UNITED NATIONS
ESCAP

SMART RAILWAY SOLUTIONS

for Trans-Asian Railway Network in the Times of COVID-19 Pandemic

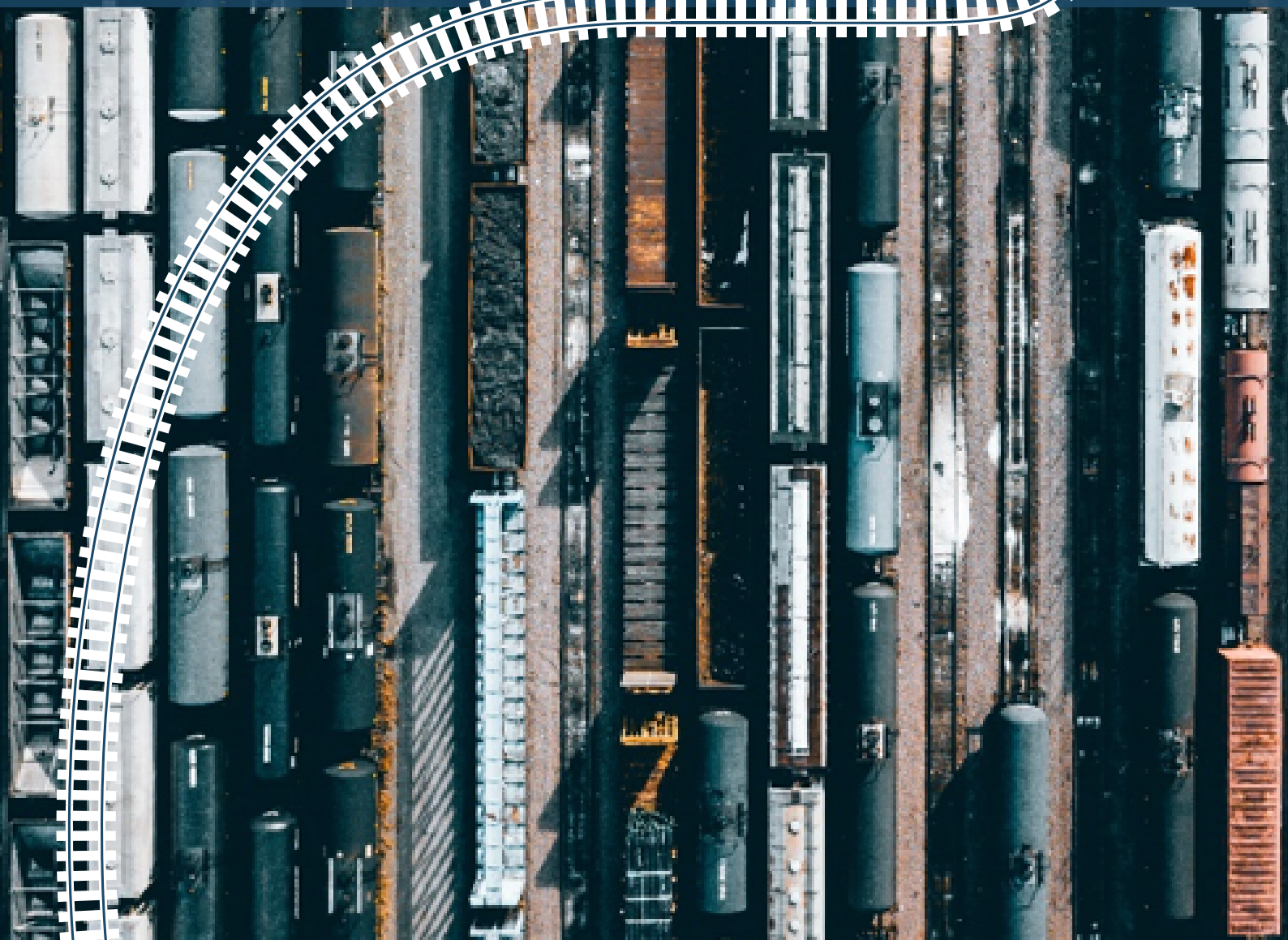

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Photo credits: photo by Campbell.

List of abbreviations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
CCTT	Coordinating Council on Trans-Eurasian Transportation International Association
CIS	Commonwealth of Independent States
EAEU	Eurasian Economic Union
ECO	Economic Cooperation Organization
EU	European Union
KTZ	Kazakhstan Railways
OECD	Organization for Economic Co-Operation and Social Development
OSJD	Organization for Cooperation of Railways
OTIF	Intergovernmental Organisation for International Carriage by Rail
RZD	Russian Railways
TEU	Twenty-foot equivalent unit
TITR	Trans-Caspian International Transport Route
TSR	Trans-Siberian Railway
UIC	International Union of Railways
UNCRD	United Nations Centre for Regional Development
UNIFE	European Rail Supply Industry Association
UTLC ERA	United Transport and Logistics Company – Eurasian Rail Alliance
WEO	World Economic Outlook

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Key Messages

1. International railway transport has undergone rapid changes over the last decade with more freight trains moving along the trans-continental corridors- a trend likely to continue.

2. This trend is leading to development of new railway routes, construction of railway infrastructure, expansion of railway services, and new alliances to serve more markets on the international railway corridors along the Trans-Asian Railway Network.

3. Over long run the geography of rail freight flows in ESCAP region and beyond, as well as the railway market in general might undergo substantive changes due to pandemic crisis that is leading to changes in supply chains and possible relocation of production.

4. Railway transport proved its resilience as a reliable mode of transport in times of pandemic. The railways now should turn this crisis around as an opportunity to further enhance the comparative advantages of railway transport through use of smart railway solutions that would strengthen competitiveness of the railways in the post pandemic environment.

5. Railways of the region need to revisit national railway plans/ strategies/investments/ business models incorporating likely impacts of the pandemic and prepare themselves better to deal with eventualities.

6. Developing railway network, expanding international railway transport, shifting to rail, enhancing sustainability and digitalizing are key priorities for railways of the region and they need to be accelerated in post pandemic world to ensure the competitiveness of the railway transport.

7. Smart railway solutions aim to expand the knowledge of railways of the region on the range of options available to deal with the emerging challenges and harness the opportunities in the era of pandemic.

8. Seven modules for smart railway solutions include following areas: railway operations, predictive maintenance, rolling stock, railway border crossings, client orientation and railway financing- each module has further sub-modules that go into specific solutions.

9. Smart railway solutions have been successful elsewhere and are potentially replicable and scalable. However, not all solutions would have equal importance or relevance for the railways of the region. Each railway could assess its own situation and determine which smart solutions would be more beneficial and applicable for them.

10. Supplementing this study on smart railway solution ESCAP has also developed a guide on smart railway solutions as a precursor to a comprehensive capacity building programme on the Smart Railway Solutions to support member railways in addressing post pandemic challenges.

Background

The COVID-19 pandemic is changing the dynamics of international freight transport as no single event has probably done before in the recent past. The outbreak of the pandemic has adversely impacted freight transported by all other modes other than by rail.

The increase in freight carried by railways is not surprising, given its distinct features, that are working to its advantage in the current situation. International railway transport uses less manpower over long distance and accordingly there are fewer health checks, unlike, for example, in road transport where checks and congestions at border crossings cause more frequent human interactions. Each freight train can carry between 40 to 70 times equivalent of lorry loads of goods in a much more safe and secure environment giving rail a distinct advantage.

The opportunities for switching more cargo to rail during the COVID-19 recovery phase and making shift towards railways more enduring in national and international transport- would require enhanced competitiveness of railway transport compared to other modes.

To support trade and transport connectivity globally in times of pandemic the United Nation agencies have jointly launched a project titled- Trade and transport connectivity in times of pandemics: with overarching objective of developing contactless, seamless and collaborative solutions to preserve and further enhance the trade and transport connectivity. In Asia and the Pacific, ESCAP is leading the project and has initiated series of studies aimed at supporting countries in this direction.

The present study on smart railway solutions has been carried out under the project with aim to identify smart railway solutions that are proven to be successful elsewhere and are potentially replicable and scalable. Not all solutions would have equal importance or relevance for the railways of the region.

Each railway could assess its own situation and determine which smart solutions would be more beneficial and applicable for them. In this regard, the study may also be seen as an inventory of smart railway solutions that would expand the knowledge of railways of the region on the range of options available to deal with emerging challenges and opportunities in the era of pandemic.

First part of the study provides context for smart railway solutions along the Trans-Asian Railway Network. It provides insight into the emerging trends in international railway transport followed by analysis of the impact of pandemic on the railway freight flows along the Trans-Asian Railway network. Identification of common priorities of the railways of region and the focus areas for specialized railway organizations follow next.

The objective of this part is to underscore the importance of using the current crisis as an opportunity to further enhance the comparative advantages of railway transport through use of smart railway solutions that would enhance the competitiveness of the railways in

the post pandemic environment.

The second part of the study provides six modules on smart railway solutions. These modules are smart railway operations, smart railway maintenance, smart train driving, smart railway border crossing, smart railway customer orientation and smart railway investing. Each module has submodules that explain the range of smart railway solutions with details.

The study is complemented by the Annexes providing information on new rail freight services in 2016-2020 and key priorities of the TARN member countries as defined in official national strategic documents as well as smart railway solutions.

PART I:

State of railway transport along the Trans-Asian Railway network prior to and during the COVID-19 pandemic

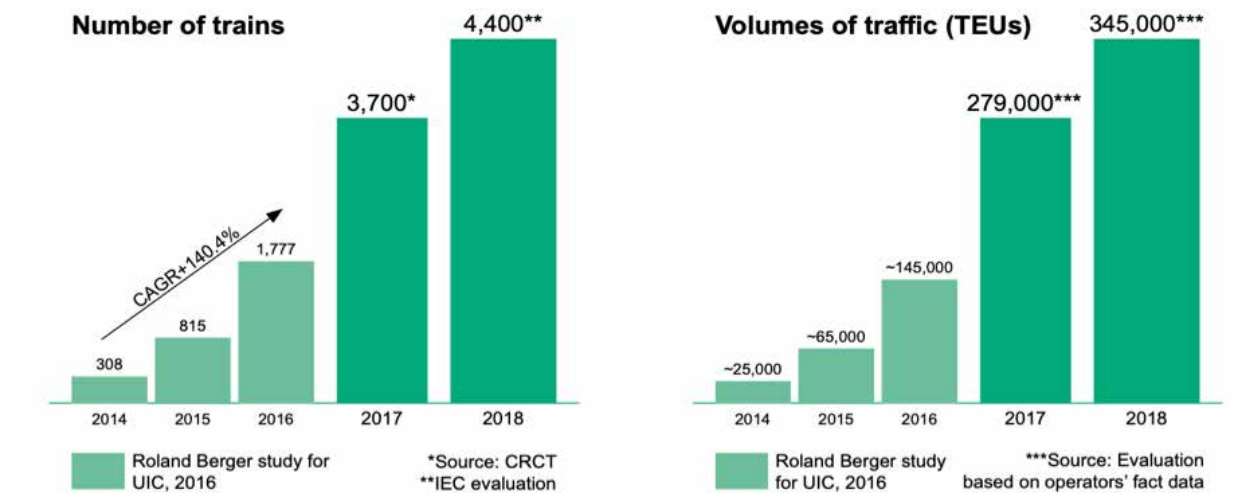
I. Emerging trends in international railway transport along Trans-Asian Railway network

This chapter identifies emerging trends in international railway transport along the Trans-Asian Railway network.

The defining trend of the last few years has been an exponential increase in the freight trains between Asia- China in particular and Europe.

