for services providers to access dark fibre optic as well as 5G mobile infrastructure.

1.2 INFORMATION NETWORKS AND DIGITAL INFRASTRUCTURE

The Connecting Europe Facility (CEF) is aiming to promote growth, jobs, inclusiveness and competitiveness through the efficient interconnection of transport, energy and digital networks within and across Member States.

Broadband internet access & continuous connectivity is a powerful socio-economic driver

- Rail Baltica: target motorways, ports, railways to enable innovative services for passengers and goods transport.
- Commercial stakeholders (i.e., telecom companies): contribute to the deployment of 5G infrastructures along cross-border corridors
- General population: ensure the continuity of 5G services across borders and in important industry cases

Important synergies can emerge from the future deployment of information networks and 5G digital infrastructure in Rail Baltica:

- In a greenfield project, such as Rail Baltica, systems can be designed with modern approaches, using more sustainable IT & networking technologies and integrating sensors, industrial approaches such as the “Internet of Things”, “Big Data” and open data in order to help reduce the lifecycle cost of the infrastructure and its operations, as well as strengthen the long-term business case.
- Implementation of existent and new technical features (RAN sharing, network slicing) combined with the 5G network features (high bandwidth, high connection density and low latency) can facilitate the deployment of 5G mobile network access in rural and less populated areas, where main operators and carriers have less incentive for improving connectivity.
- Deployment of 5G mobile networks would improve current communication network features, increases bandwidth and network capacity, and allows for new telecommunication applications.
- Deployment of 5G, Wi-Fi and fixed broadband communication networks at Smart Stations and implementation of new offers and/or services based on them.

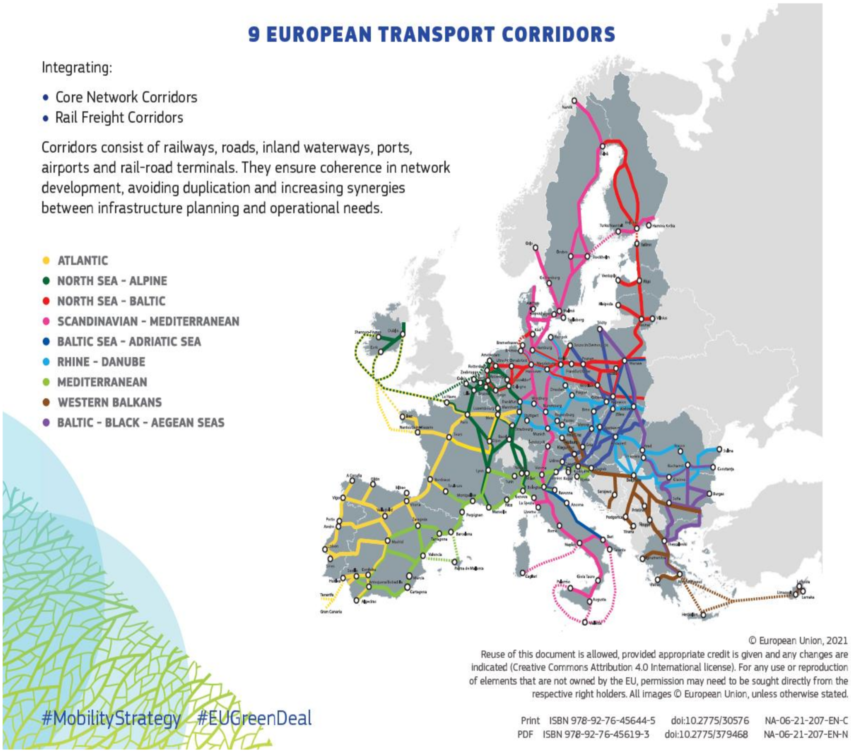
1.3 ENERGY, ESPECIALLY GRID RESILIENCE, STANDBY POWER AND RENEWABLE SOURCES

The European Union (EU) has fixed a net-zero emissions target for 2050. This will have a huge impact in sectors such as road transport and not electrified railway lines, currently heavily dependent on fossil (CO_2 emitting) fuels.

The “Fit for 55[2]” package sets a sustainability roadmap to make the European Union’s (EU) climate, energy, land use, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. In order to make the European Green Deal a reality, the modal shift from carbon-intensive modes to rail is the most efficient way to de-carbonise transport in large parts of the EU territory.

In order to contribute towards making rail transport “Fit for 55”, as well as providing an environmentally friendly alternative to road and air transport in the Baltic States, a key objective of the Rail Baltica project should be to become an environmentally sustainable infrastructure through the efficient use of renewable energy to power its energy subsystems.

Figure 1: Nine (9) European Transport Corridors (Creating a Green and Efficient Trans-European Transport Network 2021)



Source: https://ec.europa.eu/commission/presscorner/detail/en/fs_21_6779

The European Commission has proposed an amendment for the regulation of the European Parliament and Council regarding the deployment of alternative fuels infrastructure, and repealing the Directive 2014/94/EU of the European Parliament and Council COM(2021) 559 final 2021/0223 (COD) concerning the

[2] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EMPTY. 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality

creation of a new regulation for the deployment of alternative fuels infrastructure. This proposal looks for boosting the uptake of zero- and low-emission vehicles, vessels and aeroplanes and of renewable and low-carbon fuels in all modes of transport is a priority objective in the quest to make all transport modes more sustainable. This regulation specifically requires the deployment of charging/fuelling infrastructure in the TEN-T comprehensive and core network.

The proposal states that each Member State shall provide the European Commission with a draft for a state regulation and national policy framework for the development of the alternative fuels market in the transport sector and deployment of the relevant infrastructure by 1 January 2024.

This Member State regulation provision shall define the following targets for BEV and FCEV:

- The targets for hydrogen refuelling infrastructure of road vehicles: by December 2030 publicly accessible hydrogen refuelling stations with a maximum distance of 150 km along the TEN-T core and the TEN-T comprehensive network
- The targets for electric charging infrastructure dedicated to light-duty vehicles: by 31 December 2025 along the TEN-T road core network

The national policy framework shall contain at least the following elements:

(a) an assessment of the current status and future market development in regard to alternative fuels in the transport sector and of the corresponding infrastructure, considering **intermodal access of alternative fuels infrastructure and**, where relevant, **cross-border continuity**

(b) national targets and objectives pursuant for which mandatory national targets are set out in this regulation

(c) national targets and objectives for the **deployment of alternative fuel infrastructure**

(d) necessary policies and measures to ensure that the mandatory targets and objectives are met

(e) measures for promoting the deployment of alternative fuels infrastructure for **captive fleets**, in particular for **electric recharging and hydrogen refuelling stations for public transport services and electric charging stations for car sharing services**

(f) measures to encourage and facilitate the **deployment of charging stations for light-duty and heavy-duty vehicles** in private locations not accessible to the public

(g) measures to promote alternative fuels infrastructure in **urban nodes**, in particular with respect to **publicly accessible recharging points**

(h) measures to promote a **sufficient number of publicly accessible high power charging points**

(i) necessary measures for ensuring that the deployment and operation of charging points, including the **geographical distribution of bidirectional charging points**, contribute to the flexibility of the energy system and to the penetration of renewable electricity into the electric system

(j) necessary measures to ensure that publicly accessible recharging and refuelling points are **accessible to older persons, persons with reduced mobility and with disabilities**, which have to be in line with the accessibility requirements of Annex I and Annex III of Directive 2019/882

(k) necessary measures to **remove possible obstacles in planning, enabling and procuring** of alternative fuels infrastructure

(l) a deployment plan for alternative fuels infrastructure in **airports** other than for electricity supply to stationary aircraft, **in particular for hydrogen and electric charging for aircrafts**

(m) a deployment plan for alternative fuels **infrastructure in maritime ports**, in particular for electricity and hydrogen, for port services as defined in Regulation (EU) 2017/352 of the European Parliament and Council

(n) a deployment plan for alternative fuels infrastructure in maritime ports other than for LNG and shore-side electricity supply for use by sea going vessels, in particular for hydrogen, ammonia and electricity

(o) a deployment plan for alternative fuels in inland waterway transport, in particular for both hydrogen and electricity

(p) a **deployment plan including targets, key milestones and financing needed, for hydrogen or battery electric trains on network segments that will not be electrified**

As a result, Rail Baltica project delivery can promote an enhanced integration of the Baltic States' energy network, including increasing the efficiency and interoperability of electricity transmission through synchronous operation, as well as promoting renewable energy sources and clean fuels.

Many synergic opportunities arise from this matter:

- Installation of renewable energy generation sources
- Utilisation of the energy subsystem, mainly traction substations, to transfer renewable electrical energy to the electrical grid
- Development of a battery electrical vehicle charging network.
- Development of a fuel cell vehicle charging network.

In relation to the joint operation of the Rail Baltica Energy Subsystem and the public electrical network that supplies it, it must be considered that Rail Baltica has opted for the SFC route for electrification, and SFCs (Static Frequency Converters) will be installed in traction substations (TSS), instead of traction transformers. This option will slightly improve the quality of the public electrical network that feeds TSS. It is a slight improvement since the installed power in TSS is much lower than the power of the electrical network.

SFCs improves the quality of the electrical network that supplies them:

- SFCs stabilise the electrical grid voltage level. Consuming or injecting reactive energy to the electrical grid, it is possible to lower or raise the electrical grid voltage, respectively.
- SFCs improve the electrical grid power factor of the electrical grid, which implies an improvement of the system efficiency, since the losses in energy transport are less.
- Supplying a lot of SFC -TSS (TSS with SFCs), more than TR-SS (TSS with traction transformers) makes the electrical grid more meshed and, consequently, more powerful and stable.

Installing SFC in TSS is an additional measure that contributes to improving the quality and stability of the electrical network of the Baltic countries.

Other more far-reaching measures are being developed to make stable and powerful the electrical grid, for example:

- grid reinforcement in Poland and upgrading the transmission infrastructure in Lithuania, Latvia and Estonia - thus supporting the integration of the Baltic States' electricity system with other European networks.
- Baltic Synchronisation Project.

Figure 2: Baltic Synchronisation Project

Source: https://ec.europa.eu/info/news/eu-invests-over-eu-1-billion-clean-energy-infrastructure-support-green-deal-2022-jan-26_en

Finally, smart-grids solutions will be considered in the design of the Energy Subsystem. Energy Subsystem is a system in which it is possible to consume and generate energy and distribute it to the trains in an efficient and safe way. Therefore, this system represents an Electrical Power System (EPS). The railway EPS is interconnected to the public electrical network, another EPS. Both EPSs should work together considering smart-grids solutions to improve the quality of the public electrical network, to reduce the energy consumption, to make easier and more efficient the operation and maintenance of equipment and installations, to extend the useful life of equipment and installations, etc.

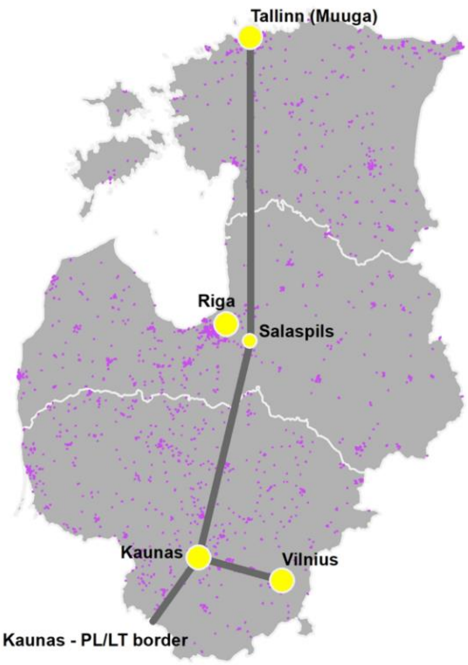
1.4 LOCAL CONNECTIONS FOR INDUSTRIAL DEVELOPMENT

Rail Baltica is designed at standard gauge of 1435mm, which differs from the gauge used for the conventional rail network in the Baltic States (1520 mm). This causes accessibility issues, mainly for freight flows (connections to industrial and logistics areas, rail-road terminals, ports, and military areas). However, many synergistic opportunities arise from this issue:

Construction of railway branches to provide accessibility for relevant private industrial or logistics areas:

- focused on intermodal and bulk freight transport
- connections to ports (Muuga, which is in the mainline, and Riga and possibly other ports not on RB mainline layout such as Paldiski, Pärnu, Ventspils, Liepāja or Klaipeda): integration with short-sea shipping
- EU support for modal shift from road to rail
- possible rolling highways / piggyback transportation services
- future gauge changeover installations for the integration of 1520 mm gauge freight rail flows

Figure 3: Schematic Map of Railway Line Location with Freight Terminals.



Source: RB Global Project Synergies Study (2021) Industrial areas are highlighted in purple (data: CORINE Land Cover, 2018)

Military Mobility:

- adaptation of transport network sections for civilian-military dual-use
- an exceptional oversize freight service according to RB Operational Plan[3]
- requirements for Military Mobility within and beyond the EU adopted by the European Council on 20 November 2018
- CEF support of €1.69 billion for period 2021-2027 following Regulation (EU) 2021/1153

Railway connections to military nodes from/to RB network should be considered a particular case of railway branches to logistic areas, with specific security measures but technically treated in a similar way.

1.5 SUSTAINABILITY, REGIONAL CONNECTIVITY, URBAN DEVELOPMENT AND LONG-TERM VALUE CREATION

It is widely recognised that high-speed railway systems support sustainable development: measures such as the reduction of energy consumption through electrification, the introduction of advanced technologies, the shift to predictive maintenance, and the inherent safety and reliability of high-speed rail systems all contribute to reaching sustainable development goals.

Furthermore, there are positive effects for **regional and urban development** such as an improvement of quality of life, as well as economic growth, measurable by comparing the data before and after the deployment of high-speed systems (e.g., changes in land use, changes of a city´s or region's image in terms of values such as modernity or innovation, the development of new economic structures stimulated by the HSR link).

Concerning long term value creation, the development of a collaborative innovation platform with small and medium enterprises (SMEs), start-ups, universities, and industrial partners, etc., should be explored, to create an innovative ecosystem of suppliers that could help develop some of the innovative synergic opportunities. Especially, since the Horizon Europe funding programme fully supports the acceleration of innovative SMEs (70% of the budget earmarked for SMEs).

[3] https://www.railbaltica.org/wp-content/uploads/2019/05/RB_Operational_Plan_Final_Study_Report_final.pdf

2 WAYLEAVES

2.1 CASE STUDY W.1: NEW SERVICES/OFFERINGS: LEASE AGREEMENTS TO ACCESS HIGH-SPEED RAIL DARK FIBRE OPTIC NETWORK (ADIF)

CASE STUDY W.1: NEW SERVICES/OFFERINGS: WAYLEAVE OF HIGH-SPEED RAIL DARK FIBRE OPTIC NETWORK
Summary
• **General information:** Spanish railway dark fibre optic business model where ADIF rents out space or facilitates the use of certain optical fibre as the owner of the infrastructure and not allowing, for instance, third parties to lay cable in its ducts. • **Location:** Spain • **Keywords:** dark fibre optic, lease, lease agreement, right-of-way/use for its installation and maintenance
Scope
The rail administrator can define the general conditions for services providers to access dark fibre optic as well as 5G mobile infrastructure and can play an important role as a Neutral Host in cities and densely populated areas. This is the current Spanish business model in which ADIF rents out spaces or facilitates the use of optical fibre as the infrastructure owner, but not allowing, for instance, third parties to lay cable in its ducts. On April 7th, 2014 several telecommunication companies submitted their offers for a tender carried out by ADIF regarding for the assignment and commercial exploitation of its fibre optic grid. None of these companies were engaged in providing rail services. ADIF's telecommunications business on the grid had an estimated annual income of around 72.4mn Euros; and an estimated annual EBITDA of 49.5m Euros. On 8 April, ADIF confirmed that, after the analysis of the presented offers, the elected duration for the infrastructure cession would be of 20 years, this period being the one that Red Eléctrica Internacional (the transmission and system operator in Spain) communicated in its offer; and beginning the auction process between the bidders: Neo Sky and REE. ADIF and Red Eléctrica Internacional collaborated in order to obtain ADIF's clients´ acceptance to the subrogation of the existing contracts to Red Eléctrica Internacional for a maximum period of 20 years. Before the process ADIF had commercialised excess capacity on its railway fibre optic network for use by telecommunications companies. As of 2014, ADIF was Spain's largest provider of dark fibre optic. It managed 25% of Spain's commercialised dark fibre optic network (17,868 km), consisting of 11,793 km along the long-haul trunk railway lines, 3,036 km along urban metro networks and 3,039 km along the high-speed railway network. Around 600 km correspond to the main national metropolitan areas of the country (Madrid and Barcelona metropolitan areas) and another 1,200 km to dedicated cable and access to clients), as well as more than 6,000 m2 of conditioned spaces for communications equipment located in premises, buildings and booths located in strategic locations. Optical fibre currently in use by the railway system (which represents about 25% of the capacity of the total outsourced network cable), have been explicitly excluded from the tender. Furthermore, the parties signed a maintenance contract under which Red Eléctrica Internacional would pay ADIF an additional 11,446,600 Euros per year, including VAT (9.5 million euros per year excluding VAT) "annually reviewable for a period of 20 years", the entire duration of the contract

CASE STUDY W.1: NEW SERVICES/OFFERINGS: WAYLEAVE OF HIGH-SPEED RAIL DARK FIBRE OPTIC NETWORK

Figure 4: ADIF and Red Eléctrica Fibre Network

Figure beside shows:

- *Adif's network in green*
- *REE's network in black.*

Source: Red Eléctrica 2016

Involved stakeholders

- Rail Administrators: the railway infrastructure administrator, ADIF, is a state-owned entity under the Ministry of Transport. It is the owner and manager of 15,130 km of railway lines and owns all corresponding wayleaves.
- Awarded public-private-partnership company: Red Eléctrica Internacional, REE, is a partly state-owned and public limited Spanish corporation that was founded by the government in 1985 for operating the Spanish electricity transmission system. REE started to deploy fibre optic cables along electricity transmission lines in 1989 and commercialised excess fibre optic capacity after the liberalisation of the telecommunications sector in 1998.
- Communication network operator: Red Eléctrica Infraestructuras de Telecomunicación ("Reintel"). In order to manage, commercialise and lease the dark fibre optic network, REE created the Red Eléctrica Infraestructuras de Telecomunicación (Reintel) subsidiary in 2015.
- Spanish anti-trust authorities (Comisión Nacional de los Mercados y la Competencia (CNMC)): The agreement ratified the awarding ADIF's fibre optic tender to Red Eléctrica Internacional, approved by the board of ADIF on April 25, and has the authorisation of the boards of Red Eléctrica and the Spanish anti-trust authorities.

Critical Discussion

Takeaways: *What has been done correctly in the specific case study?*

ADIF was Spain's largest provider of dark fibre optic. It managed 25% of Spain's commercialised dark fibre optic network. Because of the expansion of residential broadband and mobile data in metropolitan areas, ADIF has invested in the expansion of its network along the metropolitan railway rings of Madrid and Barcelona, as well as Bilbao, Seville and Valencia. In addition, ADIF owns 6,600 square meters of co-location facilities equipped for communication equipment located in a total of 158 points and 430 telecommunications towers.

With the new concession to manage ADIF's network, Reintel doubled its managed network to 32,000 km.169 Apart from taking over operations, REE also gained ADIF's costumers, which include Al-Pi, British Telecom, Cableuropa, Cogent, Colt, Islalink, Jazztel, Orange, Telefónica, Vodafone and VSNL.

CASE STUDY W.1: NEW SERVICES/OFFERINGS: WAYLEAVE OF HIGH-SPEED RAIL DARK FIBRE OPTIC NETWORK

Fail to benefit: *Which (if any) opportunities were missed and why?*

Prior to the concession agreement with REE, ADIF's fibre optic network commercialisation division was its most profitable entity. It is estimated to have contributed to annual earnings before interest, taxes, depreciation and amortisation of €49.5 million.

According to ADIF, the concession agreement with REE was part of a broader restructuring process to factor out non-core railway network activities. Additional funds were also needed to finance in the expansion of its high-speed railway network (ADIF's debt is expected to be above €17.3 billion at the end of 2015). From ADIF's point of view the servicing agreement brings economic advantages for both parties given that ADIF needs to service its fibre optic network related to the railway operations anyway (which was not outsourced). The significant economies of scale led to this servicing agreement.

Nevertheless, if this operation would have been carried out nowadays, it would probably have been structured in a different way. Instead of resorting to a 100% transfer of assets through a public-private-partnership concession contract, an agreement or an alliance could have been chosen to make a joint offer to the market while maintaining the freedom to expand investments or even to reorient commercial policy with ADIF's long-term strategies in mind.

However, in the light of the revaluation of the fibre optic business in 2019, ADIF contacted Red Eléctrica in order to renegotiate the agreement. Also, because the 5G mobile technology depends on a fixed network to operate, with many more sites (especially antennas and microcells), all of them connected by fibre. ADIF's intentions of renegotiation caused tension between the two parties, especially due to the non-competition clause signed by both parties, as ADIF reserved 25% of the fibre optic capacity for self-consumption and the agreement with REE prevented it from selling it to third parties.

Challenges: *What could be done differently given new technologies or other changes?*

ADIF is currently designing a new business model intending to manage its share of fibre optics. The intention is to take part in the promotion of 5G technology, like Reintel, and participate in the digitalisation of urban and rural areas.

Recently, the parties reached an agreement in December 2020 whereby the non-competition clause was dissolved, but the prices agreed in 2014 were maintained. This pact is key for Reintel´s business and for a possible collaboration with partners in the market.

ADIF will mainly operate the lines and sections commissioned since 2014, the optical fibre that is currently used by the railway system (which represents approximately 25% of the 16,000 km outsourced fibre cable) that was expressly excluded from the tender, and the more than 500 km of fibre optic deployed between 2014 to 2021 in its HSR infra.

Reintel on its behalf, maintains the rights to use and manage the fibre optic network (16,000 km of fibre) in accordance with the contract signed by both entities six years ago. There are still 14 years of management of the transferred assets remaining.

ADIF is designing a new strategy to determine how to exploit its assets in the field of telecommunications, for which it will resume talks with telecommunications operators and other market players in order to analyse their needs and possible commercial agreements.

In addition, in contracts of such a long duration, there is a risk of renegotiation of the contract. As evidenced in this case.

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3 DIGITAL INFRASTRUCTURE

3.1 CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY CORRIDOR

CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY

Summary

- **General information:** 5G. FRMCS. Deployment of 5G mobile network providing advanced high- bandwidth services
- **Location:** Haifa – Nazareth Light rail Train Project (Israel)
- **Keywords :** 5G, FRMCS, ETCS, ERTMS, Mobile Network, Gigabit Train

Scope

Introduction

Future rail will rely on high-capacity broadband communication networks providing reliable critical mobile broadband connectivity for faster, safer and greener travel.

5G is the latest generation of mobile networks and provides faster broadband speeds and lower latencies than previous ones, while also featuring higher capacity.

With a data rate of up to 10 Gbps and peaks of up to 20 Gbps, 5G increases speed and bandwidth 10 to 100 times compared to the previous 4G LTE technology.

Low latencies, as low as 1 millisecond, can be achieved with 5G technology, allowing the provision of services requiring minimal delays through the mobile network. Low latencies help applications run faster and significantly improve the user experience.

5G provides higher capacity and allows for up to 100 times more connected devices in the same physical area than 4G LTE technology, increasing the connection density.

5G technology can use spectrum across low (e.g., <1 GHz), mid (2.1-2.6 GHz, 3.3-4.2 GHz) or high (e.g., 26 GHz and 40 GHz) spectrum bands to provide a better coverage and support a wide range of use cases. All three ranges are relevant and needed for different services.

5G in the railway industry and FRMCS

CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY

The introduction of 5G in the railway will lead to a major transformation in railway communication networks, allowing for highly automated trains and rail operation and the implementation of new advanced use cases which weren´t possible with previous mobile generations.

With the increased need for more throughput, higher capacity and low latencies at railways, the UIC, in close collaboration with 3GPP and ETSI, has carried out a specification process to define a next-generation mobile communication system to replace the current GSM-R system deployed on railways. The new railway mobile communication system is called *Future Railway Mobile Communication System* (FRMCS).

FRCMS is the future worldwide telecommunication system designed as the successor of GSM-R but also as a key enabler for rail transport digitalization.

FRMCS will support the provision of basic operational communication services, already provided in the previous railway system (GSM-R), as well as new advanced services, requiring next-generation capabilities and features, that will transform and digitalise the railway transport.

The current mobile communication system adopted by the European Union Agency for Railways (ERA) is the GSM-R standard. The GSM-R mobile communication system is 2G technology and a fundamental part of the European Rail Traffic Management System (ERTMS), and supplier´s support has been announced to be withdrawn by the end of 2030.

ERTMS is a single European signalling and speed control system that ensures interoperability of the national railway systems, reducing the purchasing and maintenance costs of signalling systems, as well as increasing the speed of trains, the capacity of railway infrastructure and the level of safety in rail transport.

Currently, ERTMS comprises of the European Train Control System (ETCS), i.e., a cab-signalling system that incorporates automatic train protection, the Global System for Mobile communications for Railways (GSM-R) and operating rules.

As the successor of GSM-R in the European Rail Traffic Management System, FRMCS shall fulfil voice and data communication needs for ERTMS, being one of the main components of ERTMS in the future.

FRMCS specification is functional and does not define the radio access technology. However, the International Union of Railways (UIC) and the European Union Agency for Railways (ERA) show a clear preference towards 5G, being FRMCS implementation based on 5G, fully capable of support the critical communication needs of rail operators.

FRCMS Mobile Networks can be applied for providing the next services at rail:

- Critical communication services: Signalling and safety-critical applications (ETCS) and operational voice communications, fulfilling ERTMS needs.
- Performance communication services and other operation-related applications.
- Business communication services and applications: Advanced voice, data and video services; connectivity for customer services.

For the provision of critical railway communication services (ETCS and operational voice) and the fulfilment of ERTMS needs, ensuring interoperability of the national railway systems at European level, FRMCS networks need to be deployed at low spectrum bands, the same low spectrum bands that are currently used by the GSM-R system.

So, in order to implement ERTMS along the Rail Baltica corridor, enabling interoperability and supporting safe and technical compatibility of trains and infrastructure, it will only be necessary to roll out a FRMCS network supporting the low spectrum bands.

CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY

This FRMCS network will be enough for ensuring interoperability at the rail line, through the complete fulfilment of the Technical Specifications for Interoperability (TSI). The roll out of a FRMCS network supporting ERTMS (ETCS and operational voice communication) should be included in the Rail Baltica design guidelines.

Using the same spectrum bands as GSM-R and with equals radio coverage ranges, the distances between sites for deploying a FRMCS network at low spectrum bands are similar to distances required for providing the same coverage with a GSM-R network. The deployment of a low-spectrum band FRMCS network will require next generation nodes B (gNB) to be separated by the same distances as BTS nodes within a railway GSM-R network (from 7 to 15 kms depending on the surrounding land topography).

Nevertheless, a FRMCS network implemented at low spectrum band will not allow the provision of advanced services requiring high bandwidth. Implementation of some of the advanced 5G services included in performance and business applications, as video on-demand, will require rolling out a 5G network offering radio coverage at mid and high spectrum bands.

5G will not be able to deliver the fastest data speed without these mid and high band frequencies. However, mid and high frequency radio waves have a shorter useful physical range, requiring smaller geographic cells than a network based on low frequencies.

It implies smaller distances between 5G NR (New Radio) nodes, which makes it necessary to deploy a larger number of nodes and, therefore, significantly increases the costs for the deployment of a high bandwidth 5G network at the higher frequencies.

In order to provide a railway line with full coverage using 5G NR nodes radiating at high spectrum bands, and consequently being able to support advanced high-bandwidth services, radio sites need to be rolled out at distances between them even smaller than 1km, depending on the surrounding conditions.

High-performance 5G network in railway

Since the roll-out of a low-spectrum band FRMCS network along the railway line should be able to guarantee the critical communication services required for fulfilling ERTMS needs, in order to support other advanced and demanding services, an additional 5G network, supporting mid-band and high-band frequencies, should be rolled out along the railway.

Therefore, in addition to the deployment of a basic FRMCS (5G) network only needed for the provision of the critical signalling (ETCS) and operational voice communications, a correctly dimensioned 5G mobile network for offering present and future advanced services should be deployed.

Deployment of a 5G network providing advanced high bandwidth services is very expensive. Nevertheless, railway operators will be expected to deploy these networks in the mid-term in order to support Gigabit Train services in order to guarantee future service quality.

CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY

Table 2: Best Practice Example: Haifa Nazareth LRT Project. Mobile Communication Network

Haifa Nazareth LRT Project. Mobile Communication Network

Abstract:

Location:	Israel
Client:	TransIsrael
Project:	Haifa – Nazareth Light Rail Train Project
Objective:	Deployment of a mobile communication network

Haifa-Nazareth Light Rail Transit Description:

The company TransIsrael is responsible for the light rail project between Haifa and Nazareth - a national mega-project that will serve the northern population and connect communities across the Galilee and Haifa metropolitan area.

This unique project, being a first of its kind in Israel, combines urban and inter-urban public transportation. The light rail route will be a total length of 41 km and include 20 stations, connecting Haifa to Nazareth.

Use Case Description:

The mobile communication system for Haifa–Nazareth LRT Project consists of an LTE Advanced Pro network compliant to 3GPP Release 15 (supporting NSA-5G) including voice, data, video and MCPTT functionality.

This technology is a wireless broadband communications system optimised for packet services providing high throughput and low latency.

LTE Advanced Pro is 3GPP-standardised, supporting the whole standardised range of frequency-band from low bands (700-900 MHz) to mid bands (1.8- 2.1 - 2.6 GHz).

References:

https://www.transisrael.co.il/ContentPage?id=97

Involved stakeholders

Railway administrator

Mobile network operators (MNOs)

Critical Discussion

Takeaways: *What did the case study get right?*

- 5G is key for rail digitalisation, enabling the provision of new high-value services
- the 5G mobile network providing advanced services allows to manage the transmission of voice, data and video for the following on-board and on-track data services:

CASE STUDY D.1 DEPLOYMENT OF 5G MOBILE NETWORK IN RAILWAY
◦ performance communication services and other operation-related applications. On-board video surveillance system (real time video on-board). ◦ Business communication services and applications: advanced voice, data and video services. Connectivity for customer services. • 5G network providing advanced high bandwidth services allows to implement advanced services from the beginning • Cost-savings in the mid and long term can be achieved dimensioning the network for offering advanced services
Fail to benefit: *Which (if any) opportunities were missed and why?*
No high spectrum bands to meet possible future requirements have been deployed. An update might be necessary in the future.
Challenges: *What could be done differently given new technologies or other changes?*
Future 5G releases will incorporate additional functionalities that will have to be implemented through a previous network update.
References
https://uic.org/rail-system/frmcs/ https://www.transisrael.co.il/ContentPage?id=97

3.2 CASE STUDY D.2: DEPLOYMENT OF 5G MULTI-ACCESS CORE PLATFORM. MAXIMISING EFFICIENCY IN 5G ROLLOUT

CASE STUDY D.2 Deployment of 5G Multi-Access Core Platform – Maximising Efficiency in 5G Rollout
Summary
• **General information:** Mobile network final solution combines a GSM-R and a FRMCS network, integrating the different mobile generations (2G to 5G) • **Location:** Transport for New South Wales (TfNSW), Australia • **Keywords:** 5G mobile network, PS Core Network, ETCS Level 2
Scope
Independently of the mobile Network solution adopted at a railway infrastructure (e.g., GSM-R Network, FRMCS, FRMCS over 5G Network) it´s appropriate to install an integrated Core solution integrating the different Mobile generations (2G to 5G). A multi-access core platform, allowing the connection of different radio mobile access technologies, will provide flexibility in network deployment and will enable the integration of other access technologies. Main mobile telecommunication vendors include in their portfolios multi-access core platform products suitable for integrating access nodes from different mobile technologies. Multi-access core platforms can support different access technologies such as 5G, LTE, GSM/GPRS, UMTS, unlicensed wireless, Wi-Fi or fixed access, providing flexibility to the network, and supporting an easy integration with other access technologies.