In recent years, the Eurasian railway linkages between Asia and Europe are becoming major established routes for international transport, which offer viable alternative to maritime transport of goods. Although transport by rail is five times more expensive than transport by sea, it is about 1.7 times faster. This makes rail an attractive mode for transporting time-sensitive goods, such as fashion goods, electronics, car parts and perishables including food. The number of Eurasian trains exponentially increased from 308 in 2014 to about 4,400 in 2018, while the volume of traffic has grown from 25,000 TEU to about 345,000 TEU.[1] Despite the strong growth, the railway transport share covers only about 1 per cent of the freight traffic between Asia and Europe, while more than 90 per cent of goods are still moved in maritime transport.[2]

Figure 1: Key statistics of Eurasian rail freight transit 2014-2018



Source: UIC, 2020, IEC, Eurasian Corridors: Development Potential – Report (Fig.2)

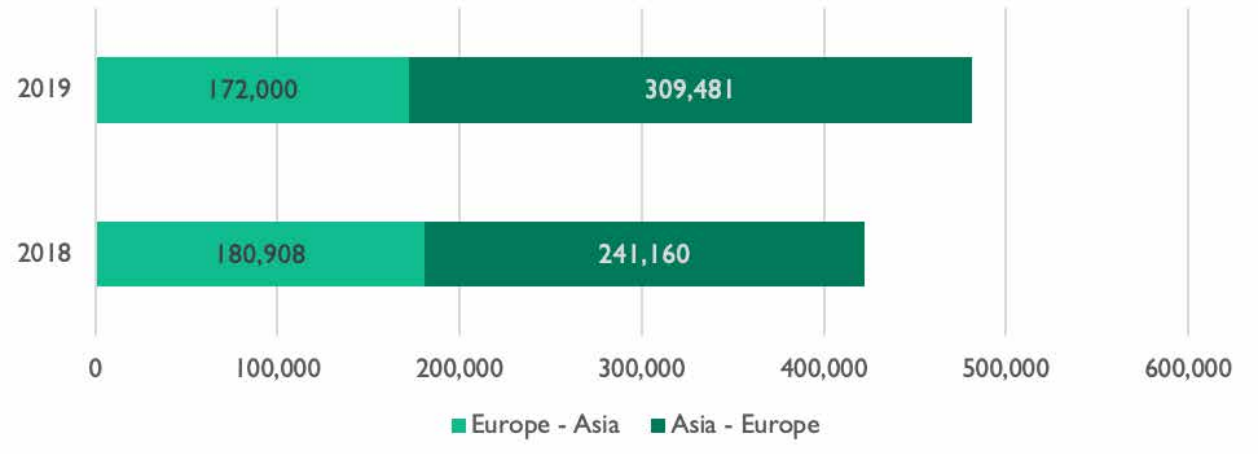
1. UIC / IEC, March 2020, Eurasian Corridors: Development Potential – Report (Fig.2: Key statistics of Eurasian rail freight transit 2014-2018). Available at: https://www.shop-etf.com/en/eurasian-corridors-development-potential-report.html
2. UIC, October 2017, Roland Berger, Study - Eurasian rail corridors: what opportunities for freight stakeholders? Available at: https://uic.org/IMG/pdf/corridors_exe_sum2017_web.pdf

Railway freight flows on Eurasian routes are expected to increase from 345 thousand TEUs in 2018, to less than 450 thousand TEUs by 2030 under pessimistic scenario (under unfavourable factors, such as decrease of rail subsidies in China), to more than 2 million TEUs under optimistic scenario (under positive factors, such as digitalization, infrastructure improvements and support measure for rail transportations). The very wide range of potential for growth (between 450 thousand TEUs and more than 2 million TEUs) is indicating that it is very important to fully identify all changes and factors that could impact the development of railway freight transport (new routes, infrastructure, terminals, new services and business models, new technologies, changes in consumer behavior, new regulations, economic changes) and to comprehensively study what will be their effect.

"The defining trend in international railway transport during the last few years has been an exponential increase in the freight trains between Asia- China in particular and Europe."

In 2019, container traffic between China and Europe grew by 14 per cent year-on-year.[3] The busiest routes from Asia to Europe were the routes from China to Central and Eastern Europe and from China to Western Europe, accounting for almost 90 per cent of all traffic. The container transportation between Asia-Europe approached 500,000 TEUs.

Figure 2: Container transport by rail along Europe – Asia – Europe in TEUs

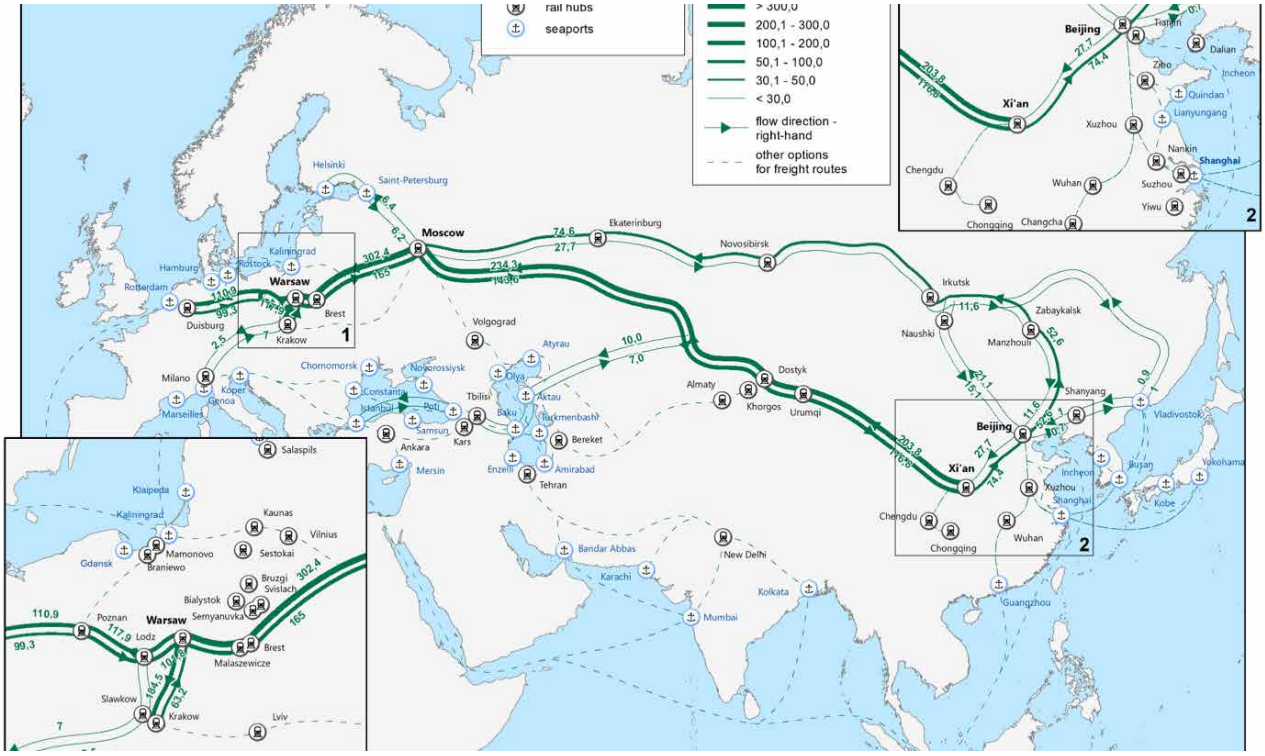


Source: CCTT Trans-Eurasian Corridors (Annual Digest) 2020, data provided by IEC based on data from operators

3. Coordinating Council for Trans-Siberian Transportation Trans-Eurasian Corridors Annual Digest 2020

As can be seen from the Figure 3, more than 80 per cent of the freight flow of containers from Asia to Europe and backwards in 2019 were transported through the railway network of Kazakhstan. Compared to the previous year, the flow of containers through the crossing point in Zabaikalsk increased, and the flow through Naushki reduced. Middle Corridor still accounted for less than 5 per cent of total transportation flows in Euro-Asian links, despite growth to previous year. There is an important disbalance in westward and eastward flows (6:4 for all container traffic, 7:3 for loaded containers) caused by differences in types of exported and imported commodities in Europe and in China.

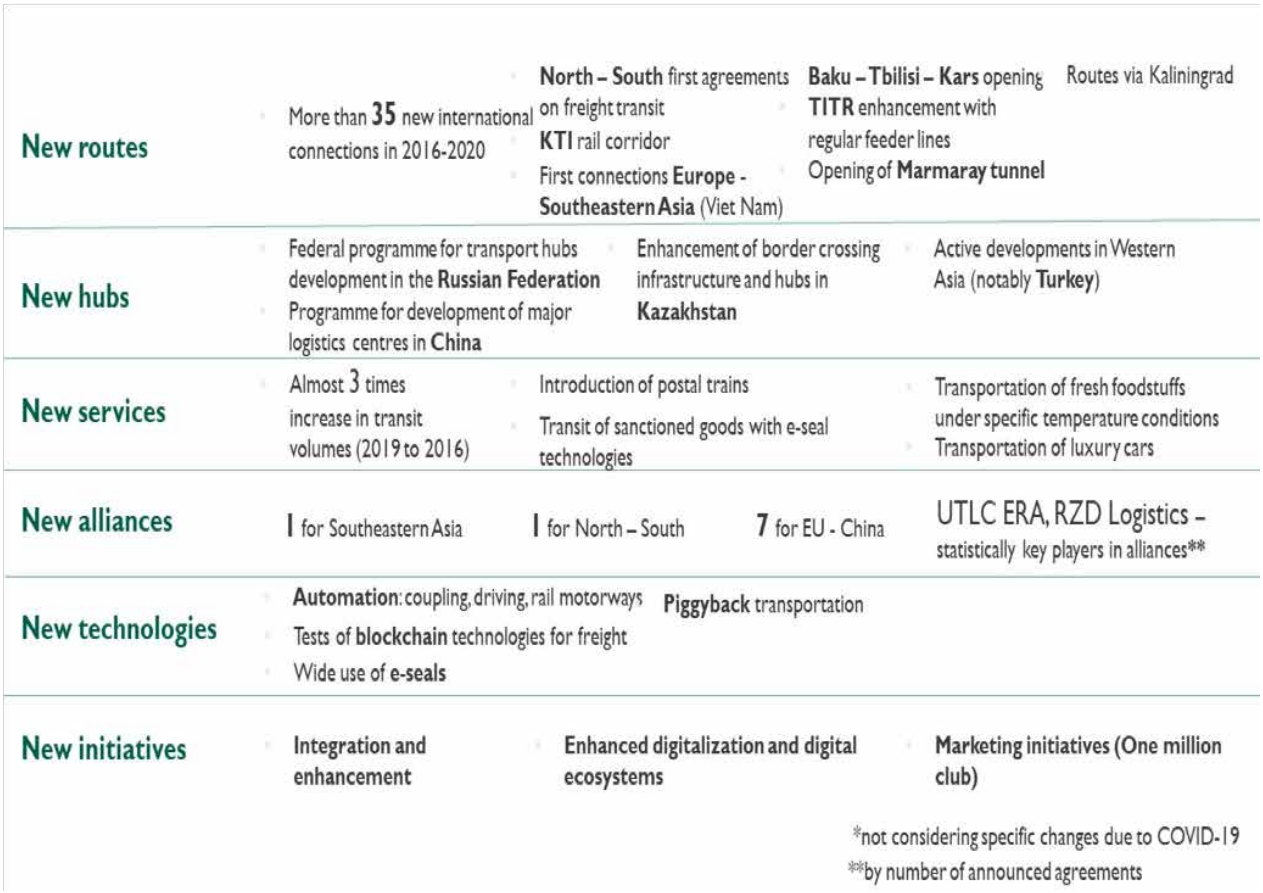
Figure 3: Allocation of Eurasian rail freight transit flows in 2019



Source: CCTT Trans-Eurasian Corridors (Annual Digest) 2020, map provided by IEC based on data from operators. This map is schematic and should not be considered as a reference for exact borders of countries.

This major trend of growing volumes of trans-continental freight flows has given rise to many related developments some of which have been captured in a recent UIC study "Eurasian corridors: development potential" that provides overview of major changes in Euro-Asian rail freight market in 2016-2019. The major trends are indicated in Figure 4 below and explained thereafter.

Figure 4: Trends along the in Euro-Asian rail freight corridors



Source: Information derived from official media releases and annual reports.

A. New trade routes for international railway transport

The total share of railways in Euro-Asian freight transit is less than three per cent though railways have been gaining and increasing their share in Euro-Asian rail freight transit, import and export during last four year. The COVID-19 pandemic has led to increase in share of railways to about four per cent, according to preliminary rough estimates.

About 95 per cent of transit traffic along the Trans-Asian Railway Network on the Euro-Asian links passes via the Russian Federation and Kazakhstan (Dostyk – Brest segment accounted for more than 80 per cent of transit traffic in 2019). New southern routes (Trans-Caspian route with links to Baku – Tbilisi – Kars new line) established within this period refer to other 5 per cent with year-to-year increase of volumes.

Growth of railway container freight traffic has resulted in diversification of routes, mainly linking East to West. New routes involve many ESCAP members, especially Central Asian countries. In last four years the railway operators have operated freight trains along many new routes as mentioned in the table below. Some main new routes that have started operations along East – West – East connections include:

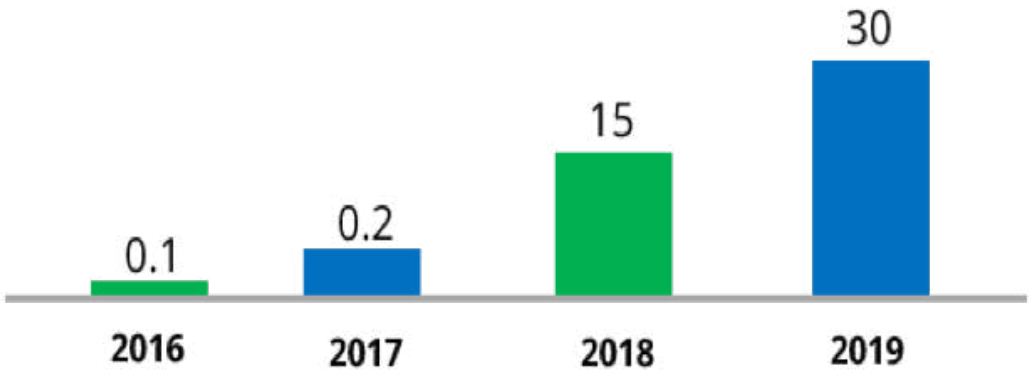
Trans-Caspian International Transport Route (TITR)[4]

In November 2013 the railway companies of Azerbaijan, Georgia, and Kazakhstan signed an agreement on establishment of a coordinate committee for development of Trans-Caspian International Transport Route. The agreement led to establishment of the committee in 2014 with three railway companies and ports along the Black Sea as its initial members with the main objective to attract freight along the route.

In December 2016, the participants of the coordinating committee for the development of the Trans-Caspian International Transport Route - Azerbaijan, Georgia and Kazakhstan - decided to establish an international association Trans-Caspian International Transport Route. The association's main objectives include attracting transit cargo, developing integrated logistics products, promoting competitiveness of the route, operating an effective tariff policy and facilitating border crossing procedures.

Further in April 2016 an agreement was signed on the establishment of the International Trans-Caspian Transport Consortium between the logistics companies of involved countries to develop logistics products with high degree on customer orientation as well organization and monitoring of container transportation along the route. These continuing efforts to attract freight to the route have led to considerable increase of container traffic along the route-- as can be seen from Figure 5 below with the number of containers touching 30,000 TEUs in 2019 form mere 100 TEUs in 2016.

Figure 5: Container traffic in the direction China-Caucasus-Turkey (thousand TEUs)



4. Based on the information available at the website https://middlecorridor.com/en

Introduction of regular feeder line service along the Caspian Sea Ports[5]

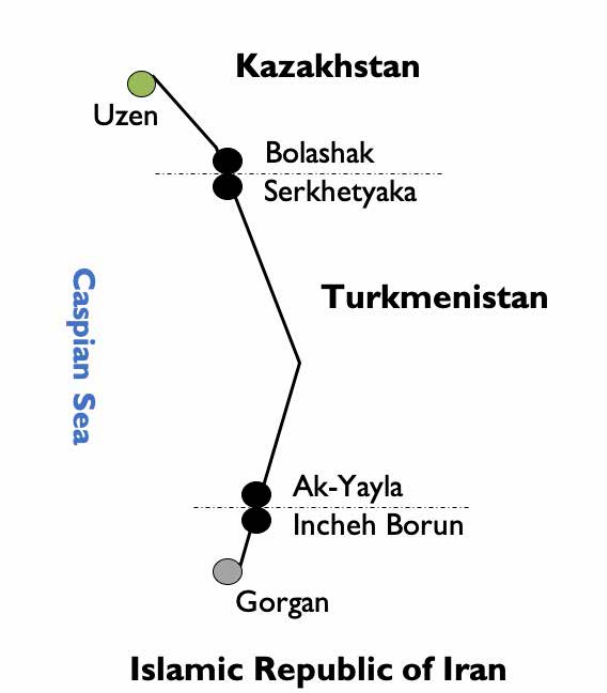
In April 2019 Kazakhstan feeder vessel "Turkestan" with containers was launched from the seaport of Aktau to the port of Baku. The feeder vessel with a capacity of 225 twenty-foot containers, enables two full container trains into a single vessel. This would further help consolidate transit cargo from China to Europe along with Kazakhstan export cargo in containers. It is expected that the feeder vessels will run regularly on a weekly basis, this would contribute to the increase of cargo traffic on the Trans-Caspian international transport route and to further developing containerisation of goods in the Caspian region.

The Trans-Caspian route is a key link along the Eurasian transport corridors and complements the system of other transit corridors of Kazakhstan. This would enable reverse traffic from Turkey, Georgia and Azerbaijan in the direction of China. Also, the active use of the border station Altynkol, the dry port of Khorgos eastern gate special economic zone, the seaport of Aktau will ensure the efficiency of transit traffic through the middle corridor with consequential benefits for all countries along the route.

Kazakhstan, Turkmenistan and Islamic Republic of Iran (KTI) railway corridor

A north south railway corridor that passes along Kazakhstan, Turkmenistan and Islamic Republic of Iran (KTI) along east of the Caspian Sea was completed in the end of 2014. The railway corridor improves connectivity among the three countries and has potential to further strengthen transport connectivity among various regions. Even though the physical connectivity along KTI railway corridor exists, the potential of the KTI and other linked railway corridors has not been fully harnessed yet.

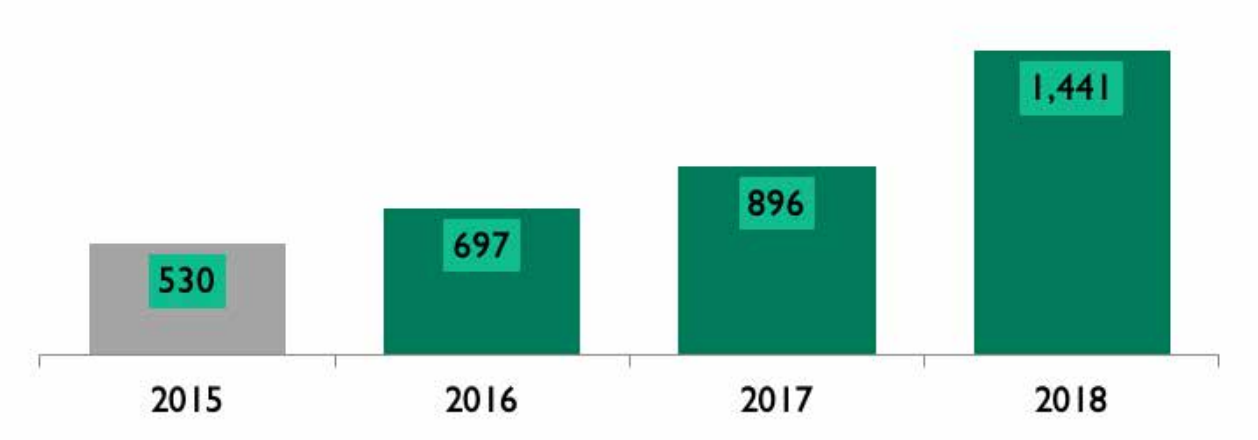
Figure 6: KTI corridor



The volume of railway freight traffic along KTI corridor has been steadily increasing from 2015 until 2018 as can be seen in Figure 7, however there are indications that a decrease of freight volumes may be expected in 2019. Present volumes of railway freight traffic are below the potential of KTI railway corridor. The cargo traffic is unevenly distributed and not balanced (with much higher traffic on northern KTI section and running in direction from north to south).

5. https://uic.org/com/enews/nr/644/article/kazakhstan-a-regular-feeder-service-on-the-trans-caspian-route-is-launched?page=modal_enews

Figure 7: Cargo traffic along KTI railway corridor (in thousands of tonnes)



Source: Based on data presented by Turkmenistan at the inception meeting for the study project on commercialization of KTI railway corridor - 10 April 2019 Tehran, Islamic Republic of Iran

The organization of block container trains along KTI corridor has been tested and the services for railway transport of containerized cargo are occasionally being offered, however the flow of containerized cargo is still limited. Linkages of KTI railway corridor with routes emanating from larger economies (e.g. Russian Federation, China, India and Europe) could increase the railway transport volumes along the KTI corridor and needs to be explored.

The potential of transit traffic along KTI corridor should be harnessed using the advantages of less border-crossings along the route. Integration of KTI corridor with other linked railway corridors and ports and addressing the physical and non-physical barriers are important factors in KTI corridor commercialization efforts that will ultimately result in increased freight flows. Such activities should be supported by introduction of efficient KTI corridor management mechanism that would increase coordination among all the stakeholders.

Opening of Marmaray undersea tunnel in Turkey for freight trains

The Marmaray Tunnel is a 13.5km long undersea railway tunnel in Istanbul, Turkey, connecting the European and Asian part of the city. The tunnel consists of two single track tunnels and was traditionally used by passenger trains. In November 2019, a freight train service through the Marmaray tunnel under the Bosporus between Asia and Europe became operational, carrying 42 TEU of electronic goods in transit from China to the Czech Republic. The service was organised by China Railway Express and took 12 days to travel from Xi'an, China through Kazakhstan, across the Caspian Sea to Azerbaijan and then to Turkey via the newly constructed Baku – Tbilisi – Kars line inaugurated in 2017. The route continues to the Bulgarian border at Kapikule, and on to Praha in Czech Republic.

Growing freight volumes via Kaliningrad region of Russian Federation

One of the important new developments in terms on new routes is the growth of transit via Kaliningrad region of Russian Federation. According to Kaliningrad branch of Russian

Railways (RZD)[6], in 2018 total transit volumes via Kaliningrad region accounted for 9,900 TEU (6,300 thousand TEU eastbound and 3,600 thousand TEU westbound). In 2019 these volumes went up nearly two times and in January – September 2020 resulted in 16,600 TEU with about one half of traffic in multimodal connections.

Growing container volumes through intermodal transit transport

Another important trend that is the increasing use of intermodal transport to further develop container services to enhance the capacity utilization of the northern corridor along the Trans-Asian Railway network. It would support tapping into the huge volume of trade between the Republic of Korea and Japan and Europe. In this regard, multimodal transport could play an important role. Russian Railways has joined hands with transport companies to launch an intermodal transit transport route between the Japan, Republic of Korea and Europe.

In June 2019, the first container was shipped by sea from Busan, Republic of Korea, to Vladivostok, Russian Federation, then to Brest, Belarus, on the Tran-Siberian Railway. From there, it was trans-shipped to 1,435 mm gauge railway track and delivered to the railway station in Brzeg Dolny, Poland. Final delivery was made in Wroclaw, Poland, with the entire journey taking 21 days, or half the time that it takes by sea. The shows the potential of intermodal transport along the norther corridor of Trans-Asian Railway network.

In October 2020, the United Transport and Logistics Company - Eurasian Railway Alliance (UTLC ERA) and Belintertrans-Germany (BIT-Germany) have launched a joint end-to-end regular multimodal service on the Altynkol, Kazakstan - Kaliningrad, Russia - Hamburg, Germany route. The service would significantly increase the transit potential in the short term, while opening additional geography of transportation. Moreover, the co-ordination of logistics processes along the entire multimodal route and the 'one window' technology will provide shippers an effective channel for planning and carrying out the transit of goods.

B. New rail infrastructure

The rail infrastructure along Trans-Asian Railway Network over recent years is being actively developed. Apart from development of new railway lines enhancement of rail hubs and dry ports capacity can be noted as an important element of rail transit efficiency. Transshippment of cargo and combination of export-import operations with transit is one of the solutions to cope with imbalanced load from East to West and vice versa, as well as from North to South and back.

Development of new routes often depends on availability of infrastructural capacities (linear and border crossing infrastructure) and in enhancement of non-linear infrastructure (logistic hubs, dry ports, marshalling yards, stations). Railway infrastructure has been actively developing over recent years and some of the important initiatives include the following.

The completion of the Baku – Tbilisi – Kars railway line in October 2017 that has opened a new railway transit route to connect the countries of Europe with Azerbaijan, Georgia, Turkey and Central Asia. It is estimated that the line could eventually transport 3 million passengers and 17 million tons of cargo annually.