Table 3: **Mobile Radio System at Transport for New South Wales TfNSW Case Study Example**

<u>**Mobile Radio System at Transport for New South Wales TfNSW Case Study Example**</u>

Abstract:

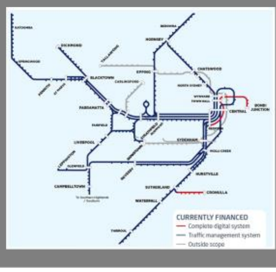
Location:	Australia
Client:	Network RailConsulting PTY. LTD. / Transport for New South Wales (TFNSW)
Project:	Integration of new railway systems for Sydney Trains
Objective:	Modernisation of Sydney's commuter rail network

Project description:

Ineco is participating in the modernisation of the commuter rail network of Sydney, operated by Sydney Trains.

The objective is to improve the signalling of the city's 815 km commuter rail network. Acting as the Systems Integrator, Ineco will be responsible for supporting the Transport for New South Wales (TfNSW) authority to define, integrate and implement the new railway systems for the network, along with Network Rail Consulting, Acmena and The Go-Ahead Group. This role is critical to enable the network to increase its capacity significantly and allow to absorb future demand.

Part of the project target is to provide a mobile data radio communications bearer for ETCS L2 and ATO communications, required for operating trains on the network. New designs establish how current GSM network will be upgraded to support ETCS.



Use Case Description:

Currently, the rail lines have a GSM solution with RAN connected to a GSM-R Core. A new packet core will be integrated into existing GSM-R core and the new GSM-R packet core solution will service ETCS.

The new solution implements ETCS over GPRS instead of over circuit Core Network (MSCs). ETCS can be implemented using Circuit Switched Data (CSD) to carry ETCS Level 2 data or packet data (PSD, i.e., GPRS/E-GPRS) as part of GSM-R.

Furthermore, the new design solution implements a new core packet for providing the mobile data radio communications bearer for ETCS, while the GSM Circuit Core is kept for operational voice services.

In order to be ready for a future evolution of the mobile network to a 5G network, the new core consists of a core platform integrating the different mobile generations

PS Core is a platform including functionalities of the nodes of the different technologies, including 2G PS Core, 4G PS Core and 5G PS Core which is compliant to 3GPP release 15. The global PS CORE platform is suitable for current 2G RAN and future evolution to a 5G RAN.

References:

https://www.ineco.com/webineco/en/content/list-key-project/integration-new-railway-systems-sydney-trains

CASE STUDY D.2 Deployment of 5G Multi-Access Core Platform – Maximising Efficiency in 5G Rollout
Involved stakeholders
Railway administrators, operators network providers.
Critical Discussion
Takeaways: *What did the case study get right?*
• The implementation of an integrated core solution may provide a stepping stone towards the migration to a 5G network. • Interoperability with the 5G industry ecosystem: GSM-R end-of-life is forecasted for 2030. Mobile railway communications will migrate from GSM-R to FRMCS 5G in next years. • Migration to all-IP network, allowing new IP services to be implemented in advance. • Multi-access core platform: main mobile network equipment vendors offer multi-access core platforms that support 5G, as well as previous generations for optimized footprint and TCO efficiency. Inversion net-cost reduction can be achieved installing a multi-access core platform suitable for the future evolution to 5G.
Fail to benefit: *Which (if any) opportunities were missed and why?*
Radio Access network is still a GSM solution, whereas the Core Network will be able to support newer mobile technologies.
Challenges: *What could be done differently given new technologies or other changes?*
With the emergence of FRMCS technology, the deployment of a 5G radio access network solution would have been possible. Current implementation necessitates a next swap for upgrading the technology of the RAN system.
References
https://www.ineco.com/webineco/en/content/list-key-project/integration-new-railway-systems-sydney-trains

3.3 CASE STUDY D.3: DEPLOYMENT OF 5G SHARED MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOS AND NON-RAIL ENTITIES.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

Summary

- **General information:** Deployment of shared mobile networks. Network sharing options. 5G use cases in non-telecom entities.
- **Location:** European countries
- **Keywords:** 5G, RAN Sharing, Neutral Host, CCAM, Industry 4.0, Smart City, Open RAN, Network Slicing

Scope

Introduction

The roll-out of 5G networks implies an important investment for all stakeholders interested in its deployment. 5G demands high investment in the radio access network and transmission network due to the following:

- 5G requires a much denser network of cell sites compare to previous mobile generations. The new radio access network densification will require 1.5-2 times more sites for mid-spectrum bands, and up to 10 times more small cell sites for high-spectrum bands, than current macro cells with LTE technology.
- Spectrum costs in new bands: 5G operators must make big investments for licensing spectrum bands in spectrum auctions.
- Very large requirement for transmission resources, requiring the roll out of optical fibre backhaul to most sites for transport capacity of n x 10 Gbps per site.

At the same time, 5G mobile coverage will improve as more antennas are deployed, so, country-wide digitalisation will require a widespread deployment of antennas in large areas and huge investments in order to take full advantage of the 5G transformational capabilities.

Usually, three to four Mobile Network Operators (MNOs) operate in each country, each of them needing to implement a 5G network covering the largest part of the country and therefore requiring costly investment. It is costly and inefficient for each 5G MNO deploying its own network.

These investments are in areas with existing network overbuild, where typically three to four MNOs already have overlapping networks, which creates a strong potential for optimisation of future infrastructure deployment with network sharing.

In that context, more efficiency and competitiveness, together with great cost-savings, can be achieved through the deployment of a shared infrastructure for all the operators. Given the significant costs involved, network sharing agreements are becoming increasingly important.

On the one hand, network sharing can help reduce costs, not only in cities and urban areas, where 5G cell density will need to be very high, but also in rural and less populated areas where main operators and carriers have less incentive for improving connectivity in rural and less populated areas: mobile operators´ deployment of 5G network can be insufficient in market-failure areas, where MNO have less incentives to invest.

On the other hand, the mobile operators' deployment of 5G network can be insufficient in market-failure areas, where MNO have less incentives to invest. In these areas, network sharing can help to lighten the roll out costs.

In conclusion, given the significant costs involved, network sharing agreements may be increasingly important, helping to reduce the 5G deployment costs and promoting a rapid expansion of 5G networks, which is necessary for digitalisation of society.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

Deployment of Shared 5G Mobile Network. Network Sharing Between Rail Administrator, MNOs and Non-Rail Entities

The Rail Baltica railway corridor will require the deployment of a 5G network supporting advanced services and not only deployed at low-band frequencies, and with complete 5G coverage along all the railway line, the same as MNOs do. Therefore, new business models for the deployment of 5G networks should be explored.

The network sharing agreements do not have to be restricted to agreements with MNOs, as other non-telecom entities are also interested in the deployment and operation of a 5G network. 5G has led to new use cases involving other entities and requiring a meshed 5G network in specific geographical areas.

Entities with infrastructure and assets distributed over large geographical areas (e.g., public transport, private companies, research and innovation entities) could benefit from managing their own 5G networks, providing advanced communication services to their main commercial and non-commercial activities.

Different business models are possible: Collaboration at cost sharing and deployment capacities

Furthermore, regulators in the different countries are easing regulatory requirements for network sharing, for promoting quick, cost-effective, and efficient deployment of 5G networks. The deployment of 5G networks is part of the European Commission's digital strategy, whose objective is to ensure uninterrupted 5G coverage in urban areas and along main transport paths by 2025.

Examples of other non-telecom entities employing 5G mobile networks:

- **Use Case 1. 5G Network Supporting Cooperative, Connected and Automated Mobility (CCAM)**

Cooperative, Connected and Automated Mobility (CCAM) is one of the trends in the automotive industry. The initiative is designed to support the European countries and automotive industry in their transition to connected and automated driving, while ensuring the best mobility environment for the public.

The communication interfaces for the CCAM implementation between different actors (e.g., vehicles, infrastructure, road) must be defined.

Vehicle-to-everything (V2X) is communication between a vehicle and any entity that may affect, or may be affected by, the vehicle. It is a vehicular communication system that incorporates specific types of communication such as V2I (vehicle-to-infrastructure), V2N (vehicle-to-network), V2V (vehicle-to-vehicle), V2P (vehicle-to-pedestrian), V2D (vehicle-to-device) and V2G (vehicle-to-grid). Vehicle-to-everything (V2X) can be based on 5G technology.

Recent V2X communication uses mobile networks (cellular V2X) and 3GPP has included C-V2X standardisation based on 5G since release 15.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

In order to be able to implement a CCAM system relying on 5G networks, a 100% complete and densified 5G mobile coverage of roads must be accomplished. Deployment of 5G networks along roads and especially, along transport corridors and higher-speed roads, are a key factor.

In conclusion, it can be stated that deployment of a totally meshed 5G network is very expensive, so new business models need to be implemented in order to reduce costs.

- **Use Case 2. 5G Network Supporting Industrial Players (Smart Factories and Industry 4.0)**

It is becoming more popular among companies to install and manage their own private and local 5G networks, and regulators at different countries are reserving specific frequency spectrums for industrial applications. For instance, in Germany, the federal government has reserved 100 MHz bandwidth (from 3.7 to 3.8 GHz) for local use, for example for industrial companies.

This process will play an important role in companies requiring 5G for implementing the Internet of Things (IoT) and other new digital applications supporting the "Smart Factory".

Apart of the 5G features of bandwidth and low latency, reliability, scalability and device connection density are crucial for the industrial sector in order to interconnect the enormous volumes of IoT-connected sensors and devices required by the Smart Factory.

Industry 4.0 includes advanced technologies such as collaborative mobile robots, self-driving machines, remotely guided vehicles, augmented reality (AR) for service and predictive maintenance, where private 5G networks offering to build the factory without wires or cables are crucial. Local 5G networks also allow to keep sensitive data locally which increases security.

3GPP release-16 specifications support key enablers for industrial IoT in 5G system, and release-17 aims to define further enhanced support for industrial IoT.

Enterprises need to acquire a spectrum from the regulator or other third-party spectrum providers, install 5G equipment (base stations, small cells, mini towers, core equipment) and connect this equipment to edge devices (embedded modules, routers, gateways, etc), in order to deploy of a private and local 5G network, making it an expensive investment.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

- **Use Case 3. 5G Network Supporting Local Campus or Smart Cities**

Private 5G networks can also be deployed by forming local campus networks, providing 5G to manufacturing and logistics areas, technology parks, university campuses, ports, mining, construction sites, commercial areas or others.

One of the main motivations to build private local mobile networks is to meet the quality, security, reliability and cost requirements of the given industry (e.g., manufacturing, mining, venues, logistics, travel).

These private local networks allow the provision of 5G specific applications and services required by the local businesses (companies, venues, commercial shops, etc.). Additional edge cloud network infrastructure can be deployed at the local area, in order to avoid data being routed out of the campus network. The businesses can then benefit from extremely low latency and a high level of IT security.

5G networks can also be deployed locally in order to encourage the implementation of advanced 5G based services in cities or towns, as a means to form part of the smart city ecosystem.

5G based communication can be used to connect everyone to everything, e.g., interconnected infrastructures including vehicles, public transport, traffic lights and others. 5G also provides advanced services for shopping centres, schools, office complexes, etc.

Deployment of local campus networks can be carried out with licensed spectrum, specifically allocated for this kind of networks, or with unlicensed spectrum, the assigned spectrum restricted for use only in the local area. Both technologies require a costly investment.

Network Sharing Options

A 5G network shared can be implemented in different ways.

Network sharing allows to reduce each MNO costs deploying their own infrastructure at every location and helps to ensure any "notspots" can be covered by shared resources.

There are different options for sharing resources between network operators:

1) **Sharing passive infrastructure** (e.g., site and tower sharing): the simplest way of optimising the available resources. It can include sharing of energy supply.

2) **Active Sharing**:

- MORAN (Multi-Operator Access Network). Everything in the RAN (antenna, tower, site, power) except the radio carriers is shared.
- MOCN (Multi-Operator Core Network). Everything in the RAN, including the carriers, is shared.

Other options for reducing deployment costs include the provision of roaming services:

Customers from one mobile operator can connect to another operator network (visited network) when moving outside the geographical coverage area of the home network. Usually, international roaming is implemented but national roaming is possible.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

New technologies open new options in terms of sharing active radio mobile resources and new Radio Access Network (RAN) architecture allows different way of sharing resources. 5G standards have introduced new ways of sharing network resources, such as Network Slicing and OpenRAN:

- **Network slicing:**

  5G network slicing is a virtual network architecture that enables the multiplexing of virtualised and independent logical networks on the same physical network infrastructure. Each network slice is a logically separated and independent end-to-end network with different requirements.

  In this context, network slicing plays and important role in 5G mobile networks designed to combine different application and use cases requiring very different service level agreements (SLA). Network slices are implemented on top of a common network infrastructure and can offer fitted solutions to specific industries.

  From a business model perspective, each network slice is administrated by a Mobile Virtual Network Operator (MVNO). The physical network infrastructure provider (the owner of the telecommunication infrastructure) leases its physical resources to the MVNOs that share the underlying physical network.

  Network slicing allows to create specific virtual networks that fit to specific clients and use cases. Depending on the use case or application, different 5G features (such as bandwidth, latency and reliability) can be required, and each separated slice shall meet these requirements.

  In addition, each of the network slices needs to be kept isolated and independent from other slices, avoiding any impact between slice's performance.

- **OpenRAN:**

  Open Radio Access Networks, or OpenRAN, is an initiative to define and build RAN architectures based on general-purpose vendor-neutral hardware, open interfaces and software. The OpenRAN specification is being defined by the O-RAN Alliance and the Telecom Infra Project (TIP).

  3GPP has defined a new architectural model in Release 15, where the gNB is logically split into three entities: CU (Centralised Unit), DU (Distributed Unit) and RRU (Remote Radio Unit).

  Additionally, the O-RAN Alliance has added a network disaggregation approach between hardware and software, specifying open and interoperable protocols and interfaces between the hardware and software modules for allowing RAN node multivendor scenarios. Open RAN can be implemented with vendor-neutral hardware and software-defined technology based on open interfaces, increasing flexibility over traditional RAN systems.

  Network disaggregation in an Open RAN approach could allow different MNOs to install different software modules in a common hardware platform (using COTS servers). The hardware/software of each MNO can be transformed into virtualized hardware/software running in a COTS server. Each MNO can also have a different radio unit connected to the common resources.

  Open RAN solutions introduce new options for resource sharing in which one network operator would own a common hardware infrastructure (CU and DU implemented in COTS servers) and would host other customers virtualized hardware/software on its platform.

  SLAs would establish key performance indicators (KPIs) between network operator and their customers.

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

Neutral Host

Neutral Host is an alternative business model that has emerged in the telecom industry during recent years and allows the deployment of a shared network in a cost-effective way. Neutral Host model provides flexibility in network deployment as it is not dependent on each operator's rollout plan.

In the Neutral Host model, instead of the individual network infrastructure deployment and management by each Mobile Network Operator (MNO), a neutral third party rolls out a "neutral" shared network infrastructure and offers private and public communication services to all the MNOs.