6. https://company.rzd.ru/ru/9401/page/78314?id=191591

The opening of the Qazvin – Rasht railway line in March 2019, a missing link in the Trans-Asian Railway network located in the Islamic Republic of Iran, completed recently could have wider implications for regional connectivity. The newly constructed railway line is part of the International North-South Transport Corridor; now, the only missing link is between Rasht and Astara, in the Islamic Republic of Iran. Once that link is completed, South Asia could be connected to Europe through the railways of Azerbaijan, the Islamic Republic of Iran, and the Russian Federation.

Another important missing link on the Trans-Asian Railway network that would connect the Lao People's Democratic Republic with China (Boten – Vientiane) is under construction and expected to be operational by 2022. The 414 km standard gauge line is being built with support from corporations in China at a cost of $5.8 billion.

Kazakhstan is investing heavily to build its railway terminals to enhance the container handling capacity. It is constructing four new container terminals at Dostyk Station to increase the handling capacity up to one million TEUs over 2021-2024 period with investment of around USD 84 millions.

Railway infrastructure enhancement in the Russian Federation, both for linear infrastructure and development of logistics hubs, would have a large positive impact on Euro-Asian rail transit, resulting in up to 250,000 TEUs in addition to existing traffic from speed acceleration only[7]. The infrastructure enhancements are being carried out under two federal programmes of Russian Federation: (a) Transport part of the comprehensive plan for modernization and development of trunk infrastructure in the Russian Federation till 2024[8] (updated in 2020 with prolongation till 2030) and federal project "Transport and logistics hubs"[9], which is a part of the comprehensive plan. The plan supposes important investments in various rail projects, including short lines to ports, upgrade and modernization of trunk railway lines and development of new high-speed railways.

One of the key expected results is acceleration of speed along the Trans-Siberian Railway to 7 days from the port of Vladivostok in the East to Krasnoe in the West, at the border with Belarus. Transport and logistics hubs programme plan creation and development with governmental support of a dozen of major rail hubs totalling in capacity not less than 51.6 mt (chosen by their location, potential, links with other projects) that should result in decrease of logistics costs for national economy by one per cent till 2024. Development of such rail hubs could have a very high positive impact on Euro-Asian transport due to possibility to combine longer transit and shorter export-import flows as well as to balance the eastbound and westbound flows which cannot be matched without such combination due to differences in exports structure in Europe and in China.

Active developments of rail hubs are also ongoing in Western Asia, and especially in Turkey, with the launch of Baku – Tbilisi – Kars route, as well as rail-ports links. Key growing hubs are Istanbul, Mersin, Samsun (maritime and rail), Ankara, Kars (rail). Besides. the first privately-run inland cargo terminal in Kocaeli province is under development by Turkish logistics company Arkas and German-based

7. UIC / IEC study "Eurasian corridors: development potential", 2020
8. http://government.ru/docs/34297/
9. http://mintrans.org/ftpgetfile.php?id=11

Duisport (Port of Duisburg) with financing from European Bank for Reconstruction and Development and Industrial and Commercial Bank of China. The total cost of the project is estimated to USD 86 million[10]

There is enormous potential for increased Europe-Asia rail freight on various routes along the Trans-Asian Railway network. The goods carried by railway could be high-value and time-sensitive goods, such as high-tech electronics, metal products, vehicles and automotive parts/spares, and chemicals. For transportation of such goods, high transportation costs could be justified if their delivery were predictable and led to a reduction in inventory requirements for firms. However, increased container transport by railway would hinge critically on railway freight trains being economical, reliable and predictable.

C. New services along the Trans-Asian Railway network

New services refer mainly to diversification of types of commodities that can be transported by rail in both domestic and international operations. These services make available transportation of new types or forms of cargo such as fresh vegetables requiring constant temperature control and control of cargo condition within a container, or small parcels requiring special management of customs and other cargo information without discharging.

Introduction of mail only freight trains

Among the most important service that is taking shape is the postal services by mail only trains to meet the need of e-commerce and medical supplies to deal with the pandemic situation. The limitations imposed on the capacity of other modes of transport is another reason why mail only trains are seen as a viable option to deliver intercontinental mail and parcels.

Given rising importance of such trains the Universal Postal Union[11] (UPU) is organizing pilots for mail only trains from China to Europe in cooperation with China, Lithuania and Polish post with each train carrying around 300 tonnes of mail and taking 14 days. Currently Lithuania is the primary destination of such trains though some would terminate in Poland from where railheads, trucks carry parcel onward to various destinations in Europe with around 30 countries.

The UPU has set task force to better understand the performance of mail transport by rail and how its use by shippers can be further enhanced. The World Customs Organization is also engaged in the matter with a view to further simplify postal, customs, rail regulations and formalities[12].

Transport of sanctioned cargo under electronic navigation seal

Transit of sanctioned cargoes across Russian Federation with the use of electronic navigation seals were allowed by decree of the President of the Russian Federation in June 2019 following the Russian government's lifting of the ban on overland transport of sanctioned goods such as fresh foods and agriculture products. This has opened potential for new service of transport of sanctioned goods between Europe and China. The transit of these goods across the territory of Russian Federation would be tracked in real time through an electronic seal. This seal is installed on the door of container when it enters Russian Federation

10. https://www.ebrd.com/news/2019/ebrd-finances-innovative-logistics-hub-in-turkey-.html
11. https://apex-insight.com/upu-organises-china-europe-mail-trains/
12. https://mag.wcoomd.org/magazine/wco-news-85/upu-postal-rail-project/

and removed when it leaves its territory.

The system will collect, process, store and automatically transmit the information to the control authorities on location and safety of the cargo en-route. Using the system, the first shipment of frozen salmon was transported form Netherland to Shanghai, China in March 2020. The demand for imported food products from Europe is growing in China and this service has further potential for growth along the Euro-Asian railway corridors.

The figure shows the routes where such system is applied, and the red dots denote the border crossings where the installation/uninstallation of the electronic seal take place by the representatives of the Russian Railways and Centre for Development of Digital Platform who manage the system.

With increase in freight trains along the Eurasian routes-new types of commodities such as perishable goods (fresh fruits and vegetables) are being explored for transportation. Around 20 percent of China's food import approximately USD 10 billion in 2019 comes from Europe. Food imports to China increased by 53 per cent over 2018. Estimates are that this segment could contribute to around 50,000 TEUs per year. Through traditional maritime routes it takes up to 40-50 days that can be brought to 13 to 14 days via railway transport[13]. This would however need supporting infrastructure such as cold storage facilities to handle imports in railway terminals.

Development of piggyback transportation

Piggyback transport involves movement of road trains, cars, trailers, semi-trailers and detachable car bodies in loaded or empty condition. A piggyback train is of a set length consisting of specialised flatcars designed for the transport of loaded or empty road trains, cars, trailers, semi-trailers and detachable car bodies (loaded or empty) loaded by one consignor at a departure station to one consignee at one or more destination stations without additional processing on marshalling yards on the way.

Figure 8: Piggyback Transportation

Source: www.railfreight.com

13. https://www.reuters.com/article/china-railway-food-idUSL3N12R2SX20151028

The development of piggyback technology in North America, Europe and China aims to switch cargoes from road to combined rail and road transport, which reduces costs on some routes by using rail transport on a large shoulder and also has an impact on reducing the negative impact of transport on the environment. European countries are taking benefit of the advantages of counter-rail transport technology in terms of using the rail shoulder in areas that are difficult for truck access, such as mountain passes and nature conservation areas.

In addition, most EU countries have restrictions on road transport as well as programmes[14] to reduce carbon dioxide emissions. The introduction of con trailer technology on some routes reduces carbon dioxide emissions, as rail transport is less "dirty" in terms of emissions. The development of infrastructure for piggyback transport and, in general, combined transport is supported by national and pan-European programmes. For example, in France, which is currently the leader in the development of piggyback transport in Europe and has a dedicated operator SNCF VIIA.

Con trailer technology may be promising on some routes and in the EAEU market due to the possibility of reducing transport costs. However, at present in Russian Federation, for example, the technology is only in its infancy: in December 2018, federal freight company (a subsidiary of Russian Railways) organised and launched in a pilot mode a piggyback transport service for one of the Russian retail networks, which provided a vehicle loaded with goods from its own fleet on the route Novosibirsk - Moscow - Novosibirsk. For transit and export-import traffic, counter-transit transport has not been used in Euro-Asian links until now.

One of the problems with the organisation of international piggyback transportation is the need to create additional terminals at rail gauge change points, which increases the investment required for this type of transport. A significant problem is the harmonisation of the regulations of different countries and the applicable law.

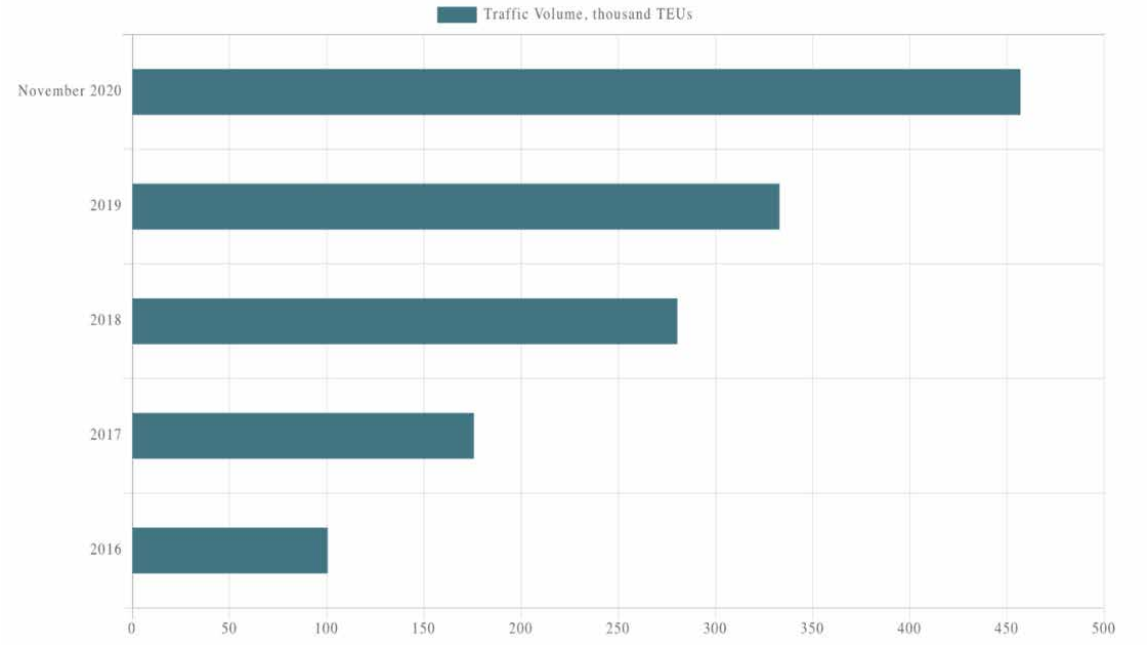
Development of piggyback technologies requires large investment programmes and governmental support. Under such conditions piggyback transportation can become a tool to reach higher level of transport sustainability and to shift to rail cargo flows (in some cases also passenger) traditionally attributed to trucking.

D. New alliances to promote international railway freight

Trans-Asian Railway Network saw a significant number of business alliances for different routes. United Transport Logistics Company- Eurasian Rail Alliance (UTLC-ERA) is the leading company in organizing container train transportation along the China- Europe route. Through its efforts the containers transported by them have been increasing consistently as may be seen from the figure below, the figure reached 455,000 TEU up to November 2020.

14. https://www.senat.fr/questions/base/2018/qSEQ181107949.html

Figure 9: Volume of traffic via routes of UTLC ERA



Source: https://www.utlc.com/en/

The company has more than 80 percent share in China- Europe-China transit container traffic transporting cargo from border of China- Kazakhstan to European union (EU) border in Poland. It has been able to reduce the transit time from China border to EU border from 6.3 days in 2017 to 5 days in 2020. The company has developed initiative like "One million club" being a new interaction platform for various rail operators along the Eurasian railway corridors.

The company has also developed first rail transit index the Eurasian Rail Alliance Index (ERAI) with an objective to keep the consignors updated on the current rail transit rates. It is a composite index consisting of the various costs involved to transit container shipments along the Eurasian rail corridor in the territory of the Eurasian Economic Union between China and the EU such as rates charged by respective railways, cost of fitting platforms, cargo delivery speed and travel time, seasonality and workload of infrastructure. The index affords (a) transparent online calculation of the transport costs on Asia- Europe- Asia routes direction; (b) analysis of different time periods and selection of the optimal transport mode;(c) provides a new level of accessibility and openness of railway transit services.