The Neutral Host acts as a neutral operator, managing the active/passive mobile network infrastructure and providing mobile network services to operators and third-parties demanding coverage and capacity in complex environments. The Neutral Host model addresses network densification and improves cost-efficiency.

The Neutral Host model combines two concepts: 'hosting' and 'neutrality' and, depending on the level of involvement of the Neutral Host in operating the network, there exist different Neutral Host models: exclusively passive model, passive and active model, neutral (wholesale) operator model.

It is important to highlight that the Neutral Host model in radio access networks has been leveraged with 5G features, such as disaggregated architectures and network slicing, allowing multiple virtualised logical networks on the same physical network infrastructure.

Table 4: Best Practice Example: 5GMED: Sustainable 5G Deployment Model for Future Mobility Along the Figueres–Perpignan Mediterranean Cross-Border Corridor

5GMED: Figueres–Perpignan Mediterranean Cross-Border Corridor Example

Abstract:

5GMed will demonstrate advanced Cooperative Connected and Automated Mobility (CCAM) and Future Railway Mobile Communications System services (FRMCS) along the "Figueres – Perpignan" cross-border corridor between Spain and France.

Enabled by a multi-stakeholder computer and network infrastructure deployed by MNOs, Neutral Hosts, as well as road and rail operators, based on 5G and offering support for AI functions.

Cross-Border corridor description:

- Border between Spain and France: 65 km between Perpignan and Figueras
- Value proposition: high-speed rail track + highway run very close to each other = deploy a single multi-stakeholder infrastructure
- Two different scenarios:
  - Spain: Single 5G MNO + Sidelink
  - France: 5G IaaS model for MNO & PaaS for other stakeholders

Topics:

- Cross-operator service orchestration
- Innovations in multi-connectivity supporting high-speed vehicles and trains
- Self-sustainable 5G access network infrastructure that can be deployed when power and backhauling resources are scarce
- Enhancements to speed up roaming transitions across MNOs and Neutral Hosts
- Novel high-speed access network architectures for railways
- The ability to support AI enabled functions executing at the edge of the network

4 different Use Cases will be implemented during the project:

- Use Case 1: Remote Driving
- Use Case 2: Road infrastructure Digitalisation for Intelligent Management of the Connected and Automated Vehicles Mobility
- Use Case 3: FRMCS Applications and Business Service Continuity
- Use Case 4: Follow-ME Infotainment

References:

https://5g-ppp.eu/5gmed/

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

Table 5: **Best Practice Example: Cellnex On Tower France Acting as a Neutral Host**

Cellnex On Tower France Acting as a Neutral Host

Abstract:

On Tower France was created in December 2019.

On Tower France currently manages more than 5,700 sites throughout France and has launched a programme to roll out 2,500 new sites by 2023.

Cellnex Telecom, with a portfolio of approx. 128,000 sites in Europe, facilitate the mass rollout of mobile broadband services.

On Tower France owns the infrastructures and is one of the key players in the sector.

Co-Location services Description:

- On Tower France offers co-location services, installing its own infrastructure and allowing for mobile carriers to install their telecommunications and wireless radio broadcast equipment.
- The infrastructure, located strategically to offer maximum coverage, is designed to adapt to different technological needs (broadband, point-to-point connections, or mobile communications), in both urban and rural settings.
- The co-location service comprises the provision of access to a power supply, security, and conditioning of the infrastructure for the installation of client equipment, and operation and maintenance services.

Clients:

Cellnex Telecom's hosting service is a solution trusted by the leading telecommunications operators in Europe:

Movistar, Orange, Vodafone, Yoigo, Wind, Más Móvil, TIM, KPN, Tre, Bouygues Telecom, Tim Mobile, Tele2, SFR, Free Mobile, Everything Everywhere, etc., as well as several of the leading European mobile network operators (MNOs).

References:

https://www.cellnextelecom.com/on-tower-france/

https://cellnextelecom.fr/en/co-location/

Table 6: **Best Practice Example Cereixal Smart Tunnel**

Cereixal Smart Tunnel Case Study Example

Abstract:

Location:	Cereixal tunnel on the A-6 (Lugo) of the road network of the Ministry of Transport, Mobility and Urban Agenda (MITMA).
Project:	Installation of sensors and 5G coverage in the Cereixal tunnel.
Framework:	5G Galicia (Spain) Pilot project promoted by the Ministry of Economic Affairs and Digital Transformation.
Objective:	Smart road implementation, which communicates with connected vehicles and thus offers driving assistance.

Use Case Description:

This intelligent tunnel sends information to drivers about the weather conditions at the exit, road works, slow vehicle warnings, possible congestion, accident, obstacle on the road, presence of a pedestrian, vehicle in the opposite direction or sudden braking during their journey through the tunnel, as well as a warning of the entry of an emergency vehicle.

Vehicle receives information from the 'smart' tunnel, which had been equipped with 5G sensors that transmit data and images in real time.

Technologies Applied:

First tunnel in Spain with the ability to connect with vehicles thanks to:

- C-V2X (cellular vehicle-to-everything) communications
- IoT (Internet of Things), sensors
- 5G network edge computing.

Sensors (opacimeter, sliding pavement, visibility, weather station)

Cameras (DAI, thermal, detection of dangerous goods, detection of electric vehicles)

Implementation of the use cases required to deploy 5G antennas that provide coverage both inside and outside the tunnel, IoT sensors and video cameras, a MEC (Multi-Access Edge Computing) server near the base station that provides coverage to the vehicles and a 5G router in the tunnel itself to be able to collect the information of what is happening in it through the IoT sensors and installed cameras.

References:

https://www.revistaitransporte.com/testing-of-smart-tunnel-and-assisted-driving-with-5g/

https://www.ineco.com/webineco/en/news/ineco-promotes-smart-roads-collaborating-deployment-5g-cereixal-tunnel

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES

Table 7: **Best practice example: Spanish Railway Administrator (ADIF) Mobile Network Sharing Model**

<u>Spanish Railway Administrator (ADIF) Mobile Network Sharing Model</u>

Spanish Railway Administrator (ADIF) Mobile Network Sharing Model Description:

Spanish Railway Administrator (ADIF) provides mobile network resources to MNOs through a Neutral Host model, building an independent and separated passive infrastructure to share by all the interested MNOs.

Use Case Description:

Currently, the Spanish Railway Administrator (ADIF) shares passive infrastructure with the Spanish mobile network operators. ADIF offers the operators a site and a telecommunication tower for installing their active RAN equipment, and, additionally, ADIF provides energy to the site.

In order to avoid any non-authorised entrance in railway area, the area allocated for the operator's site is separated from the railway line through a fence with an independent point of access.

References:

http://www.adifaltavelocidad.es/es_ES/infraestructuras/telecomunicaciones/telecomunicaciones.shtml

Involved stakeholders

Railway administrator, Mobile Network Operators (MNO), road administrations, road operators, regulators, non-telecom entities, industrial players and municipalities.

Critical Discussion

Takeaways: *What did the case study get right?*

Railway operator and other entities can collaborate in the deployment of 5G mobile networks, sharing resources with two or more operators for reducing costs and increasing the services offered.

Special attention must be paid at cross-borders, areas where 5G coverage changes between MNO from different countries without handover (no existing handover between networks belonging to different operators.)

A 5G mobile communication network can be deployed by an operator or a third-party and offering Neutral Host services to MNO or other non-telecommunication entities, contributing to the deployment of digital 5G communication networks in rural, less populated areas or market-failure areas.

Fail to benefit: *Which (if any) opportunities were missed and why?*

CASE STUDY D.3 DEPLOYMENT OF SHARED 5G MOBILE NETWORKS BETWEEN RAIL ADMINISTRATORS, MNOs AND NON-RAIL ENTITIES
Currently, the Spanish rail administrator sharing model only includes passive equipment.
Challenges: *What could be done differently given new technologies or other changes?*
New technologies open up new possibilities in terms of sharing active radio mobile resources. New radio access network architecture allows different way of sharing resources. Network disaggregation in Open RAN approach could allow different MNOs to install different software modules in a hardware common hardware platform (distributed unit and centralised unit). Each MNO can also have a different radio unit connected to the common resources. The infrastructure owner can act as a Neutral Host owning and managing the RAN hardware and providing hosting hardware for the MNOs software. This way operators can also manage remotely their virtualised software nodes.
References
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3.4 CASE STUDY D.4: COMMUNICATION TRANSPORT NETWORK BASED ON FIBRE OPTIC TECHNOLOGY

CASE STUDY D.4 Communication Transport Network Based on Fibre Optic Technology

Summary

- **General information:** Deployment of optical backbone transport networks.
- **Location:** Haifa – Nazareth Light Rail Train Project (Israel)
- **Keywords:** Transport Network, Backbone Network, FO

Scope

Deployment of Fibre Optic Transport Networks

The deployment of fibre optic high-speed backbone networks offers new possibilities and makes new telecommunication services possible.

Railways are going both digital and wireless. Smart management, HD video surveillance, Wi-Fi connections, and wireless transmission services are becoming increasingly important to railway systems. The growing bandwidth demand of the railway systems will demand more transmission resources on the own backbone networks. Railway backbone networks face huge challenges.

Introduction of a modern fixed transport network based on fibre optic technology (e.g., OTN-Optical Transport Network or other transport networks based on WDM-wavelength division multiplexing) will increase the railway communication backbone network capacity, releasing bandwidth for non-rail uses.

The deployment of a transport network helps to create a managed optical backbone transport network along the Baltic corridor suitable for other non-rail uses. This network could be used for offering telecommunication transport and access services to areas along the line and at its proximity.

Fibre optic transport networks provide next functionalities to a fixed communication network:

- multi-services access network
- ultra-high bandwidth: enabling the use of multiple DWDM wavelengths on a single fibre core
- low latency: cloud-based services require low-latency network
- long-haul: increasing distances between transmission nodes
- high reliability: enabling networks to prevent multiple points of failure
- high security by physically isolating mission-critical services that are related to the security of railway systems
- network smart operation, administration and maintenance (OAM)

Additionally, fibre optic transport network nodes can be a perfect interface for interconnection with non-railway access communication networks.

Although transport nodes can be installed at distances of up to 80-120 km, in those areas where they are a perfect interface for interconnection with non-railway access communication networks, those transport nodes can be easily installed along the rail line or transport corridor, in locations with 5-20 km distance from each other, offering access to the FO backbone network to third parties.

These third-parties or communication operators can offer local access (e.g., metro Ethernet, PON, FTTx, etc.) to small villages, residential or industrial areas, through the railway corridor FO backbone network connected to the third-parties or communication operator core nodes of their own transport network.

CASE STUDY D.4 Communication Transport Network Based on Fibre Optic Technology

Table 8: Best Practice Example **Haifa Nazareth LRT Project. FO Backbone Transport Network**

Haifa Nazareth LRT Project. FO Backbone Transport Network Case Study Example

Abstract:

Location:	Israel.
Client:	TransIsrael
Project:	Haifa – Nazareth Light Rail Train Project
Objective:	Deployment of a fibre optic backbone transport network.

Project Description:

TransIsrael company is responsible for the light rail project between Haifa and Nazareth - a national mega-project that will serve the northern population and connect communities across the Galilee and Haifa metropolitan area.

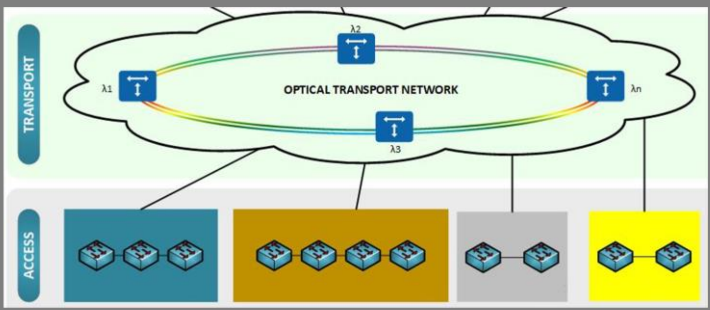
This unique project, being a first of its kind in Israel, combines urban and inter-urban public transportation. The light rail route will be a total length of 41 km and include 20 stations, connecting Haifa to Nazareth.

Use Case Description:

The communication backbone network at Haifa Nazareth project provides a transmission medium for all voice, data and video traffic between all LRT System facilities, such as the operations control centre, the depot, the stops, as well as other Haifa Nazareth LRT project wayside facilities.

This communication transport network is based on OTN technology: it provides a transport, switching, management, monitoring and survival functionality of the signals through optical fibre.

10GbE, 40GbE and 100GbE are mapped in OTN signals (OTU) and transmitted in different wavelengths over the same fibre using DWDM technology (50GHz spacing DWDM channels) with at least 80 wavelengths per fibre optic core in this deployment.



References:

https://www.transisrael.co.il/ContentPage?id=97

CASE STUDY D.4 Communication Transport Network Based on Fibre Optic Technology
Involved Stakeholders
Railway administrator, transmission communication network operators and suppliers
Critical Discussion
Takeaways: *What did the case study get right?*
A fibre optic transport network deployment allows the implementation of logically and physically separated networks, with dedicated data switches and optical fibre cabling. It provides a transport, switching, management, monitoring and survival functionality of the signals through the optical fibre. It provides redundancy of paths for fault protection.
Fail to benefit: *Which (if any) opportunities were missed and why?*
This network is only planned for providing services to the own railway line. Being the network capacity deployed bigger than the capacity demanded by the own railway, surplus transmission resources could be used for other non-railway applications. Given the distances involved, alternatives to OTN can be considered, such as making use of commodity switches and pluggable optics. Such options can increase flexibility and improve the scalability of the network.
Challenges: *What could be done differently given new technologies or other changes?*
Fibre optic transport network equipment features, and capacity are evolving and improving very quickly. Equipment vendors release new products each year with additional functionalities and bigger transmission rates and throughput. In order to avoid a future network obsolescence, equipment must support smooth upgrading and network must support scalability and flexibility and allow future network growth and provision of superior data rates. Fibre optic transport network must be based on open standards, to guard against over-reliance on a single vendor, and to allow future network expansion and upgrading without depending on the initial network vendor.
References
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3.5 CASE STUDY D.5: "SMART STATION" - COMMUNICATIONS AND ADVANCED SERVICES

CASE STUDY D.5: "Smart Station" - Communications and Advanced Services

Summary

- **General information:** Deployment of a high-band backbone communication network required for implementing services associated to the Smart Station at ADIF high-speed stations (fibre optic fixed access and Wi-Fi access), fulfilling the necessary requirements of redundancy and reliability.
- **Location:** Malaga, Spain
- **Keywords:** smart station, IoT, WI-FI, FTTx, Gigabit access

Scope

Scope 1: Deployment of a high-band backbone communication network required for implementing services associated to the Smart Station at ADIF high-speed railway stations (fibre optic fixed access and Wi-Fi access), fulfilling the necessary requirements of redundancy and reliability.

The communication network can provide the next functionalities:

- Fibre optic high-band network connecting switches and facilities.
- Multi-access equipment located along the station (allowing at least gigabit access).
- Wi-Fi access at the station, available for clients and workers
- FTTx to shops at commercial areas and other facilities

Wide band Wi-Fi 6 improved connection in environments with a high volume and density of end-devices, allowing the deployment of the Internet of Things (IoT) for station management.

Scope 2: Implementation of new use cases based in 5G or fixed broadband access at the high-speed station Maria Zambrano (Málaga). Installation of infrastructure and devices needed for the supply of advanced new use cases, all framed in the strategic plan of digitalisation and implementation of Smart Stations.