Among other alliances to foster international railway freight transport during recent years include development of East – West – East transit and related infrastructure and alliance of Chinese, Russian and European companies to enhance transit flows, DP World's agreement with the Government of Kazakhstan on ports and hubs development. More precisely, new project will be implemented in the Special Economic Zones (SEZ) in Aktau and Khorgos, as both the facilities play an important role in enhancing rail transport connectivity along the China- Europe route. The development of Special Economic Zone in Aktau will stimulate economic growth of the Kazakhstan and more importantly – it will make Kazakhstan the largest transport and logistics hub in Central Asia.

Also, for development of North – South – North connections: RZD Logistics (Russian Federation) and Indian operator Container Corporation of India Ltd have agreed to explore logistics opportunities in Russia, India along the International North-South Transport Corridor. In February 2020 both companies signed a service agreement to transport cargo between India and Russia using a single invoice. The two entities had signed an MoU last year to this effect.

For inclusion of South-east Asia to Eurasian connections Ratraco, a logistics subsidiary of Vietnam Railways, agreed with its Belarusian counterpart Belintertrans to join forces in launching new rail freight links from Viet Nam to Europe and to Belarus particularly.

II. Common priorities of the railways of members of Trans-Asian Railway network

Member countries of Trans-Asian Railway Network have different levels of railway development and modal share of rail that impacts on their railway strategies being implemented.

Review of the available documents on railway transport in member countries indicate following areas for priority as reflected in the table below (a) railway network development, (b) international railway transport (c) shift to rail; (d) sustainability and (e) digitalization Various countries apply different national strategies and specific focuses depending on their current level of rail development, as well as on other priorities.

A. Railway network development

Development of railway network is priority of most countries in the region. The construction of new lines as well as rehabilitation of existing lines to increase capacity of network is being pursed with overarching objective of increasing the capacity of railway network to meet increasing demand for freight and passenger transport. The network development is also aimed at modal shift to rail and promotion of railways as environmentally sustainable mode of transport.

As may be seen in the Box below Indian Railways have been constructing dedicated railway freight corridors with overarching objective to enhance reliability of railway freight operations. This would be done by among others increasing average speed of freight trains. More details on railway network development projects of TAR member countries are provided in the Annexes 2-6.

Box 1: Construction of Dedicated Freight Corridor by Indian Railways

Indian Railway are constructing Dedicated Freight Corridors (DFC) to enhance reliability of railway operations and set up Dedicated Freight Corridor Corporation of India Limited (DFCCIL) to supervise and manage the corridors. The DFCs consist of two railway routes, the Eastern and the Western freight corridor, and runs at a total length of 3.360 kilometers.

The Eastern DFC runs from Punjab to West Bengal and the Western DFC runs from Jawaharlal Nehru Port (Mumbai) to Uttar Pradesh. The corridors would boost capacity of railway freight infrastructure enabling considerable increases in productivity leading to significant reduction in unit transport costs as well and carbon emission due to shift of freight to rail.

The project further builds on the recent success of the railway freight sector, which was able to improve freight volumes without substantial investments in infrastructure due to increased axle loads, reduced turn-around times, and reduced unit costs. The DFC are likely to further improve competitiveness on freight operations of Indian Railways.

For network development railways could benefit from focus on such areas as:

- Establishing traffic control systems with basic digital operations
- Connectivity with railways of other countries and facilitation of border crossings
- Funding tools to support financing construction and network upgrade
- Transportation modelling to simulate various scenarios and make optimal investment decisions.

B. International railway transport

This is priority for countries with historically developed network, high modal share of railways, and especially for land-locked countries in Central Asia. The landlocked developing countries along the Europe-China route, particularly, Kazakhstan has seen increasing volume of railway transit traversing through their country. Other countries have also started to build the transit infrastructure to benefit from this trend.

For international railway transport organizations such as OSJD and OTIF play major role as they provide legal interoperability along the international railway corridors. They also can provide major initiatives for harmonized environment of international railway transport on such areas as border crossing facilitation including electronic data interchange, regional traffic management systems.

Countries that are developing international railway transport could benefit from work in areas such as:

- Advance electronic information exchange
- Reduce border crossing delays through efficient data interexchange between railways and control agencies to complete regulatory formalities and operational requirements
- Institutional arrangements for harmonizing of formalities
- Railway-customs interfaces for efficient exchange of information
- Freight flows modelling to adjust the capacities of border infrastructure

C. Shift to rail initiatives

In most countries in the region road transport dominates the modal share in both freight and passenger transport in some countries reaching as high as 80 to 90 per cent. This has obviously led to unbalanced development in modes of transport as railway transport has not got the priority in required investments. As a result, modal shift to more sustainable modes of transport is a policy priority for many ESCAP countries to mitigate the negative externalities of transport.

The national transport strategy of Thailand intends to increase freight proportion by rail from 1.5 per cent to 5 per cent. Indian railways have committed to increasing the amount of freight transported by rail from about 35 per cent in 2015 to 45 per cent by 2030[15]. For most countries the shift to rail is not going to easy as there are multiple challenges that needs to be addressed including those of financing.

A comprehensive strategy needs to be devised by each railway to increase their modal share and this needs a differentiated and calibrated approach designed for each

15. https://news.un.org/en/story/2020/10/1074552

country depending on its priorities and requirements. Table in annex provides the details of TAR countries that have official shift to rail initiatives in rail or transport strategic documents.

D. Sustainability in railway transport

Over the past many year's railways are considered as a necessary element for sustainable and greener transport. Shift to rail policies are combined in search for more greener solutions and testing of new technologies for railways. Decarbonizing railway transport through electrification of rail network is being pursued by many railways in the region- however this choice cannot be followed indiscriminately as electrification is expensive and if there is not enough traffic to justify it may turn out to be a losing proposition.

Therefore, alternative solutions are being explored on the developed networks such as by using modern rolling stock and traction: either fuel cells and hydrogen trains or battery trains, as well as use of hybrid rolling stock. These technologies are most commonly being tested for passenger transportation, and in recent years resulted in a breakthrough for application of hydrogen and battery trains both in Europe and in Asia.

In Europe railways are an important element of intergovernmental sustainability support programme resulting in the European Green Deal Investment Plan and other linked financing tools- such an overarching framework to encourage investment in sustainable modes of transport can be considered in ESCAP region as well.

Promoting sustainability, Railways are not only transport mode and part of transport connectivity but can also be source of innovative technological solutions such as on:

- Intensive digitalization, automation, e-interoperability
- Technologies for predictive maintenance
- Smart technologies for international carriage (for all issues from maintenance to operations)
- Use of new types of financing tools (like bonds, venture investment funds, etc.)

E. Digitalization

Digitalization has been a priority for many railways in the ESCAP region. The COVID-19 pandemic has accelerated this process and the need for digital solutions, so re-focus of national transport and rail strategies on the objective of digitalization is expected. In addition, a data-driven nature of the most of state-of-the-art solutions should be noted. Data is becoming a new asset of railways, and this is already considered within some national documents in the railways of TAR member countries. The spread of digitalization in railways however varies considerably among the countries in the region.

Larger railways of the region such as China, India and Russian Federation have digitalized many aspects of their railway operations. As can be seen in the Table below Russian Railways have adopted a comprehensive strategy for digitalization in 2019.

Box 2: Sustainability initiatives in Indian Railways[16]

Indian Railways has an ambitious plan to make one of the world's largest and most complex railway networks a net zero carbon emitter by 2030 in part, with support from the United Nations Environment Program (UNEP).

It has been working on greening the railways, with over half of the network electrified, and further target to electrify the entire network within next three to four years. The electrification of railway network would introduce a centralized and efficient power system with high proportion of energy coming from renewable sources.

It would eventually wean out high carbon emitting diesel engines. To ensure that source of energy itself is environment friendly- the Indian Railways has embarked on a mission to enhance energy efficiency and replace fossil fuel sources with renewable energy sources like solar and wind to achieve net zero carbon emissions by 2030. Reaching this goal would mean eliminating emissions of 7.5 million tonnes of carbon dioxide (CO2) each year, about the same as two coal power plants.

Indian Railways is also looking to make stations and installations green certified. Over 100 water treatment and recycling plants have been established to support such certification.

In addition, the Ministry of Transport of China has issued a guidance on promoting new infrastructure in transportation in 2020 for further accelerating digitalization and new technologies in railway transport. The guidance proposes to plan and promote intelligent rail transport, use more modern technologies on the train control system and railway operations, equip intelligent railway monitoring facilities to achieve real-time monitoring, remote diagnosis, and intelligent maintenance. According to the guidance, by the year of 2035, the level of railway automation, digitalization in China would be considerably enhanced. It may be however be underscored that digitalizing railways in the ESCAP region is fraught with multiple challenges such as the digital divide, fragmented levels of development of railways and concerns on data protection and cyber security. Therefore, harnessing the full potential of digitalizing railways of the region require a strategy, reflecting among others upon (a) a regional consensus on key areas to be digitalized along with a way forward to scale them up, (b) a plan of action to support railways of landlocked and least developing countries in leapfrogging to digital railways, and (c) a platform to share and learn from experience of digitalizing railways.

16. https://news.un.org/en/story/2020/10/1074552

Box 3: Digitalization of Russian Railways

Comprehensive digital strategy of Russian Railways adopted in 2019, including e-data exchange with other railways and non-rail authorities

In the course of the Long-Term Development Programme until 2025 Russian Railways has allotted RUB 168 bn (EUR 2,36 bn) to IT development. RUB 99 bn will go towards informatization, RUB 65 bn towards equipment and communication upgrades and RUB 4 bn towards the Intelligent Railway Transportation Management System (IRTMS).

The overarching "Digital Railway Concept" encompasses funding for Digital Railway R&D. Eight digital platforms will be created to achieve the digital business goals of Russian Railways: for multimodal passenger transportation, for multimodal cargo transportation, for the operator of linear infrastructure; for the logistics operator of e-commerce, for non-production processes, a transport process management platform, a traction rolling stock platform.

To ensure the functioning of the target digital platforms, priority is given to the creation and development of a digital technological base. In particular, it is planned to apply advanced domestic innovation developments based on the following digital technologies: data storage and management, data exchange, information and technology infrastructure, the industrial Internet of things, quantum computing, distributed registry.

Source: Russian Railways

Table 1: Priorities of TAR member countries (non-exhaustive)

Country	Key rail-related strategic documents	Priorities
Azerbaijan	2017 Railway Sector Development Program[17]	
Bangladesh	Seventh Five Year Plan (2016-2020)[18]; Railway Master Plan (2010 – 2030)[19]	

17. https://www.adb.org/projects/48386-004/main#project-documents
18. http://nbr.gov.bd/uploads/publications/154.pdf
19. http://railway.gov.bd/sites/default/files/files/railway.portal.gov.bd/page/79cb80ef_3268_44cd_93c3_09e9bb7f61ab/1.%20Introduction_Master%20Plan.pdf

Country	Key rail-related strategic documents	Priorities
Cambodia	Connecting Greater Mekong Subregion Railways - A strategic framework - ADB[20]	
China	13th Five-Year Plan for Economic and Social Development of the People `s Republic of China 2016-202021	
India	100 Days Action Plan of Ministry of railways – 2019	
Iran (Islamic Republic of)	Iran Vision 2025[22]	
Kazakhstan	Development Strategy of National Transport Company of Kazakhstan till 2025[23]	
Kyrgyzstan	National Development Strategy of Kyrgyz Republic till 2040[24] Key directions of railway transportation development 2014-2020[25]	
Lao People's Democratic Republic (the)	Connecting Greater Mekong Subregion Railways - A strategic framework - ADB	
Malaysia	National Land Public Transport Masterplan – SPAD – 2013[26]	
Mongolia	Concept of sustainable development of Mongolia till 2030[27]	
Myanmar	National Transport Masterplan[28]	