CASE STUDY D.5: “Smart Station” - Communications and Advanced Services

Table 9: Best practice example: Maria Zambrano “Smart Station” Advanced Services Case Study Example

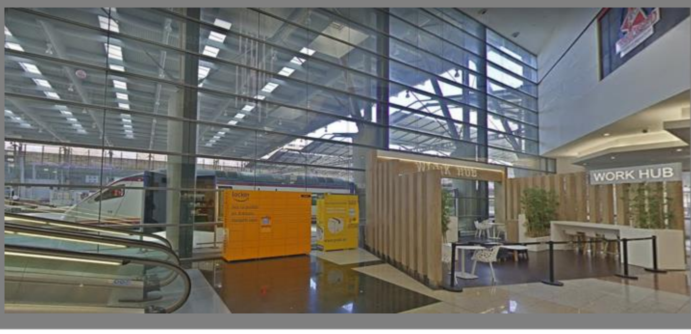
Maria Zambrano “Smart Station” Advanced Services Case Study Example

Abstract:

Location: Maria Zambrano, Malaga (Spain)
Company: ADIF (Spanish Railway Administrator)
Objective: Modernisation of Sydney's commuter rail network

Project Description:

Implementation of new use cases based in 5G or fixed broadband access at the high-speed rail station Maria Zambrano (Málaga). The actions are included in the strategic plan for digitalisation and implementation of Smart Stations.



Use Case Description:

The new services, developed in collaboration with a technology partner, are:

- **Facial recognition system for passenger access to the boarding area:** the system can also be used together with a knowledge factor like an Aztec code (type of 2D barcode) at the boarding ticket, as suitable means to provide an effective two-factor authentication solution. 5G or Wi-Fi network access allows to locate the control area and recognition devices where it is necessary, without any cabling needed, and providing the required bandwidth.
- **Biometric recognition access control system for employees and station workers**, can be used to limit the access to restricted areas (only workers).
- **App with AR** (augmented reality) for guiding passengers through the station and for supporting maintenance works at the station. Service based on 3D BIM modelling of the station.

References:

https://www.europapress.es/andalucia/malaga-00356/noticia-vodafone-concluye-casos-uso-5g-desplegados-estacion-maria-zambrano-malaga-20211020160253.html

CASE STUDY D.5: “Smart Station” - Communications and Advanced Services
Involved stakeholders
• **Rail operators and communication network operators**
Critical Discussion
Takeaways: *What did the case study get right?*
Rail station buildings and facilities can be complemented with the implementation of high-capacity communication networks over which advanced services can be provided. This additional project transforms a normal rail station into a “Smart Station”. Special attention must be paid to the interfaces and connection between “Smart Stations” and “Smart Cities”. The Smart Station strategy must be totally integrated with the Smart City strategy, in order to create mutual benefits and advantages. Smart Stations play an important role in the city that goes beyond been a simple transport hub. Formats and interfaces for data interchange between the servers in both Smart Cities and Smart Stations must be established for optimal operation.
Fail to benefit: *Which (if any) opportunities were missed and why?*
Optimisation and important cost saving can be achieved including “Smart Station” requirements in railway station design from the beginning.
Challenges: *What could be done differently given new technologies or other changes?*
The Spanish railway administrator ADIF is currently implementing and developing “Smart Stations”, in order for the latest technologies to be implemented. Anyway, Smart Station projects should also pay due attention to the integration between the “Smart Station” and the “Smart City”, and the importance of connecting the station to the city.
References
https://www.europapress.es/andalucia/malaga-00356/noticia-vodafone-concluye-casos-uso-5g-desplegados-estacion-maria-zambrano-malaga-20211020160253.html

3.6 CASE STUDY D.6: SHARING OF EDGE COMPUTING AND CLOUD CENTRES

CASE STUDY D.6: Sharing of Edge Computing and Cloud Centres

Summary

- **General information:** Provision of edge computing data centre infrastructure services
- **Location:** European Union
- **Keywords:** 5G, Edge computing, Cloud, Neutral Host

Scope

The European Commission is promoting cloud computing, being one of the key priorities of the digital agenda for Europe.

The objective is establishing a competitive European cloud supply and fostering cloud adoption in the EU private and public sectors, in order to build technological autonomy and data sovereignty in Europe.

The railway administrators can play a relevant role in edge computing. Railway corridor edge computing resources can provide proximity (low latency) and high bandwidth optical fibre connectivity to industries implementing edge computing solutions.

Railways can share edge computing hardware in its data centres, acting as a Neutral Host, or offering space to install the edge computing equipment of third parties. Some European and American telecommunication companies are offering a neutral hosting solution providing edge computing services.

Involved Stakeholders

- **Rail administrators, transmission communication network operators, technological and industrial companies**

Critical Discussion

Takeaways: *What did the case study get right?*

Railway administrators deploying edge computing centres will be ready for the implementation of new 5G advanced services based on low latency and proximity.

Fail to benefit: *Which (if any) opportunities were missed and why?*

Deployment of edge computing centres from the beginning of the 5G deployment shall avoid future delays in implementation of new services.

Challenges: *What could be done differently given new technologies or other changes?*

This new technology is not yet widely implemented *in the railway sector*.

References

https://www.americantower.com/us/solutions/data-centers/edge/
https://cellnextelecom.fr/en/home-page/products-services/edge-datacenters/

4 ENERGY

This section describes the following four energy case studies:

- Installation of renewable energy generation sources: photovoltaic (PV) modules, and mini wind turbines
- Utilization of energy subsystems, mainly traction substations, to transfer renewable electrical energy to the electrical grid
- Development of battery electrical vehicle charging infrastructure (BEV charging infrastructure)
- Development of fuel cell electrical vehicle charging infrastructure (FCEV charging infrastructure)

4.1 CASE STUDY E.1: INSTALLATION OF RENEWABLE ENERGY GENERATION SOURCES. PV MODULES AND MINI WIND TURBINES.

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines
Summary

• **General information:** solar PV and mini wind generators
• **Geographical location:**
  ○ E1.1 and E1.4: Spain
  ○ E1.2: Belgium
  ○ E1.3: Finland
  ○ E1.5: Austria
• **Keywords:** renewable energy, distributed generation, PV, wind turbines, self-consumption

Scope
Photovoltaic (PV) modules, and mini wind turbines produce renewable energy for reducing the environmental impact and the costs of the electricity bill through self-consumption of the energy and selling the surplus of energy generated that cannot be consumed simultaneously in the railway itself. The sub-cases of the study related to **solar PV** are shown in table format below.

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Table 10: Best practice example: small renewable energy parks in Spanish railway administrator (ADIF) *properties*

E1.1. ADIF Properties

Abstract:

Location:	Spain
Client:	ADIF
Project:	Measures for complying with the objectives of ADIF's Fight Against Climate Change Plan for the period 2018-2030
Objective:	Installing solar PV plants in ADIF properties

Project Description:

ADIF has promoted the installation of small renewable energy parks in its properties, within its Fight Against Climate Change Plan for the period 2018-2030 (which define its energy efficiency policies to be adopted in ADIF installations). ADIF is currently designing and procuring a big number of PV plants, especially of small power, between 30 and 100 kW. In addition, Spanish regulations require the construction of renewable energy generations facilities in new buildings.

ADIF is not installing batteries in its installations because all the energy is instantaneously consumed or transferred to the grid, and therefore batteries are not necessary.

Use Case Description:

- Large station: Albacete Los Llanos Station

This solar plant installed on the roof of the carpark has a peak power is approx. 150 kWp. The PV modules occupy an area of 1200 m^2 and produce 163.460 kWh/year. The type of connection is self-consumption with surplus.

Figure 5:PV Panels in Albacete Los Llanos Station

Source: ADIF

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

- Medium-sized station: Salamanca Station

The solar plant, located on the roof of the station has 100 PV modules of 235 Wp, i.e., a total peak power of 23.5 kWp. The PV modules occupy a surface of 500 m^{2}.

Figure 6:PV panels in Salamanca Station

Source: Google maps

- Regional station: Gádor Station

The mini solar plant on the porch of the station covers a surface of about 50 m^2 and has a peak power of 7 kWp.

Figure 7: PV panels in Gádor Station

Source: Google maps

References:

https://www.vialibre-ffe.com/noticias.asp?not=5110
"Fight against climate change". https://www.adif.es/-/cambio-climatico

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Table 11: Best Practice Example: Belgium's Solar Tunnel

E1.2 Belgium's Solar Tunnel

Abstract:

Location: Belgium
Client: Infrabel
Project: Belgian Solar Tunnel
Objective: Installation of 16000 PV modules, each at a 245 Wp

Project Description:

Infrabel is responsible for the management, maintenance, renewal, and development of the Belgian railway network.

There are 16000 PV modules, each one of 245 Wp capacity, on a total surface area of 50000 m^2 installed on the roof of this railway tunnel on the high-speed line between Antwerp and the Dutch border. The annual output of this project is about 3,6 GWh.

Use Case Description:

In December 2010 the installation was completed but only connected to the rail infrastructure services, meaning that the energy was only used to power lighting, screen displays, heating and signalling. In June 2011 a new connection was created so that the energy can be used to power trains, both standard and high-speed.

Figure 8: PV modules in Belgium

Source: The Guardian

References:

https://premierconstructionnews.com/2011/10/28/belgian-solar-tunnel-is-an-international-milestone/

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Table 12: Best Practice Example: Helsinki Maintenance Depot Solar Power Plant

E1.3 Helsinki Maintenance Depot

Abstract:

Location:	Finland
Client:	VR Group
Project:	Solar power project
Objective:	Installation of 2264 PV modules, with a rated output of 928kWp

Project Description:

VR Group is a responsible service company in the fields of travel, logistics and maintenance.

VR Group has started out with its own energy production. A solar power plant has been installed in the Helsinki depot and the produced energy can be used to maintain trains more environmentally friendly in the future.

Use Case Description:

The solar power plant built on the roof of the Pendolino Hall Station, deployed in the end of 2020, consists of 2264 PV modules and is one of the largest plants in Finland, with a nominal power of 928 kWp. The electricity obtained from the power plant is directed to the maintenance of Pendolino trains and it covers about 25% of the hall's annual need for electricity.

Figure 9: PV Panels in Finland

Source: Fleet Care

References:

https://www.vrfleetcare.com/en/vr-fleetcare/news/trains-are-maintained-with-the-electricity-produced-by-one-of-the-largest-solar-power-plants-in-finland-080220211127/

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

The sub-cases of study related to **wind turbines** are shown in table format below.

Table 13: Best Practice Example: Mini wind Turbines, Spanish Railway Administrator (ADIF*)*

E1.4 Mini Wind Turbines in ADIF Properties

Abstract:

Location:	Spain
Client:	ADIF
Project:	Actions for complying with the objectives of ADIF's Fight Against Climate Change Plan for the period 2018-2030
Objective:	Installation of mini wind turbine plants in ADIF properties

Project Description:

ADIF has promoted the installation of small renewable energy parks in its properties, within its Fight Against Climate Change Plan for the period 2018-2030 (which defines its energy efficiency policies to be adopted in ADIF installations)

Use Case Description:

This technology is not as proven as photovoltaic panels, as the installation is more complex (impact on buildings structures, safety distances, visual impacts, etc.).

ADIF has installed a prototype in its Railway Technology Center (CTF) in Málaga. The mini wind power plant has a maximum power of 15 kW divide in three ENAIR 70-220V mini wind turbines. For an average wind speed at the axis height of 5,09 m/s, the annual energy produced was 5105 kWh/year.

Figure 10:Mini Wind Turbines in Malaga

Source: ADIF

References:

https://www.energias-renovables.com/eolica/adif-instala-minieolica-en-su-centro-de

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Table 14: Best Practice Example: Höflein Lower Austria Wind Power Plant to Produce Traction Power

E1.5 Höflein, Lower Austria. Wind Power Plant to Produce Traction Power

Abstract:

Location: Austria
Client: ÖBB
Project: Wind plants ÖBB
Objective: Installing wind plants in ÖBB properties

Project Description:

ÖBB is the mobility and logistics service provider of Austria and one of the most punctual railway operators in Europe.

The world's first wind power plant to produce traction power is to be built in Lower Austria. It will feed directly into the catenary, supplying the trains with wind energy directly and with low losses.

Use Case Description:

With the commissioning, the in-house generation of renewable energy will increase by about 6,75 GWh, with a maximum capacity of 3 MW. Furthermore, the wind power plant will increase efficiency in the energy grid of ÖBB-Infrastruktur AG.

The construction of the prototype wind turbine forms the basis for the construction of further wind turbines. The intention is to further increase the share of self-generated electricity from renewable sources in the railway power supply.

Figure 11:Mini wind Turbines in Austria

Source: ÖBB-Infrastruktur AG

References:

https://infrastruktur.oebb.at/en/projects-for-austria/traction-current/solarenergy/wilfleinsdorf

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

A **generation mix** including wind and solar PV

Table 15: Best Practice Example: The Green Valley Lines in Wales

E1.6 The Green Valley Lines in Wales

Abstract:

Location:	United Kingdom
Client:	The Green Valleys
Project:	Proposal
Objective:	Installing PV and wind plants to decarbonizes the Green Valley train lines

Project Description:

The Green Valleys (Wales) is a multi-award-winning community interest company based in the Brecon Beacons, Wales. We inspire and support communities to generate sustainable, social, economic, and environmental benefits through transition to a low carbon emission future.

This project proposal in Wales consists of electrifying the Core Valley lines injecting power onto the rail from renewable energy sources.

Use Case Description:

The company Riding Sunbeams estimates the optimal renewable power capacity to fulfill this purpose is 21 MWp of solar and 42 MWp of wind capacity. With this capacity, 38% of the traction demand of these new electrified lines can be satisfied. More than 50% of the sites would be required to achieve this level of generating capacity have been identified.

According to Riding Sunbeams, the financial viability depends largely on the cost of the power converter to match the output of the renewable generators with the overhead catenary system (OCS).

The critical point is obtained a bespoke converter at a price below 250,000 $/MW and can export surplus electricity to the grid.

The high investment costs of integrating storage systems alongside renewable generation points make this not advantageous. However, it could have applicability in isolated locations where grid capacity is weak or if ancillary service sales agreements can be reached with the grid.

References:

https://www.ridingsunbeams.org/

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Ways of storing energy produced in electricity generation plants from renewable sources

Storing the electrical energy produced in renewable energy generation plants would make it available for consumption at the required moment. However, storing energy implies a high investment that would not be necessary if excess energy production, the difference between energy generated and energy consumed, could be transferred to the electricity grid and be discounted from the electricity bill or sold to the electricity companies (DSO and TSO).

Electrical energy cannot be stored as such and therefore needs to be transformed into mechanical or chemical energy. Different technologies need to be applied depending on the amount of energy to be stored.

Before implementing a storage system, a detailed analysis of the technology to be used should be carried out, depending, among other things, on the amount of energy to be stored, the investment to be made, the lifetime etc.

Currently, the technology that is gaining ground in the renewable energy sector is lithium-ion batteries, Li-Ion, because they have high electrochemical power and can accumulate big amounts of energy. The batteries are compact, lightweight and highly efficient.

Their main drawback is the high cost, however, the situation seems to be changing as prices fell by 85 % between 2010 and 2018, and their cost is expected to be halved by 2030 compared to today's level.

The main drawbacks of batteries, apart from their high costs, are the environmental impacts. Throughout the life of the batteries, from the manufacturing to recycled batteries, there is a high environmental impact.

The extraction of the raw materials, such as lithium, cobalt, nickel, cadmium, lead, mercury… require large quantities of energy and water which represents a significant social and environmental cost of all this battery manufacturing.

The lifespan could decrease dramatically if operating temperature rise, degrading the batteries much faster than normal. Such an increase in heat and eventual overheating can lead to a chemical reaction. Consequently, the electrolyte liquid can dissolve, generating additional heat that aggravates the process. This can lead to combustible gases like methane, ethane, and hydrogen leaking or escaping from the battery. This becomes highly flammable in combination with the oxygen in the air.

In addition, in the case of a thermal runaway, even after the fire is extinguished, the batteries can still generate tremendous amounts of heat and reignite fumes, hampering rescue efforts.