20. http://hdl.handle.net/11540/1037
21. https://www.greengrowthknowledge.org/national-documents/13th-five-year-plan-economic-and-social-development-peoples-republic-china#:~:text=Republic%20of%20China-,The%2013th%20Five%2DYear%20Plan%20for%20Economic%20and%20Social%20Development,the%20People's%20Republic%20of%20China&text=This%20plan%20is%20to%20serve,among%20the%20people%20of%20China.
22. https://www.mcls.gov.ir/en/irv; https://irandataportal.syr.edu/20-year-national-vision
23. https://www.railways.kz/sites/default/files/development_strategy_ktz_until_2025.pdf
24. http://www.president.kg/sys/media/download/52135/
25. https://online.zakon.kz/Document/?doc_id=31613734
26. https://www.apad.gov.my/sites/default/files/nlptmp_bi_version_8_nov_13.pdf
27. https://www.greengrowthknowledge.org/national-documents/mongolia-sustainable-development-vision-2030#:~:text=Mongolia%20would%20achieve%20the%20following,per%20cent%20through%202016%2D2030.
28. https://openjicareport.jica.go.jp/pdf/12230728_01.pdf

Country	Key rail-related strategic documents	Priorities
Russian Federation	Transport Strategy of the Russian Federation till 2035[29]; Long-term development programme of JSCo Russian Railways till 2025[30]; Comprehensive Plan for the modernization and expansion of trunk infrastructure of Russian Federation till 2024[31]	
Tajikistan	National Development Strategy of Republic of Tajikistan till 2030[32]	
Thailand	Thailand National Transport Master Plan 2011-202033; Thailand's Transport Infrastructure Development Strategy 2015-2020[34]	
Turkey	TCDD 2019-2023 Strategic Plan[35]	
Turkmenistan	National Programme for Social and Economic Development of Turkmenistan until 2030[36]; Programme of the President of Turkmenistan for Social and Economic Development for the period 2019-2025[37]	
Uzbekistan	Transport strategy of Uzbekistan till 2035[38]	
Viet Nam	Transport Strategy 2020	

29. https://mintrans.gov.ru/ministry/targets/187/191/documents
30. http://static.government.ru/media/files/zcAMxApAgyO7PnJ42aXtXAga2RXSVoKu.pdf
31. http://static.government.ru/media/files/MUNhgWFddP3UfF9RJASDW9VxP8zwcB4Y.pdf
32. https://nafaka.tj/images/zakoni/new/strategiya_2030_en.pdf
33. https://esci-ksp.org/archives/project/thailand-transport-and-traffic-development-master-plan-2011-2020
34. http://www.otp.go.th/uploads/tiny_uploads/PolicyPlan/1-PolicyPlan/M-MAP2/25600629-PDF1-Dr.Pichet.pdf
35. http://www.sp.gov.tr/tr/stratejik-plan/s/1892/T.C.+Devlet+Demiryollari+Isletmesi+Genel+Mudurlugu+_TCDD_+2019-2023
36. http://turkmenistan.gov.tm/?id=19229
37. https://www.mfa.gov.tm/ru/articles/4
38. https://regulation.gov.uz/uz/document/3867

III. Initiatives of railway and subregional organizations

This chapter aims at providing a brief and non-exhaustive comparison of initiatives of the railway and subregional organization. Based on the types of publicly available realized and project studies a profile of each organization is formed. In relation to this profile, organizations also propose different tools and studies for post-pandemic recovery, from international benchmarking to direct financing.

There two main approaches used by these organizations: country-based approach: focus on national priorities and available tools with stronger assessment of economic, social and environmental effects of transport projects. This approach is mainly used by development banks (except for CAREC corridor-based programme). And second is corridor-based approach: focus on international links, connectivity, interoperability and internationally (widely) acceptable solutions.

Dedicated rail organizations usually combine the two approaches with additional tool-based (or solution-based) approach arising from the practice of railways. Several directions of strategies of organizations needs to be mentioned within this study as a they are linked to the key policies and trends described in Chapter 2.

Railways as a central pillar of sustainable transport: This direction has been most actively developed by UNCRD (Environmentally sustainable transport development solutions and trainings), ASEAN (as a part of Master Plan on ASEAN Connectivity 2025).

International railway connectivity: Such policy approach is usual for international institutions working with land-locked countries such as the CAREC programme of the ADB and the Economic Cooperation Organization. In the beginning of 2020, a new CAREC Transport strategy 2030 was issued focussing on ten projects in Central and Eastern Asia

accounting for 5 per cent of total financing for railway projects announced in the first quarter of 2020.

ECO actively supports railway connectivity in Central Asia as well: one of the recent projects carried out in partnership with ESCAP refers to development and commercialization of Kazakhstan – Turkmenistan – Iran railway corridor. UIC's report "Eurasian corridors: development potential" presents results of a mathematical modelling of the impact of various factors and programmes, as well as of the economic background on the volumes transported and allocation of flows by different corridors between Europe and Asia.

Rail interoperability and digitalization: Technical interoperability of railway transport is mainly addressed by dedicated organizations, such as Intergovernmental Organization for International Carriage by Rail (OTIF), Organization for Cooperation Between Railways (OSJD) and UIC by issuing various standards, international railway solutions, technical specifications. But a new trend to address digitalization is also being separately addressed by Eurasian Economic Union (EAEU) through development of digital corridors[39]. All the trending policies are being at least partly implemented among the TAR member countries. But due to existence of different organizations focused on different subregions there is a lack of uniformity in application of such railway policies and solutions that results or could result in inefficient network connectivity along the TAR member countries.

In 2018-2019 a concept of EAEU digital transport corridors was developed as a part of EAEU digital agenda with objective of reaching e-interoperability resulting in time and cost savings for rail transport. Common ontologies, catalogues and standards, single object and subject systems are being advocated for use to avoid new barriers within the cross-border space and to reach the necessary synergetic effects for all the participants of integration processes. The concept includes analysis of key factors and conditions for the establishment of a uniform digital transport ecosystem, analysis of existing constraints and alternatives, proposal on organizing scheme. Starting from 2020 this concept should result in further development of the digital ecosystem.

Digital issues will most probably be in the focus of UIC, as well as almost all other organizations in the post-pandemic realities. Until now UIC has worked out a series of IRS (International Railway Solutions) on traffic management and train communication systems (elaboration of documents on Future Rail Mobile Communication System is ongoing). UIC also provides documentary support on international ticketing for passenger transportation.

The profiles of these organization are tabulated in the Table 2 below.

39. http://www.eurasiancommission.org/en/nae/news/Pages/17-05-2018-2.aspx

Table 2: Profiles of international organizations presented in Asia (non-exhaustive)

Organization	Type	Types of rail-related activities	Region(s)	Connectivity	Border crossing	Rail interoperability	Sustainability	Digitalization	Financing
ASEAN	Subregional organization	Soft	South-eastern Asia						
EAEU	Subregional organization	Soft	Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russian Federation						
ECO	Subregional organization	Soft	Western and Central Asia						
UN ESCAP	Multilateral organization	Soft	ESCAP member countries						
UN CRD	Multilateral organization	Soft	Global (HQ – Japan)						
CCTT	Non-governmental multilateral organization	Soft	Eurasia						
ADB	Development bank	Hard + soft	Global Focus on Central Asia in CAREC programme						
AIIB	Development bank	Hard + soft	Global						
The World Bank	Development bank	Hard + soft	Global						
OTIF	Intergovernmental rail organization	Soft	Eurasia						
OSJD	Intergovernmental rail organization	Soft	Eurasia						
UIC	Non-governmental international rail organization	Soft	Global						

Lower importance

Highest importance

Indirect financing (research and assistance)

Direct financing of projects

IV. Impact of COVID-19 pandemic on railway freight flows along the Trans-Asian Railway network

A. Macroeconomic background

Current situation in global economy is a first-of-its-kind crisis, combining a global economic slowdown with an unexpected fast de-globalization caused by COVID-19 pandemic, and intentional closure of borders. It is apparent that the rapid growth of Euro-Asian freight volumes that was observed in recent years due to positive economic dynamics may not continue in the near future by itself, and strategies of the market players would require changes.

The current macroeconomic situation differs from normal slowdown cycle, as it is reinforced by a 'virus crisis', and thus, it is not just economic recession, but economic plus pandemic crisis with the following characteristics.

Supply shock instead of demand

Usual economic recession leads to the decrease of credit financing volumes, fall in stock markets and decline in demand. Due to suspension of production and border closures to prevent spread of pandemic, a supply shock is observed. Supply chains are broken at different stages, and interruptions or suspensions on the earlier stages stop impact final production. The supply shock would impact demand.

New measures of support are required

The supply drop cannot be overcome by usual anti-crisis measures of support from governments and national banks. And, as the situation is the unique one, no proved solutions exist. There is no tested recipe for governmental position on the additional support to infrastructure or transport operators for this case.

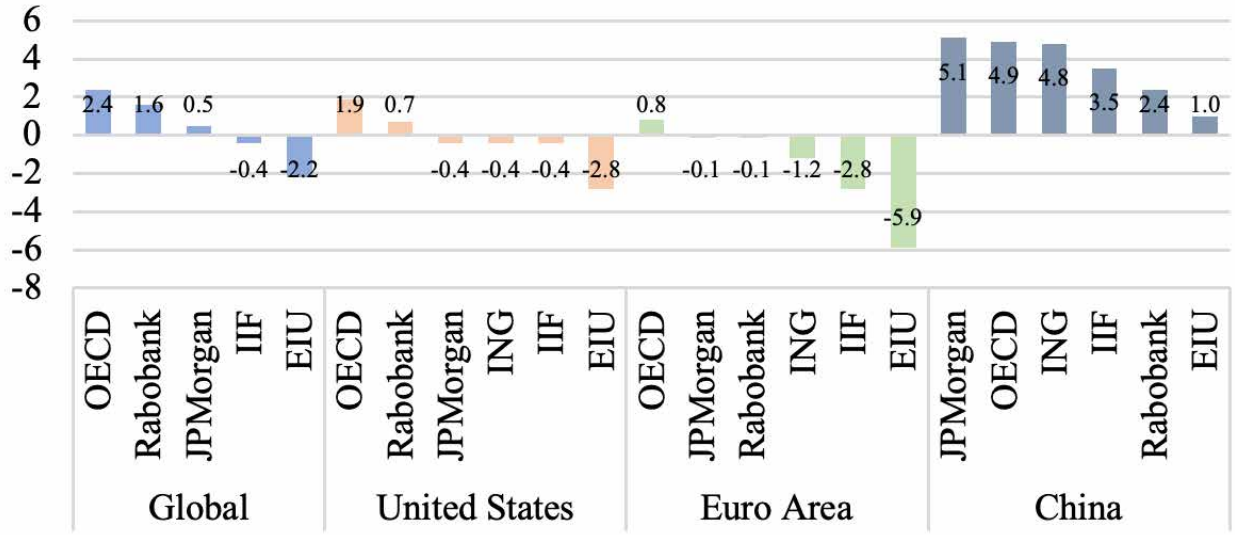
Trade recovery would be delayed due to lack of uniform responses

The spread of COVID-19 virus followed by asynchronous and non-uniform actions of countries for closure and opening would negatively impact trade restoration. The case of China is an illustrative example: being reopened first, China faced under shipment of goods that were ready for export, but at the same time was limited by the suspension of production in the EU.

Future economic trends are hard to predict

Further development of economic situation depends on non-economic factors: spread of COVID-2019, decisions of governments and businesses, effectiveness of anti-crisis measures. All this causes disparity in figures proposed by different experts, as well as decreases the average accuracy of the forecasts.

Figure 10: Differences in GDP forecasts by regions.



Source: official publications of indicated institutions, as of April 1, 2020

B. Transport connectivity along the Trans-Asian Railway network

The transport connectivity along the network was affected due to closure of borders by the countries. The impact on connectivity along the network during the pandemic has been considered by a topological connectivity index. The index is used to evaluate the network connectivity linked only to border closures and not to rail network performance (speed, traffic carried etc. – these factors are considered as unchangeable). Most of the border crossings remained opened for freight traffic, while considerable of them were closed to passenger transport. It is reflected in the value of index which was 0.62 considering the closure for passenger transport and 0.85 for freight transport indicating deeper adverse impact rail connectivity for the passenger transport. The methodology for calculating index as well as the border crossing considered are provide in the annex to this Note.