For example, in Japan, sodium-sulphur batteries at Mitsubishi Materials Corp.'s Tsukuba plant in Ibaraki prefecture caught on fire on Sept. 21. It took firefighters more than eight hours to control the blaze, and authorities declared it extinguished on Oct. 5.

Another case in Melbourne a fire damaged two Tesla Inc battery units. The fire was first detected on July 30 when smoke was spotted coming out of one Megapack and then erupted into flames, which took several hours to subside. It took three days before fire authorities declared the site under control.

Other storage systems that should be considered in the technology analysis could be:

- other types of batteries (e.g., NiMH, Li-polymer)

- super capacitors

- flywheels

- hydrogen

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

- compressed air

Figure 12: Mix Wind and Solar PV

Source: Iberdrola

Involved stakeholders

Public promoters:

- Ministries of Transport
- Railway infrastructure manager
- Regional and local authorities

Private companies:

- Industrial or logistic areas.
- Rail service operators.
- Shippers.

Critical Discussion

Takeaways: *What did the case study get right?*

The connection of small renewable energy generation plants is considered in the design guideline (non-traction power supply system)~~.~~ If small renewable energy generation plants are considered in the systems design phase, their construction must be compatible with the expected timeline. It involves an additional cost but is compatible with CEF funding priorities and contributes to achieve the objectives of “Fit For 55”.

PV modules: This business line should be taken into consideration. For example, in Germany, with a similar climate to the Baltic countries, the installation of PV modules is skyrocketing, and it is one of the European benchmarks in this type of installation, and, in Finland, as previously commented, solar powers plants have been installed to supply railway installations.

Installing solar panels that harvest energy from renewable sources requires an important investment, particularly if a large area, such as the roof of a train station, depot etc. However, the cost of the energy that is no longer provided by the electrical grid may cover this investment in a matter of 10-15 years in medium and large installations.

Mini wind turbines:

CASE STUDY E.1 Installation of Renewable Energy Generation Sources. PV Modules and Mini Wind Turbines

Wind turbines installation is highly recommended because the wind conditions in the Baltic countries are excellent.

They can be installed in Rail Baltica properties such as parking lots, buildings, etc.

It is a proven technology which aims to reduce the environmental impact and the energy costs.

Fail to benefit: *Which (if any) opportunities were missed and why?*

In case distributed microgeneration is not considered in the first design stages, it would cause problems to add it in the future, such as:

- Infrastructure not adapted, so they must be modified, which implies:
    - higher costs
    - service interruptions
    - adoption of non-optimal solutions that would have been considered in the design stages.

For example, In Spain, the traditional designs of railway buildings and installations did not contemplate the installations of renewable energy sources. Nowadays, this is causing a high investment to build these installations and services interruption.

Challenges: *What could be done differently given new technologies or other changes?*

Nowadays, PV technology is the main source of renewable energy for distributed micro-generation due to the following reasons:

- It is a proven and low-cost technology: easy to install, operate and maintain, with low investment, and low maintenance and operating cost. It is a technology totally adaptable to the required power. Installing more or less PV modules, the required power can be achieved.
- The amortisation period is short, but this depends on the weather conditions like the amount of solar radiation in the location.

Long lifespan of the PV modules and other equipment of the installations: between 25-30 years. Mini wind turbines are also a proven technology and adaptable to the required power, there are mini wind turbines of many different powers.

Distributed generation. The new plants of renewable energy generation should be located close to the consumption points, thus reducing the transport energy losses, and achieving greater energy efficiency.

It should be combined different kinds of generation of electricity from renewable sources (mini wind and PV panels) to optimise energy generation cycles within 24-hour periods. This means that a constant generation cycle is maintained, both during the day and at night, with solar energy being the main generator during daytime and wind energy during night-time.

References

- ADIF web page https://www.adif.es/comunicacion-prensa/notas-prensa?
- Company dedicated to mini wind turbines https://www.enair.es/en/installations/installation/ADIF-ctf
    - European press https://premierconstructionnews.com/2011/10/28/belgian-solar-tunnel-is-an-international-milestone/

4.2 CASE STUDY E.2: UTILISATION OF THE ENERGY SUBSYSTEM, MAINLY TRACTION SUBSTATIONS, TO TRANSFER RENEWABLE ELECTRICAL ENERGY TO THE ELECTRICAL GRID

CASE STUDY E.2 Utilisation of the Energy Subsystem, Mainly Traction Substations, to Transfer Renewable Electrical Energy to the Electrical Grid
Summary
• **General information:** Utilisation of the Rail Baltica electrical infrastructure, mainly traction sub-stations (TSS), to transfer the electrical energy generated by power plants, especially solar plants, located close to the Rail Baltica electrical infrastructure, to the electrical grid. • **Location:** Spain • **Keywords:** bidirectional TSS
Scope

• The main targets are:
  ○ generation of renewable energy to feed the traction system and to sell the surplus to the electrical companies (DSO and TSO).
  ○ creation additional functionalities for the TSS. So far, the main function has been to transform or convert the voltage of the electrical grid into the voltage suitable for trains. The additional functionality of TSS would be to transfer the produced energy in nearby (preferably renewable energy) generation plants to the electrical grid.
• The project is focused on the high-speed lines due to the greater intensity of average consumption per substation and the greater availability of land around these high-speed substations.
• The business model is based on maximising self-consumption of the energy produced, as well as the sale of surpluses to the market. The target is to implement thus measure in the coming years.

CASE STUDY E.2 Utilisation of the Energy Subsystem, Mainly Traction Substations, to Transfer Renewable Electrical Energy to the Electrical Grid

Table 16: Best Practice Example: Dual Use of TSS. RENFE and ADIF

E.2.1 RENFE Will Invest 233M € in 390 MW of Self-consumption for High-Speed Trains

Abstract:

Location:	Spain
Client:	RENFE and ADIF
Project:	Actions to achieve the objectives of ADIF's Fight Against Climate Change Plan for the period 2018-2030
Objective:	Installing solar plants in ADIF properties

Project Description:

The project includes the implementation of up to 46 PV plants next to the high-speed traction substations in pursuance of reducing the electricity costs by at least 40 million per year. The adaptation of the traction substations and the construction of the PV plants will be carried out in eight years.

Use Case Description:

Photovoltaic solar energy is suitable for this project because the production of electrical energy by photovoltaic panels and consumption are usually at the same time, which is an advantage over other renewable energy sources in a self-consumption model. In order to facilitate this project, the traction substations of high-speed railway lines must be adapted.

RENFE will reduce the costs of its high-speed services.

References:

https://www.pv-magazine.es/2021/09/30/renfe-invertira-unos-233-millones-en-390-mw-de-autoconsumo-para-el-ave/#:~:text=FV%20Comercial%20%26%20Industrial-,Renfe%20invertir%C3%A1%20unos%20233%20millones%20en%20390%20MW%20de%20autoconsumo,la%20red%20de%20alta%20velocidad.

Involved stakeholders

Railway administrators, transmission system operators, promoters interested in the construction of electric recharging points, technology companies and manufacturers of photovoltaic plant equipment.

CASE STUDY E.2 Utilisation of the Energy Subsystem, Mainly Traction Substations, to Transfer Renewable Electrical Energy to the Electrical Grid
Critical Discussion
Takeaways: *What did the case study get right?*
• The main benefit of producing renewable electricity in company-owned generation plants to reduce the electricity costs because the consumption is lower and surplus energy (energy that cannot be self-consumed) is sold to the electrical grid. • All this contributes to achieving the “Fit for 55” objectives. • The project helps lowering the traction energy costs.
Fail to benefit: *Which (if any) opportunities were missed and why?*
As it concerns an existing infrastructure, in order to facilitate the transfer of these renewable energy to the grid it is necessary to modify the traction substations with all that it entails, with more complex and expensive changes and leaving that infrastructure inoperative while the modification is carried out.
Challenges: *What could be done differently given new technologies or other changes?*
This possibility should be considered from the very beginning of the systems design phase as it is an option with great potential for the future. The adaptation of the traction substations to transfer energy from nearby renewable plants to the electrical network does not require the consideration of new technologies, the new necessary equipment is similar to that used in the substation.
References
• Spanish press https://www.europapress.es/economia/noticia-renfe-instalara-placas-solares-paliar-incremento-precio-luz-20211202191359.html

4.3 CASE STUDY E.3: DEVELOPMENT OF BATTERY ELECTRICAL VEHICLE CHARGING INFRASTRUCTURE (BEV CHARGING INFRASTRUCTURE)

CASE STUDY E.3 Development of a BEV Charging Infrastructure
Summary
• **General information:** the project involves capturing the electrical energy from ADIF´s electrical infrastructure to supply electric car chargers, with the objective of installing around 400 electric charging points in station vehicles parks. • **Location:** Spain • **Keywords:** charging infrastructure, BEV
Scope
There are three options depending on how the energy is obtained: • feed chargers from the catenary (Overhead Catenary System (OCS)): direct current 3kV or alternating current 25kV, are compatible with this option. However, both connections are very expensive and complex due to the conversion of the OCS voltage into the electric car input charge voltage. • feed from direct current or alternating current traction substations. • feed from transformation centres (substations MV/LV, medium voltage / low voltage) in stations.

CASE STUDY E.3 Development of a BEV Charging Infrastructure

Table 17: Best Practice Example: ADIF BEV Charging Infrastructure

E.3.1 ADIF BEV Charging Infrastructure

Abstract:

Location:	Spain
Client:	ADIF
Project:	Actions to achieve the objectives of ADIF's Fight Against Climate Change Plan for the period 2018-2030
Objective:	Installation of 400 charging points in stations

Project Description:

ADIF has promoted the installation of electric car chargers in 65% of all its stations in its Fight Against Climate Change Plan for the period 2018-2030 (which defines the energy efficiency policies to be adopted in ADIF installations).

Use Case Description:

There are:

- 370 points of charge in conventional (non-high speed) stations.
- 30 points of charge in high-speed railway station

The installation of electric chargers fed from the electrical infrastructure owned by ADIF is one of the measures included in its Plan to Fight against Climate Change for 2018-2030.

The power of the electrical car chargers is minimum 100 kW and maximum 500 kW.

Figure 13: ADIF BEV Charger

Source: ADIF

References:

https://cincodias.elpais.com/cincodias/2020/11/03/companias/1604424168_917645.html

CASE STUDY E.3 Development of a BEV Charging Infrastructure
Involved Stakeholders
Transmission system operators, promoters interested in the promotion of BEV. Technology companies that want to prove new technology, manufacturers of electric vehicles.
Critical Discussion
Takeaways: *What did the case study get right?*

• Promotion of electro-mobility as a tool to meet the de-carbonisation objectives of "Fit for 55".
• Electrical car chargers could be fed from:
  ○ **Non-traction power supply system** in installations such as: medium voltage cable line installed along the track; substations MV/LV along the track.
  ○ **Traction power supply system** in installations such as: traction substations, autotransformers centres (paralleling post, PP, and switching post, SWP).
• Therefore, installing car chargers involve reviewing the following guidelines: "non-traction power supply" and "traction power system".
• Feeding from the OCS should not be considered, due to the high cost and complexity. This case complies with European regulations and creates the basic infrastructure for the charger network that is necessary for the viability of the electric car.
• Support from CEF Transport, through the **Alternative Fuels Infrastructure Facility (AFIF**)

Fail to benefit: *Which (if any) opportunities were missed and why?*
Not having considered the electrical vehicle chargers in the systems design can lead to very complex and expensive solutions to supply the chargers, such as to feed them from the catenary through converters that do not exist on the market. If the charging network is not considered in the initial systems design phase, it will inevitably have to be upgraded at a later stage as new directives and policies are encouraging and forcing the development of a charger network. This would imply modifications and higher costs in the future.
Challenges: *What could be done differently given new technologies or other changes?*
Including vehicle chargers from the design stages of the energy subsystem enables this system to be designed according to the necessary final dimension and to include all the necessary equipment. In this way, the investment is significantly lower, and it is possible to meet deadlines. The installation to feed the car chargers does not require the consideration of new technologies, it is a very simple one, basically, similar to supplying power to another low voltage consumer (equipment). This case complies with European regulations and creates the basic infrastructure for the charger network that is necessary for the viability of the electric car.

CASE STUDY E.3 Development of a BEV Charging Infrastructure
References
• ADIF communication and press http://www.ADIF.es/en_US/empresas_servicios/implantacion_puntos_recarga_electricos/implantacion_puntos_recarga_electricos.shtml • Digital media news https://cincodias.elpais.com/cincodias/2020/11/03/companias/1604424168_917645.html

4.4 CASE STUDY E.4: DEVELOPMENT OF A FUEL CELL ELECTRICAL VEHICLE CHARGING INFRASTRUCTURE (FCEV INFRASTRUCTURE)

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)
Summary
• **General information:** use of hydrogen to supply FCEV vehicles (e.g., cars and trucks) from a hydrogen station with fuel pump • **Location:** Europe • **Keywords:** hydrogen, FCEV, "Fit for 55", refuelling station, zero-emissions
Scope

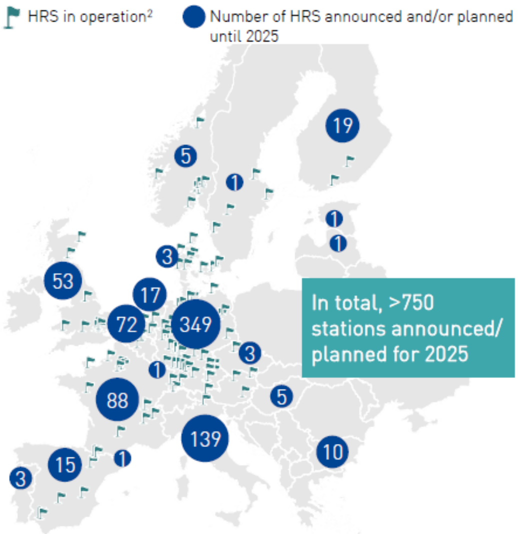
It is expected that after EU approval of proposal of amendment of Directive 2014/94/EU on the deployment of alternative fuels infrastructure that Member States shall ensure that, in their territory, a minimum number of publicly accessible hydrogen refuelling stations are put in place by 31 December 2030.

In the proposal currently under negotiation, the requirement is that Member States shall ensure that accessible hydrogen refuelling stations with a minimum capacity of 2 t/day and equipped with at least a 700 bar dispensers are deployed with a maximum distance of 150 km in-between them along the TEN-T core and the TEN-T comprehensive network.

They shall ensure that by 31 December 2030, at least one publicly accessible hydrogen refuelling station is deployed in each urban node.

In line with the "Fit for 55" package: Extending the European Hydrogen Backbone:

Figure 14: Hydrogen Refuelling Stations (Current and Planned in Europe)



Source: Hydrogen ROADMAP fuel cells. Hydrogen joint undertaking (2019)

An analysis on the best location shall be carried out for such refuelling stations that shall in particular consider the deployment of such stations in multimodal hubs where also other transport modes could be supplied.

The proposal involves use the hydrogen to supply FCEV vehicles (e.g., cars and trucks) from a hydrogen station with fuel pump and promotes the rollout of hydrogen refuelling stations at a maximum distance of 150km in-between

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

stations with the geographical scope extended along with the Trans European Network for Transport (TEN-T) core network and urban nodes.

For maritime solutions, the promotion of hydrogen and hydrogen derived fuels is included in the proposal with clear targets to reduce emissions, starting already in 2025 with a cumulative effect.

Hydrogen storage, transportation and distribution has been trialled globally and technology developers have moved beyond the proof-of-concept phase, and as a consequence**, the hydrogen refuelling infrastructure network is growing steadily,** as well as the regulatory framework for its support (standard 2014/94/UE).