Passenger operations

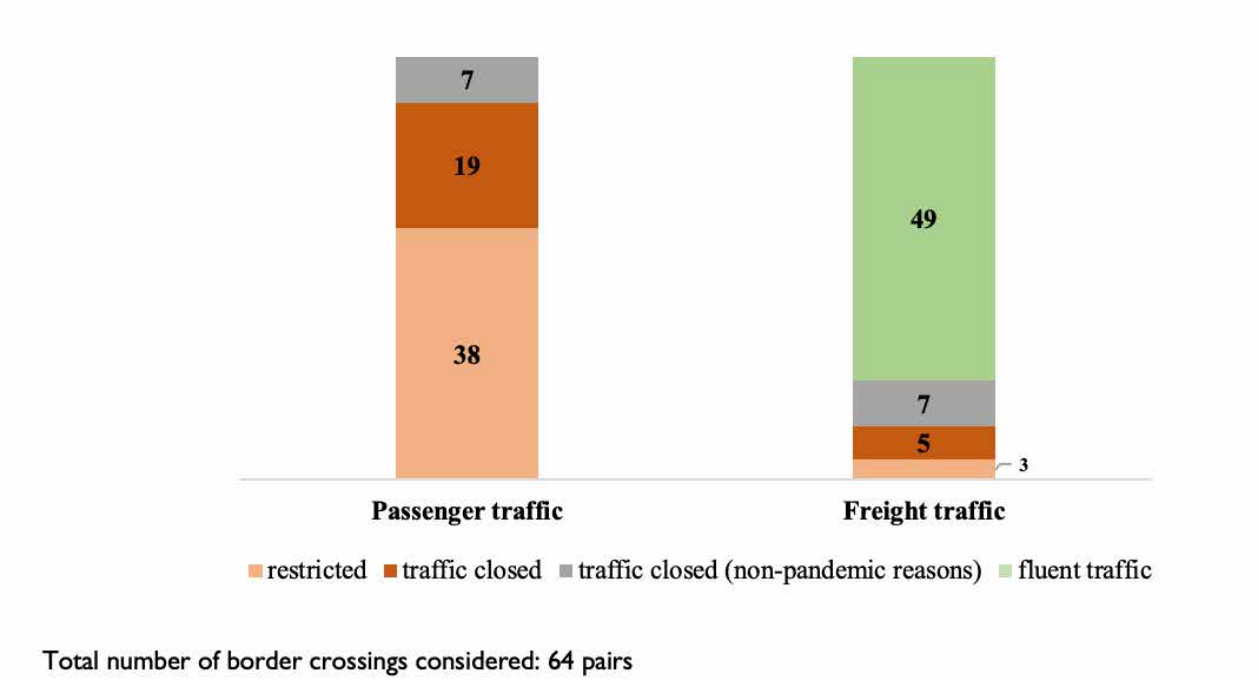
As of September 2020, more than 50 per cent of the railway border crossings operate with severe restrictions and others are closed for any passage. The set of restrictive measures vary from country to country such as: temporal restriction for entry except for certain citizens (members of official delegations and diplomatic missions, family members of citizens, employees at transportation) and mandatory health tests for those who enter. At some border crossings like Singapore – Malaysia measures are moderate and additionally permit entry with work permission with a mandatory 14-days staying home.

Passenger traffic is restricted at borders of the countries in Central Asia. Some borders at Caucasus region are closed due to non-pandemic reasons. As can be seen in the Figure 12, Connectivity index for rail passenger transport is the lowest due to high restrictions at many border crossings: the connectivity index equals 0.66 with COVID-

19 measures, which is about a 30 per cent less compared to non-pandemic situation.

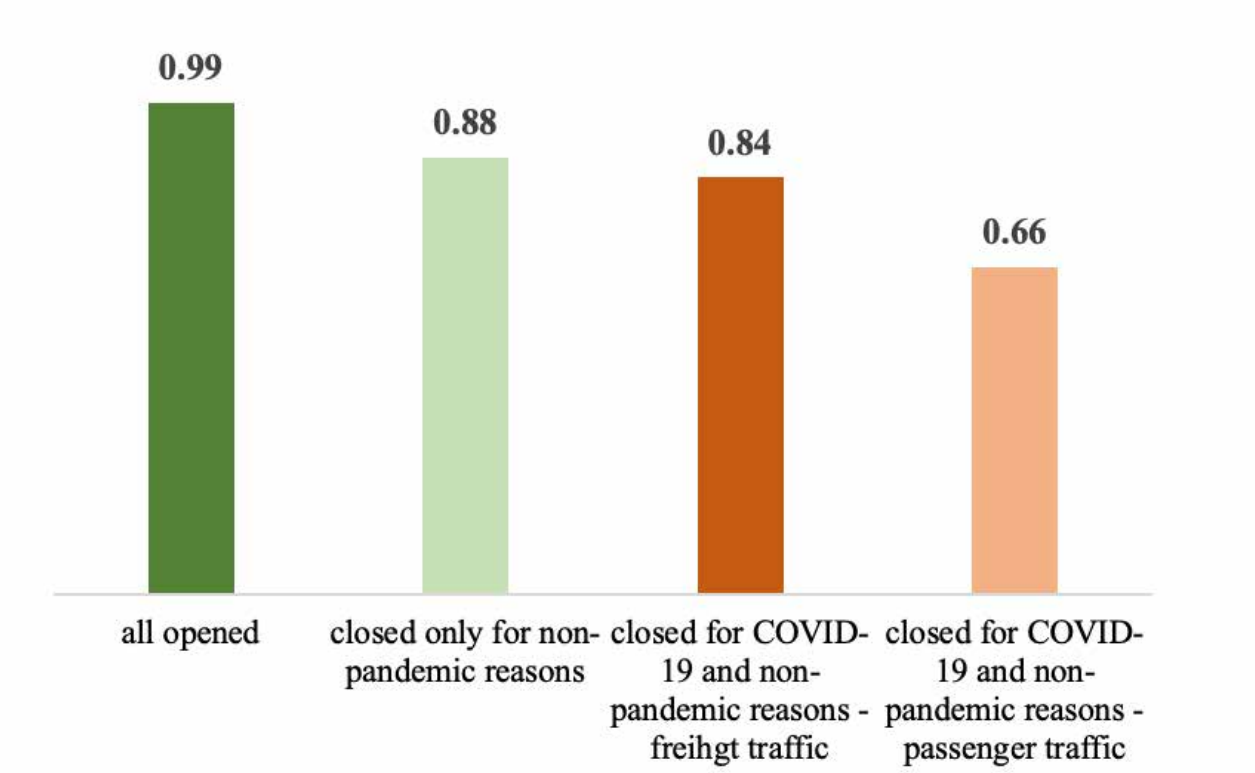
In addition, currently there is no border crossing with fluent passenger traffic. Not only border crossing is restricted, but also international passenger train services are almost fully suspended. As of September 2020, most closed areas are Central Asia (with almost all border crossings of Turkmenistan) being closed, South Asia (India and neighboring countries), Eastern Asia (Mongolia and Democratic People's Republic of Korea). Other countries have also imposed serious restrictions and have no operational international train services. A recent study done by ESCAP on efficient operations of international passenger trains along Trans-Asian Railway Network has indicated enormous untapped potential for such trains. To harness this potential, it recommended that the railways of the region to further harmonize border crossing issues for passengers, streamline facilities at railway stations and encourage extensive use of new technologies to enrich passenger experience and in undertaking regulatory controls. Though the pandemic has dealt a blow to the nascent market of international rail passenger transport operations in ESCAP region, the railways can use this time to strengthen their infrastructural and institutional capacity and prepare themselves better for post-pandemic rail passenger operations.

Figure 11: Status of border crossings in ESCAP member countries[40] during the Pandemic



40. As of September 15, 2020

Figure 12: Topological connectivity index of Trans-Asian Railway Network[41]



Freight connectivity

Freight traffic situation is fluent at 49 pairs of border crossings out of 64, according to available data. Some countries have established green lanes to ensure faster clearance of food, relief and essential supplies. Extra priority is provided for processing of any goods related to COVID-19 pandemic (like medical stuff). At the same time, attendants are subject to health check at many borders. Transit is mostly fluent without additional checks but with a health check of attendants. In recent months, the situation changed at Islamic Republic of Iran's border crossings with Turkey, Pakistan, Turkmenistan where borders were reopened on mutual agreement. The highest number of freight traffic restrictions geographically have been observed in Eastern Asia. According to the connectivity index, freight traffic along the Trans-Asian railway network operated smoothly despite some restrictions at North-South corridor.

The loosening of restrictive measures on freight traffic since May 2020 increased the connectivity index to 0.84 for rail freight in comparison to 0.79 in May 2020- its value before COVID-19 was 0.88. Still, it should be noted that during the pandemic there were no major changes in rail freight connectivity, most of the border crossings being fluent for cargo transportation with some minor restrictions or procedural requirements for sanitation of rolling stock.

Even though rail freight transportation is generally exempted from border crossing restrictions, there are other types of constraints

41. As of September 15, 2020. Only full closure is considered for calculation of index.

that affect operational connectivity and increase transport time such as imposing special procedures for rail staff. For example, all trains arriving to Turkmenistan are subject to disinfection[42].

An important constraint for seamless rail freight operations is existence of paper-based documents which is still being used in most countries in the region. Railway staff (locomotives, stations, marshalling yards) of one country is obliged to pass required papers to the railway staff of other side, as well as to border authorities. This requires physical interaction imposing additional health checks and special procedures for the papers themselves as in case of China – Viet Nam where all paper documents are being subject to disinfection. To reduce the paper from railway transport, many countries automated and digitalize the operations to cope with the pandemic risks.

C. Initiatives by railways of region during COVID-19

In response to COVID-19 outbreak and its impact on connectivity along Trans-Asian Railway Network many initiatives to facilitate remote services, electronic linkages between customs and railways have been implemented or in process of implementation in different countries, especially in transit ones. Selected measures taken by railways of the region are indicated in the Selected measures by railways of the region during COVID-19 below.

More comprehensive picture of special measures taken by different countries as a part of policy response policy to pandemic in ESCAP region can be found in the note on:" Policy responses to COVID-19: Transport connectivity in Asia and Pacific"[43]. However, with respect to railways following trends are apparent.

- Most national railway strategies have yet to considers the full impact of COVID-19 pandemic in medium and long term
- There is no dedicated funded support programme for railways at international level yet[44]
- Railways proved to be reliable transport means to maintain the sustainable connectivity along the Trans-Asian Railway network- as the rail freight flows avoided major restrictions
- Pandemic helped in promoted faster solutions and special regulations (like establishment of green lanes for medicine products)
- Pandemic gave further momentum to digitalization of railway transport even in countries with relatively low level of digital services
- New solutions for customers and services, primarily digital, were proposed in many countries.

42. https://wiki.unece.org/download/attachments/101548532/405%20-%2010042020%20-%20Geneva%20-%20UNECE%20-%20cargo%20procedures.pdf?version=1&modificationDate=1586847133274&api=v2
43. https://www.unescap.org/resources/policy-reponses-covid-19-transport-connectivity-asia-and-pacific
44. Unlike the issuing of directive 2012/34/EU in the EU that followed calls for support from international railway organizations. https://www.railjournal.com/news/ec-proposes-economic-relief-measures-to-support-rail-through-pandemic/?utm_source=&utm_medium=email&utm_campaign=17474

Table 3: Selected measures by railways of the region during COVID-19

China	Additional national and international rail freight services were launched or enhanced during the COVID-19 outbreak (e.g. a rail-based freight services to Wuhan, increased frequency of transcontinental train services and ocean-to-rail services). The National Development and Reform Commission said in July allocated 200 million yuan (28.3 million US dollars) from the central budget to support the construction of transportation hubs in five freight assembly cities: Zhengzhou, Chongqing, Chengdu, Xi'an and Urumqi[45].
Georgia	Within the framework of the measures to prevent the spread of COVID-19, movement of the freight vehicles through the customs checkpoint on Georgian-Azerbaijani border (including transit and rail freight traffic) is ensured according to the specially developed protocol in 24-hour regime.
India[46]	A set of measures to boost freight transportation by rail via tariff and non-tariff regulations, as well as communication initiatives (like publication of direct contact numbers and website details which can be accessed by traders for transporting freight) was set up by Indian Railways.
Islamic Republic of Iran[47]	The Railway of Iran (RAI) installed wagon disinfecting tunnel at Kapikoy border with Turkey for accepting and dispatching wagons via Razi border. It is observing health protocols for railway personnel by supplying personal protection equipment. All the technical data of disinfection equipment and tunnels at the borders shared with railways of Turkmenistan and railway borders reopened on 10 June 2020.
Kazakhstan[48]	All railways-related processes to be carried out remotely in electronic system. The system allows customers to pay fees, fines without leaving home. In addition, for the period of the state of emergency, KTZ (national railway administration) abolished fines, fees and charges associated with the carriage of goods
Kyrgyzstan	Kyrgyz Temir Zholu (national railways) waived charges, fees or penalties for storing cargo on the container site and on the wagon located at Kyrgyz Temir Zholu railway stations. The company also reduced the cost of transportation by rail for coal exporters by 30 percent, at a distance of up to 30 km for the Southern branch of Kyrgyz Temir Zholu.
Russian Federation	RZD (Russian Railways) set up an Emergency Response Center to support shippers and enhance coordination of all links in the transport chain. Also, a simplified procedure for remote interaction with freight customers has been established.