There are numerous associations and business clusters that promote the development of hydrogen refuelling stations and related infrastructure across Europe:

Table 18: Best Practice Example Benchmark of Hydrogen Fuelling Stations Promotors and Associations

Association	Objectives	Geographical scope
Hydrogen Mobility Europe (H2ME)	**Flagship project giving fuel cell electric vehicle (FCEV) drivers access to the first truly pan-European network of hydrogen refuelling stations:** Hydrogen Mobility (H2ME) is a project financed by the FCH 2 JU and divided into two actions H2ME1 and H2ME2.	Denmark, France, Germany, Iceland, Netherlands, Norway, Sweden and UK
Scandinavian Hydrogen Highway Partnership (SHHP)	Regional union of clusters of companies, research centres and other entities. One of the objectives was the creation of a network of 15 HRS and 30 satellites hydro-generators for large fleets of vehicles.	Norway, Sweden and Denmark
Nordic Hydrogen Corridor	Deployment study for the introduction of eight new hydro-generators, hydrogen production units through electrolysis and 100 fuel cell vehicles along the Swedish TEN-T network in the 2017-2020 execution period, allowing zero emission transport between the capitals of the Nordic countries with fuel cell vehicles (framed within the Connecting Europe Facility (CEF)	Norway, Sweden, Denmark and Finland
Hydrogen Valley-Northern Netherlands	The Northern Netherlands has become the first region in Europe to receive a subsidy for its so-called Hydrogen Valley (approved by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) of the European Commission). It concerns a subsidy of 20 million euro with a public-private co-financing of 70 million euro for development of a fully functioning green hydrogen chain in the Northern Netherlands.	The Netherlands

There are many applications for FCEV charging infrastructure in mobility and transport:

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Table 19: Best Practice Example Transport of Hydrogen as a Compressed Gas in Multiple-Element Gas Containers

Transport of hydrogen as a compressed gas in Multiple-Element Gas Containers (MEGC)

Abstract:

Location: Europe, Canada and USA
Client: Rail Freight operators
Project: Hydrogen Transport Containers

Use Case Description:

Another related opportunity is the transport of hydrogen as freight, similar to other bulk liquids or gases. As with any other such cargo, hazard analysis is required, but in the short-term transport by rail is likely to be more efficient than by road or waiting for pipelines.

A study conducted by DB Energie attempted to assess the feasibility of hydrogen transport across the rail network to support refuelling stations, including and analysis concerning which technologies are available and suitable for hydrogen transport, review regulatory requirements and examine the cost-effectiveness compared to existing road transport

Figure 15: Transport of Hydrogen as Freight (Similar to Other Bulk Liquids or Gases)

From left to right: Tank wagon, container trailer (MEGC) with vertical cylinders bundles, and container trailer (MEGC) with horizontal cylinder bundles .

Multiple-Element Gas Containers (MEGC) development

The study by DB Energie concluded that there are no hydrogen transport containers approved for rail traffic yet, only for road traffic, but that as the requirements are very similar, it is to be expected that certification for use on rails could be obtained within six to eight months.

In North America, the US Federal Railroad Administration (FRA) has conducted a full-scale shell impact test (Test 11) of a surrogate DOT-113(2), a double-walled tank car (i.e., tank-within-a-tank) designed to transport authorized cryogenic liquids (such as LH2) by rail.

Figure 16: Multiple-Element Gas Containers (MEGC) Development

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Table 20: Best Practice Example Transport of Hydrogen as a Compressed Gas in Multiple-Element Gas Containers (MEGC)

Transport of Hydrogen as a Compressed Gas in Multiple-Element Gas Containers (MEGC)

The DB Energie study shows that the **40 ft standard container size** allows for maximum flexibility in handling on **road and rail**, as it can be used as swap bodies on flat wagons for rail transport or on chassis for road transport. This allows multimodal, flexible handling within all common logistics standards at the loading and unloading points.
With the 40 ft MEGC, it is possible to keep the total truck mass below 40 tons and to transport a large amount of hydrogen in the pressure stages of 500 bar and 300 bar:

- At 500 bars, the MEGCs contains just over 1,000 kg of H2.
- At 300 bars, with a little more than 700 kg H2.

Transport of hydrogen as a dangerous good:

For hydrogen transport, the requirements for the transport of dangerous goods specified in the Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods and the associated obligations of those involved apply. There are no other regulations, such as special regulations or other legal and operational challenges relating to dangerous goods, for the transport of hydrogen by rail.

In principle, there are no regulatory quantity restrictions for rail transport for dangerous goods, provided that the transport of the substance is permitted. Thus, only the maximum permissible wheelset load of 22.5 tons, and the maximum length of the freight trains of 700 meters limit the possible quantity that can be transported. Furthermore, individual deviations from possible axle loads, freight train lengths and tunnel restrictions can restrict the maximum amount of hydrogen that can be transported on individual sections. The route must be checked before each new route with regard to individual restrictions.

References:

https://cutric-crituc.org/wp-content/uploads/2021/01/Rail-Innovation-in-Canada-Top-10-Technology-Areas-for-Passenger-and-Freight-Rail-2.0.pdf

https://blog.lea-hessen.de/wp-content/uploads/2020/08/Potenzialbeschreibung-Wasserstofftransport-%C3%BCber-das-Schienennetz.pdf

SP 20534 Special Permit to transport LNG by rail in DOT-113C120W rail tank car. https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/safe-transportation-energy-products/72911/environmental-assessment.pdf

SECTION 6: CRYOGENIC LIQUID TANK CARS https://www.aar.org/wp-content/uploads/2017/12/AAR-2017-Field-Guide-for-Tank-Cars-BOE.pdf

https://railroads.dot.gov/elibrary/full-scale-shell-impact-test-dot-113-tank-car-surrogate

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Table 21: Best practice example Zero-Emission Fuel Cell Buses for Aberdeen, Scotland

Zero-Emission Fuel Cell Buses for Aberdeen, Scotland

Abstract:

Location: Aberdeen, Scotland
Client: Aberdeen City Council
Project: Fuel Cell Zero-Emission Buses. Part of JIVE and JIVE2

Project Description:

Part of JIVE (Joint Initiative for Hydrogen Vehicles across Europe), Aberdeen City Council has implemented Europe's largest fleet of hydrogen fuel cell buses, replacing ten polluting diesel buses on the city's streets with zero-emission buses.

Project Promoters: implementation of the fleet of hydrogen fuel cell buses in Aberdeen was co-financed through two projects funded by the European Fuel Cell and Hydrogen Joint Undertaking (FCH JU): High V.LO-City and HyTransit. Other Scottish, UK and European partners came together to co-fund the balance of the project, including the UK's Innovation Agency, Innovate UK, the Scottish Government, Scottish Enterprise, as well as Aberdeen City Council.

The hydrogen bus refuelling station (Kittybrewster site) has supplied the highest volume of hydrogen of any refuelling station in Europe, with the highest efficiency of any refuelling station in Europe and has achieved an overall level of availability of over 99%.

The commercial-scale hydrogen station is owned and operated by BOC, a member of the Linde Group. The facility has three electrolysers to produce the hydrogen on site from water, with extremely low emissions. The hydrogen is then compressed to 500bar and stored ready for dispensing at 350bar when required. A purpose-built hydrogen fuel cell bus maintenance facility is co-located at the depot and refuelling station.

The hydrogen in the buffer tanks is piped to two Linde IC90 ionic compressors that compress the hydrogen in five stages to either 500 bars for the bus fleet, or 900 bars for private car refuelling.

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Zero-Emission Fuel Cell Buses for Aberdeen, Scotland

Use Case Description:

The refuelling station at Kittybrewster has provided a reliable source of transport-grade hydrogen since 2015, and demonstrates that a well-designed electrolyser installation that incorporates redundancy / modularity would be a good model for the rail industry to adopt. In terms of specific learning points, these are summarised as follows:

- The refuelling station has achieved a high level of availability of over 99%. This has been achieved in part through having a modular design with multiple electrolysers that can operate independently, and multiple compressors that can also operate independently.
- The alkaline electrolysers have a warm-up period, so in order to maximise efficiency, it is desirable for the electrolysers to operate for long periods, rather than repeatedly switching on and off.
- The site operates largely unattended, and maintenance of the electrolysers is required every six months and annually for the compressors.
- Although the on-site storage totals 500 kg, only 180 kg of this is considered useable in the event of production problems, as the pressure in the storage tanks will equalise with the pressure in the tanks on the vehicle.
- The commercial arrangement is for BOC Linde to supply hydrogen at a given price, with limits set on the minimum and maximum quantities that are to be supplied annually.
- Revise the commercial arrangement is for BOC Linde to supply hydrogen at given price, with limits set on the minimum and maximum quantities that are to be supplied annually.

Figure 17: Fleet of Hydrogen Fuel Cell Buses

References:

Intelligent Power Solutions to Decarbonise Rail Hyd-Energy: Feasibility and Concept Design of Future Hydrail Enabled

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Table 21: Best Practice Example FCEV Powered Trains. Coradia iLint

FCEV Powered Trains: *Coradia iLint* Hydrogen Fuel Cell Powered Train, Alstom

Abstract:

Location:	Europe
Client:	Alstom
Project:	Coradia iLint hydrogen fuel cell powered train

Project Description:

Fuel cell trains will play a key role in the transition to a zero-emission economy. Hydrogen powered trains are able to provide a cost effective zero-emission alternative to diesel for routes which cannot be electrified

Use Case Description:

Fuel cell battery powered trains are in a very early stage of market introduction, but an increased commercial interest towards FCH trains during last years resulted in the first promising train prototypes being developed and tested. While the technology is potentially feasible in some specific use cases, the broader commercial readiness and performance have yet to be proven.

Specifically designed for operation on non-electrified lines, it enables clean, sustainable train operation while ensuring high levels of performance.

Another application is **retrofitting existing diesel shunters for use at intermodal freight terminals,** in order to de-carbonise shunting activities (splitting trains, reordering the wagons and substituting new trains), as operation of shunters usually does not allow for a catenary-electric solution.

Figure 18: Coradia iLint Hydrogen Fuel Cell Powered Train

References:

https://www.alstom.com/press-releases-news/2021/8/alstoms-coradia-ilint-hydrogen-train-runs-first-time-sweden

Involved stakeholders

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Public promoters:

- European bodies: DG MOVE, CINEA, TEN-T corridor coordinator
- Ministries of Transport
- Regional and local authorities: research facilities, universities
- Public transport entities: regional bus services providers

Private companies:

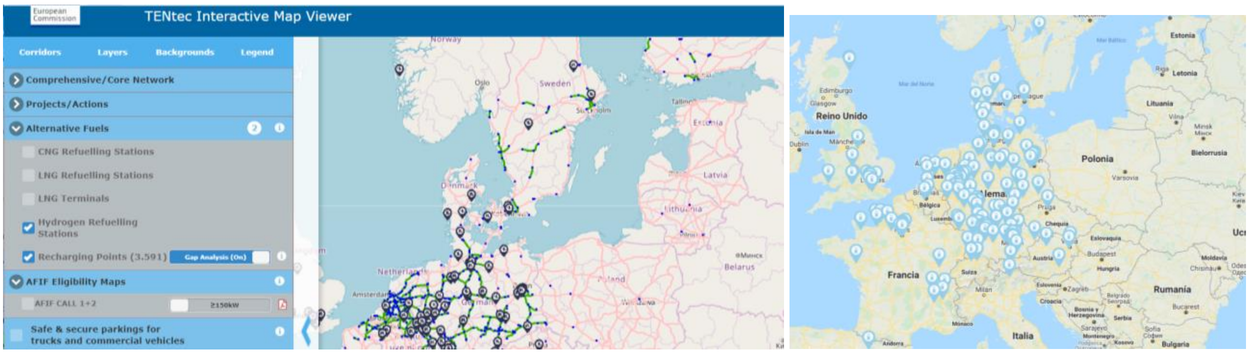
- Hydrogen supply chain industry companies
- FCEV manufacturers

Critical Discussion

Takeaways: *What did the case study get right?*

Two key developments have contributed to the growth of hydrogen in recent years: the cost of hydrogen supply from renewable energies has dropped and continues to fall, while the urgency of greenhouse gas emission mitigation has increased, and many countries have begun to take action to de-carbonise their economies, notably energy supply and demand. The hydrogen debate has evolved over the past two decades, with a shift in attention from applications for the auto industry to also include sectors that are difficult to de-carbonise such as energy-intensive industries, trucks, aviation, shipping and heating applications.

Figure 19: Current Refuelling Station Across Europe - European Alternative Fuels Observatory (2020)



TEN-TEC Interactive Map Viewer Hydrogen // Refuelling station across Europe - European Alternative Fuels Observatory (2020)

The case study is aligned with the "Fit for 55" regulation, which promotes the rollout of hydrogen refuelling stations at a maximum distance of 150 km in-between stations with the geographical scope extended along with the Trans European Network for Transport (TEN-T) core network and urban nodes.

Hydrogen can help tackle various critical energy challenges. It offers ways to de-carbonise a range of sectors – including intensive and long-haul transport, chemicals, and iron and steel, where it is proving difficult to significantly reduce emissions. It can also help improve air quality and strengthen energy security. In addition, it increases flexibility in power systems.

Fail to benefit: *Which (if any) opportunities were missed and why?*

CASE STUDY E.4: Development of a Fuel Cell Electric Vehicle Infrastructure (FCEV Infrastructure)

Currently the hydrogen fuelling infrastructure is limited, and the cost of producing and delivering hydrogen fuel to service stations is high for small quantities, and it is still cheaper to produce hydrogen from fossil fuels than from renewable energy.

Additionally, fuel cell vehicle production costs will have to drop considerably from their current levels and consumer understanding of the technology and its benefits will have to improve for fuel cell vehicles to reach the mainstream market.

Challenges: *What could be done differently given new technologies or other changes?*

Funding mechanisms: To support the transition to more fuel cell vehicles, some governments are funding the rollout of the initial hydrogen stations when fuel cell vehicle deployment is low and highly uncertain, as indicated in reports previously cited. In addition to this, car manufacturers with early fuel cell models in the market are directly covering the fuel costs of the hydrogen for several years after the initial lease or purchase of their fuel cell vehicles

Policy makers should also consider how to create legislative frameworks that facilitate hydrogen-based sector future compliance.

Fuel cell vehicle technology is progressing and opening up greater possibilities for low-carbon emission transport. Reductions in fuel cell costs, volume mass, and hydrogen storage cost have greatly contributed to enabling the initial fuel cell market entrants. Fuel cell vehicle efficiency advantages, the ability to produce hydrogen from renewable sources, and fuel cell vehicles' long-range and quick-fuelling capability make hydrogen fuel cells a promising long-term option for a de-carbonized transport sector.

References

IRENA (2019), Hydrogen: A renewable energy perspective, International Renewable Energy Agency, Abu Dhabi

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https://railroads.dot.gov/elibrary/full-scale-shell-impact-test-dot-113-tank-car-surrogate

5 LOCAL CONNECTIONS FOR INDUSTRIAL AREAS

5.1 CASE STUDY I.1: CONSTRUCTION OF RAILWAY BRANCHES FOR RELEVANT PRIVATE INDUSTRIAL OR LOGISTICS AREAS - EUROPEAN EXPERIENCE

CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas
Summary
• **General information:** construction of dedicated railway branches, in order to provide accessibility for relevant private industrial or logistics areas. • **Location:** Germany, France and Spain • **Keywords:** industrial, logistics, branches, nodes
Scope
Construction of dedicated railway branches in order to provide accessibility for relevant private industrial or logistics areas. • Construction of railway branches to connect freight hubs with the Rail Baltica network. • Improvement of existing privately owned rail sidings, or construction of new ones, and their adaptation to the standard gauge. The selection of relevant industrial nodes close to RB rail layout would allow increase the intermodal transport, as well as other kind of freight transportable by rail, such as bulk goods. Case study in Germany, France and Spain: national strategies to promote rail freight transport using national and European funding for the construction, adaptation or improvement of private freight terminals and their connections to the railway network.

CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Table 22: Best Practice Example: Germany Rail Freight Masterplan

Rail Freight Masterplan

Abstract:

The Rail Transport Master Plan, published by the Federal Ministry of Transport and Digital Infrastructure (BMVI) in June 2017 and developed with the support of representatives from the entire sector, comprises a set of measures to permanently promote the transport of goods by rail and offer higher quality rail freight services to shippers at more competitive prices.

The main objectives of this master plan are the following: to guarantee a high-capacity infrastructure, to make extensive use of the innovation potential and to improve the transport policy framework.

Description:

The master plan defines ten areas of action:

1. Provide a high-capacity infrastructure for the rail freight sector
2. Advance in the digitalisation of rail freight transport
3. Increase the level of automation of railway operations
4. Accelerate technological innovations in rolling stock considering economic efficiency and environmental performance
5. Promote multimodality and guarantee access to the rail network
6. Expand electric traction on railways and in the logistics chain
7. Significantly reduce access charges to the rail network and service facilities
8. Limit levies and tax burden
9. Guarantee comparable standards in labor and social legislation and safety requirements for all modes of transport.
10. Intensify initial training and continuing professional development.

Funding Measures:

Under the framework of this Rail Transport Master Plan, Germany has implemented a package of aid to promote the modal shift of freight from road to rail, with an annual budget of 40 million euros, applicable in the period between 2021 and 2025. The measure seeks to serve as support for companies that choose to connect their facilities with the public rail network. Additionally, Germany has approved a direct subsidy program of 600 million euros for rail freight operators operating in the insulated wagon segment.

References:

https://www.bmvi.de/SharedDocs/EN/publications/rail-freight-masterplan.html

CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Table 23: Best Practice Example: France National Strategy for the Development of Rail Freight

National Strategy for the Development of Rail Freight

Abstract:

This strategy has been established with the objective of doubling the modal share of rail freight in France by 2030, from 9% to 18% tonnes/km, enshrined in the law on the fight against climate change.

The strategy aims at responding to four major challenges:

- ensure the viability of services and the sustainability of the economic model of rail freight operators.
- improve the quality of service provided by SNCF Réseau.
- strengthen the performance of infrastructure allowing the development of rail freight.
- develop coordination with maritime and river transport.

It involves all the agents concerned by rail freight, including three main partners: the 4F Alliance "French Rail Freight of the Future" representing in particular the operators SNCF Réseau and the Professional Association of Shippers (AUTF).

Description:

The strategy provides the following necessary measures:

1. The establishment of aid or support mechanisms for modal shift and the development of combined transport, in compliance with the relevant European rules for State aid

2. The development of a rail component to supply logistics to urban areas

3.The modernisation and pooling of territorial infrastructures, in particular capillary lines, service lines, branched terminal installations and freight terminals

4. Development of multimodal freight exchange hubs and infrastructures

5. To strengthen the rail service to ports, major seaports and their hinterland

6. Development of transnational rail freight corridors

Funding measures:

Following the aid measures announced in the summer of 2020 and later included in the French 2021 finance law, this strategy pursues to maintain until 2024 an additional annual budget of 170 million euros to support the operation of rail freight and combined transport services.

References:

https://www.ecologie.gouv.fr/sites/default/files/210909_Strategie_developpement_fret_ferroviaire.pdf

CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Table 24: Best Practice Example: Spain Freight 30

Freight 30

Abstract:

In line with axis 6 of the Strategy for Safe, Sustainable and Connected Mobility 2030 of the Spanish Ministry of Transport, Mobility and Urban Agenda (MITMA), called "Intermodal and Intelligent Logistics Chains", the "Freight 30" initiative has been launched with the aim of promoting rail freight transport as the backbone of multimodal logistics chains, from the dual perspective of the post-COVID-19 economic recovery and the achievement of the de-carbonisation and transport sustainability objectives.

Within this initiative, a series of actions and measures with an impact in the short and medium term have been identified, whose implementation before 2030 will boost an increase in modal share of rail freight transport in Spain from 5% to 10% tons-km and, therefore, will reduce the negative externalities associated with freight transportation (pollution, accidents, noise, congestion, etc.).

Description:

Freight 30 proposes 29 actions, grouped into 6 thematic blocks:

- Infrastructure
- Capacity Management
- Terminals
- Rolling Motorways
- Digitalisation
- Aid

These actions will be developed within the 2021-2030 period, although some of them, mainly those related to aid, will be implemented before 2025.

Funding measures:

Ten actions are proposed in the block related to Aid, 8 of them directly linked to the MITMA Recovery, Transformation and Resilience Plan (PRTR).

Among these eight actions linked to PRTR, there is a specific aid for the construction, adaptation or improvement of private freight terminals and their connections to the railway network, with the aim of supporting the connection to the railway network of those industrial facilities whose goods have a high potential to be transported by rail, thus promoting modal transfer from the road.

References:

https://www.mitma.gob.es/ferrocarriles/mercancias-30

CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Involved Stakeholders

Public promoters:

- Ministries of Transport: elaboration of a plan for the promotion of freight transport
- Railway infrastructure manager: establishment of connection agreements
- Regional and local authorities: land property and road traffic management

Private companies:

- Industrial or logistic areas: project proposal of railway facilities
- Rail service operators: agreement for the provision of railway services
- Shippers: establishment of consortiums in logistic areas

Critical Discussion

Takeaways: *What did the case study get right?*

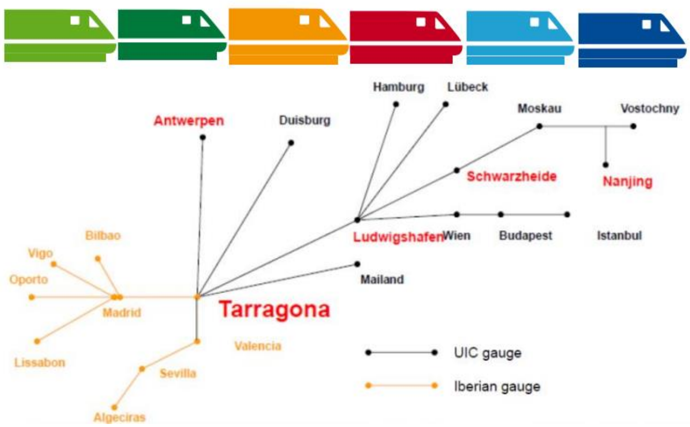
Railways branches with relevant freight hubs would enhance **new commercials opportunities related to both, the domestic and international market**. The new infrastructure could provide an alternative way of freight transport, **transferring to railway part of the goods movements that take place by road**.

- Synergies with private companies, improving the logistic supply chain
- New rail branches to industries will contribute to the **deployment of 5G network** and **boost the eligibility of RB projects applying for CEF funds**
- Increase of rail freight traffic in RB project
- External costs saving from modal shift from road to rail
- Higher safety of freight transport
- Railway branches to military bases would enhance military mobility

Fail to benefit: *Which (if any) opportunities were missed and why?*

Facilities linked to railway branches conditioned by the **overall and future strategies of the national railway network**, and by **financial issues**.

Figure 20: BASF Case (Chemical Industry). Rail Freight Terminal for Transport to the Rest of Europe from Tarragona



CASE STUDY I.1 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas
Example: BASF Case (Chemical Industry) • The chemical company BASF intended to build a new freight terminal to transport its production by rail to the rest of Europe from the factory based in Tarragona • This decision was conditioned by the installation of the standard gauge in the Mediterranean Corridor • The timing and planning of the installation of the third rail on the corridor, which would allow the circulation of standard gauge trains, dissuaded them from building of the freight terminal and the construction of the railway branch to the factory.
Challenges: *What could be done differently given new technologies or other changes?*
• Consideration in the planning and implementation phase of rail connections to industrial facilities • Establishment of prior agreements between stakeholders • Possible rolling highways / piggyback transportation services • Gauge changeover installations for improving rail network accessibility
References
National strategies for the promotion of rail freight and combined transport: • Germany:https://www.bmvi.de/SharedDocs/EN/publications/rail-freight-masterplan.html • France:https://www.ecologie.gouv.fr/sites/default/files/210909_Strategie_developpement_fret_ferroviaire.pdf • Spain: https://www.mitma.gob.es/ferrocarriles/mercancias-30

5.2 CASE STUDY I.2: CONSTRUCTION OF RAILWAY BRANCHES FOR RELEVANT PRIVATE INDUSTRIAL OR LOGISTICS AREAS - NORTH AMERICAN EXPERIENCE

CASE STUDY I.2 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas
Summary
• **General information:** construction of dedicated railway branches, in order to provide accessibility for relevant private industrial or logistics areas. • **Location:** United States of America • **Keywords:** industrial, logistics, branches, nodes
Scope
The construction of dedicated railway branches in order to provide accessibility for relevant private industrial or logistics areas is widely developed in North America (USA and Canada), as American railroads, unlike European railway networks, for the most part are **owned by private organisations who are responsible for their own maintenance and improvement projects**, rather than government owned or operated. As for new connections from industrial sites to the railway network, in general terms, **the industry will be responsible for the construction, ownership and maintenance of all remaining track from the railway network ownership point into the site of the industry**. If the proposed turnout is located in an existing industry owned track, the industry shall construct, own and maintain this track. Final ownership and maintenance points will be determined by the rail network owner and shall be described in a private side-track agreement that the industry shall sign with the rail network owner. US railroad companies have dedicated sections on their websites (links below), including guideline documents intended to provide information and guidance for the design and specifications for the construction of private railroad tracks and their supporting platform. It is also important to highlight that the industrial railway branches to be constructed in North America are usually larger, as the length of a freight train in the US is often 1,500 - 3,500 meters, whereas in Europe freight train lengths are closer to 750 meters (although Rail Baltica has been designed for longer trains).

CASE STUDY I.2 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Case study of Union Pacific Railroads (UPRR): Design and construction of private sidetracks

Design technical specifications

Any design, materials and methods of construction for all aspects of proposed improvements impacting UPRR (Union Pacific Railroads) owned or maintained property, shall be in accordance with the most current edition of the technical specifications (*UPRR General Conditions and Specifications, UPRR Engineering Track Maintenance Field Handbook, and UPRR Standard Drawings*), which provides the minimum requirements for industry owned and maintained property, as well as the checklist for industry track submittals and sample plans/exhibits, which are periodically revised.

UPRR technical specifications mostly follow and reference the *American Railway Engineering and Maintenance-of-Way Association* (AREMA) documents and handbooks, widely used in the United States and Canada that include practices regarding design, construction and maintenance of railway infrastructure.

Table 25: Example of Checklist for Industry Track Submittals, in which different required items are listed, as well as the correspondent technical specifications

Industry Name	Project Location

Firm Name	Submitted By

Checklist Color Codes
Drawing Required
Switch
Signal
Drainage/Structures
Roads
Clearances
Profiles
Not Required
Do Not Include

Item	Description of Items to be Shown on Submittals	Railroad Work			Non Railroad Work			References & Resources
		Concept planning	Design Plans	Const. Plans	Concept planning	Design Plans	Const. Plans	
1	Aerial Imagery: show in background in monotone							Section XX of UPRR Industrial Track Specs
2	Rail Weight: all existing and proposed track							Section XX of UPRR Industrial Track Specs
3	Typical Sections: show/label existing ground, proposed subgrade and subballast, ditches, all dimensions depths of ballast and subballast, and horizontal/vertical clearances							Section XX of UPRR Industrial Track Specs
4	Drainage Study: submit hydrologic and hydraulic design calculations for all drainage improvements or modifications							Section XX of UPRR Industrial Track Specs
	…							

https://www.up.com/cs/groups/public/@uprr/@customers/@industrialdevelopment/@operationsspecs/@specifications/documents/up_pdf_nativedocs/doc_up_ind_submittals_check.xlsx

CASE STUDY I.2 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Structures

As mentioned in the UPRR Industrial Track Specifications: "*Any rail bridge located within 500 feet (152m) of a proposed or existing point of switch shall be subject to review by UPRR Structures for determination of required bridge modifications. Upon evaluation, UPRR will notify the industry of necessary walkway/handrail or other project specific requirements. If the structure is owned or maintained by the UPRR, the design and installation of the walkway and handrail system shall be completed by UPRR at the industry's expense. If the structure is owned or maintained by the industry, the industry will design and install the walkway and handrail system. The design of the walkway and handrail system shall be reviewed and accepted by UPRR prior to construction*."

Access roads and road crossings

As depicted in the UPRR Industrial Track Specifications: "*The industry shall be responsible for providing suitable temporary and/or permanent access for use by UPRR for purposes of construction, providing rail service, and maintenance of UPRR owned or operated equipment. Suitable access may include, but not be limited to, properly constructed and maintained access roads, at-grade crossings, bridges, or grade separations.*

As a general policy, UPRR prohibits the construction of new public or private roadways across tracks owned by UPRR. If a project requires the construction of a new crossing across UPRR owned or operated tracks, written authorisation will be required from UPRR Public Projects and all applicable governing agencies."

Construction

Citing the UPRR Industrial Track Specifications: "*No work of any type shall be performed on UPRR rights of way, which could affect UPRR roadbed, or track, without written permission and evidence of proper insurance as may be required. Construction of industry structures, roadbed, track, etc., shall not begin prior to receiving UPRR's approval of final plans.*

Industry shall obtain all necessary approvals and permits required by governmental agencies for all work on UPRR right of way, including but not limited to grading, drainage, vegetation, erosion control, and siltation prevention devices.

Inspection of the completed track will be made by UPRR personnel and will not be placed in service without such approval.

All materials and methods of construction used for the proposed project shall comply with UPRR accepted plans and meet UPRR standards and specifications. UPRR prefers that Industries have their rail contractor furnish UPRR track material for projects requiring UPRR track construction."

Maintenance:

After the track is placed in service, the industry shall maintain its portion of the track in a condition at minimum in compliance with FRA Class I track. Failure to maintain track in a proper manner may lead to suspension of service until the defective condition(s) are corrected.

CASE STUDY I.2 Construction of Railway Branches for Relevant Private Industrial or Logistics Areas

Involved Stakeholders

Private companies:

- Industrial or logistic companies: project proposal of railway facilities
- Rail network owners: agreement for the provision of private sidetracks

Critical Discussion

Takeaways: *What did the case study get right?*

Railways branches with relevant freight hubs would enhance **new commercials opportunities related to both, the domestic and international market**. The new infrastructure could provide an alternative way of freight transport, **transferring to railway part of the goods movements that take place by road**.

Relevant information concerning the development of private side-tracks, such as **technical guidelines or administrative procedures**, is clearly presented in dedicated sections in the rail operators webpages, as well as contact information for the person responsible for assistance.

Technical specifications include restrictive criteria for **surrounding structures (such as rail and road overpasses or underpasses) and *access roads and road crossings*,** which clearly limits what can and cannot be done in the railway branch surrounding area, and especially regarding safety and protections.

Challenges: *What could be done differently given new technologies or other changes?*

Following the market structure in North America regarding railway industry (privatisation oriented), the industry has to finance the entirety of the railway branch, as generally there is no financial support (aids or financial schemes) from public promoters or railway network owners.

It should be noted that these circumstances apply to big industrial sites in North America within a huge privatised market, whereas in Baltic states the industrial sector may not reach this size and railway branches projects might require financial support for economic feasibility.

References

US railroad companies: UPRR, BNSF and CSX have dedicated sections on their websites, including documents describing the processes, defining the rules which apply to any private rail section:

- UPRR: https://www.up.com/customers/ind-dev/index.htm
- BNSF: https://www.bnsf.com/ship-with-bnsf/rail-development/build-rail-served-facility/
- CSX: https://www.csx.com/index.cfm/customers/industrial-development/build-or-expand-a-rail-served-facility/build-a-rail-served-facility/