45. http://epaper.chinadaily.com.cn/a/202008/11/WS5f31ecafa3107831ec7542fa.html
46. https://zeenews.india.com/economy/indian-railways-takes-several-initiatives-in-tariff-non-tariff-field-to-boost-freight-operations-amid-covid-19-challenges-2306001.html; https://www.transportjournal.com/fr/home/news/artikeldetail/indian-railways-seizes-opportunity.html
47. https://www.unescap.org/sites/default/files/5_Session%202_Iran.pdf
48. https://www.railjournal.com/regions/europe/irj-in-brief-coronavirus-cd-partially-resumes-services-ns-builds-ventilator-powerpacks-china-donates-face-masks-to-mav/

Russian Federation (cont.)	The Government of the Russian Federation proposed reduction of rail transportation tariffs through subsidizing the carriers. Subsidies will vary from between 25.000 and 77.000 roubles depending on the type as well as the destination of the transit cargo[49]. The new measure covers transit routes between ports on the Pacific, Baltic and Black seas, as well as checkpoints on the border with Finland, Belarus, Poland and Azerbaijan.
Turkey	Turkish Railways is undertaking freight transport with Iran without human contact and all freight trains are disinfected both before and after the trip[50].
Uzbekistan	Uzbekistan Railways developed a software for processing and providing preliminary electronic information to customs authorities for goods transported by rail. Uzbekistan Railways extended until the end of 2020 a 30 percent discount on the transportation of all goods transported through Uzbekistan to the south of the Kyrgyz Republic and in the opposite direction.
Viet Nam	Viet Nam railway continued in freight operations with China after due precautions that included 100 per cent equipped with anti-epidemic tools such as glassed, PPEs, masks and clothing. The documentation related to trains is also decontaminated[51].

D. Impact of COVID-19 on railway freight along the Trans-Asian Railway network

The section dwells on the impact the crisis has and would have on rail freight from two perspectives- connectivity and freight flows/ markets that are further explained below.

Connectivity

The situation caused by pandemic is characterized by differences in passenger and freight connectivity due to full or partial closures of national borders and border crossing procedures. Going forward their would-be challenges related to easing of border crossing restrictions or partial restrictions depending on the how the pandemic situation evolved in each country. This could lead to high level of uncertainty regarding further restrictions, decreasing planning period for freight shippers and all other stakeholders. Potentially asynchronous actions by countries and significant differences in admission rules from country to country and additional health checks for personnel accompanying the cargo through the border crossings (if any necessary) will be other challenges on rail connectivity and this could reduce first and last mile connectivity.

There are several opportunities arising from the pandemic having implications for connectivity. In short run they include priority/ green lanes for transit freight trains introduced by many countries. Also, railway border crossings have less restrictions than road leading to balance shifting towards rail freight. Over long-term railways freight could become even more competitive for international and national connectivity as it is faster (than sea), cheaper (than air), and requires less staff (than trucks). The pandemic has given encouraged e-connectivity and overall digitalization of rail freight transit and use of electronic documents that could further boost the comparative advantages of railway freight.

49. http://government.ru/en/docs/40269/
50. https://www.unescap.org/blog/covid-19-pandemic-international-freight-trains-lead-way-future
51. https://www.unescap.org/sites/default/files/10_Session%202_VietNam.pdf

Rail freight flows and market

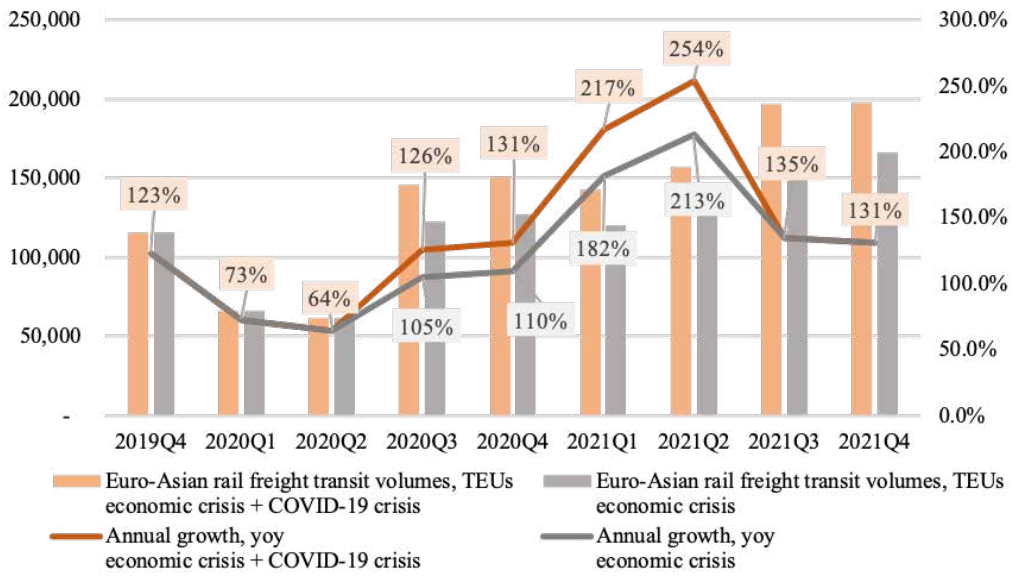
The distinctive feature of this double crisis is that not only freight volumes and market shares would change but also geography of transportation and the structure of market due to the disruption of supply chains and asynchronous actions by railways. Many of the current expectations are based on 'baseline' or even optimistic economic assumptions not considering potential impact from de-globalization that the pandemic may lead to.

Accordingly, key challenges to rail freight flows would come from slowdown of economic growth and therefore of regional and international trade. Prolonged slowdown could disrupt the supply chains resulting in suspension of some rail services such as project-based logistics. However, in short term under shipment of goods and the necessity for fast, reliable and relatively cheap transportation services of medical goods till the pandemic persists may result in higher demand on fast rail services.

As the active spread of COVID-19 and related changes in freight transport started in 2020, not much data is available to assess likely impact. What can still be predicted is the difference between cyclic economic crisis (slowdown) that has been developing since the end of 2019 and additional pandemic crisis.

While cyclic economic crises lead to slowdown in growth, decrease in demand and decline in volumes - the COVID-19-related crisis, which is spreading faster, has resulted in under-delivery of already produced goods. This lack of supply which varies significantly for commodities needs to be addressed after containment measures are lifted and that provides short-term opportunities of larger transport volumes (+20-40 per cent in comparison to situation without pandemic)) for railways - which is faster than sea and less exposed to risks of transport restrictions than roads. This is clear given the freight flows for transit Euro-Asian routes via Kazakhstan, notably via Dostyk and Russian Federation and Belarus, were 75 per cent higher in the second quarter of 2020 than for same quarter in 2019.

Figure 13: Possible impact of economic crisis and the pandemic on railway freight flows[52]



Source: IEC modelling with TMF software based on JPMorgan and ING forecasts (as of April 1, 2020)

Figure 13 indicates possible impact of economic crisis and pandemic on rail freight flows. It indicates growth of rail freight traffic by quarters in percentage to previous year (123 per cent in Q4 2019 means +23 per cent to Q4 2018). Overall traffic increases in 2020 and 2021 in comparison to 2019 following trade growth. Additional volumes (annual growth line indicated in orange) related to the pandemic cause a higher increase than the one that could be predicted before COVID-19 outbreak.

Still in 2021 the growth rate of volumes will most probably slowdown due to an expected slowdown in both Asian and especially European economies. Additional rail flows generated by specific conditions of the pandemic could partly or fully (depending on additional measures of support from governments and joint strategies of rail market stakeholders) disappear due to shift back from rail to road, maritime and air transportation of general cargo, postal flows and e-commerce goods, as well as to no demand for medical cargo flows.

A prolonged pandemic with significantly asynchronous trends of COVID-19 spread and recovery in Europe and Asia would deepen economic crisis further decreasing demand and under-delivery. In any case, COVID-19 pandemic has led to disruptions and could even permanently impact the regional and global supply chains. Despite the challenges, railways would have chance to become a remedy for quick restoration of Euro-Asian links due to inherent advantages-faster, flexible in volumes (also suitable for smaller amounts and parcels), coverage of long distances and lower prices in comparison to air.

52. Note: This chart does not intend to provide any projections of freight volumes or timeline of changes, it is supposed to illustrate the peculiarities of COVID-19 pandemic impact on rail freight transportation.

PART II:

Smart Railway Solutions for greater sustainability and resilience along the Trans-Asian Railway network

Overview of the part II on Smart Railway Solutions

This part of the study explicates on the Smart Railway Solutions for deepening sustainable railway transport along the Trans-Asian Railway Network. This part elaborates on the seven modules for smart railway solutions and include following areas: railway operations, predictive maintenance, rolling stock, railway border crossings, client orientation and railway financing- each module has further sub-modules that go into specific solutions.

The first module is explicating on the smart railway operations – it has two submodules- one is on automation of railway terminal and the second one on automatic train operations.

The first submodule covers: automation of loading/unloading including stacking, storing, transporting the cargo/containers at and between terminals, and facilitation of container transshippment; use of intelligent gate systems; automation of train formation / marshalling including in automatic wagon coupling; and state-of-the-art terminal/yard management IT systems.

The second submodule covers advance traffic management systems using modern technologies including European Railway Traffic Management System, the Chinese Train Control System.

The second module on smart railway maintenance elaborates on conditional and predictive maintenance along with related case studies. The next module is on smart train driving expanding on automatic train operations and potential benefits of such operations including energy efficiency and cost reduction.

The fourth module on smart railway border crossings details on electronic information exchange between railways and among railways and control agencies; use of new technologies in railway operations; harmonization of customs formalities for international railway transport; joint border controls and single stop inspection.

The next module on smart railway customer orientation demonstrates the use of railway freight mobile application for customers for easy access the information. The final modules on smart railway investment explain on various options to finance railway investments. Modelling tools are explained that would help create scenarios to optimize railway investments.

Smart railway solutions have been successful elsewhere and are potentially replicable and scalable. However, not all solutions would have equal importance or relevance for the railways of the region. Each railway could assess its own situation and determine which smart solutions would be more beneficial and applicable for them.

A. Smart railway operations

A1. Automation of railway terminals

Optimization of the processes at railway stations, terminals shunting, and marshalling yards could be supported by smart railway solutions based on automation and could include:

- Automation of loading/unloading, including stacking, storing, transporting the cargo/containers at and between terminals, and facilitation of container transshippment
- Use of intelligent gate systems
- Automation of train formation / marshalling including in automatic wagon coupling
- State-of-the-art terminal/yard management IT systems.

The railway stations, terminals shunting, and marshalling yards have many distinctive characteristics and differences with regard to size, type of railway operations offered, type of goods/wagons they are dealing with, location, number and type of stakeholders, and opportunities for logistics operations to be organized. Accordingly, various smart railway solutions based on automation, are being developed to better reflect the specific needs railway stations, terminals and yards.

Automation of loading/unloading

The processes for loading/unloading of goods in railway transport depends primarily on the type of cargoes (e.g., in bulk, palletized and/or containerized) and corresponding type of wagons being used.

For example, loading of bulk cargo (e.g., coal, ore, grain) in hopper wagons could be automated with Train load-out (TLO) systems, which are safe, efficient, and accurate. With automated TLO systems, the loading could be controlled both locally and remotely, and the train could be loaded while moving in low speed with minimal use of human workforce.

Automated systems for unloading of bulk cargo could be employed in various options depending on different types of wagons used (such as ordinary open wagons and/or hopper wagons).

Automated loading and unloading for palletized cargo and smaller loads transported in covered wagons. These systems offer automation by transporting of pallets to covered wagons with unmanned vehicles, as a replacement for use of standard mechanical loading/unloading with forklifts.

One of the priorities for development of railway transport in the region is increasing efficiency of containerized cargo movements. The automation of the loading/unloading process at container terminals can be achieved by automated rail mounted gantry (RMG) cranes or rubber tyred gantry (RTG) cranes, however fully automated solutions presently are still not very common at railway terminals.

Figure 14: Example of Train Load Out operators' screen

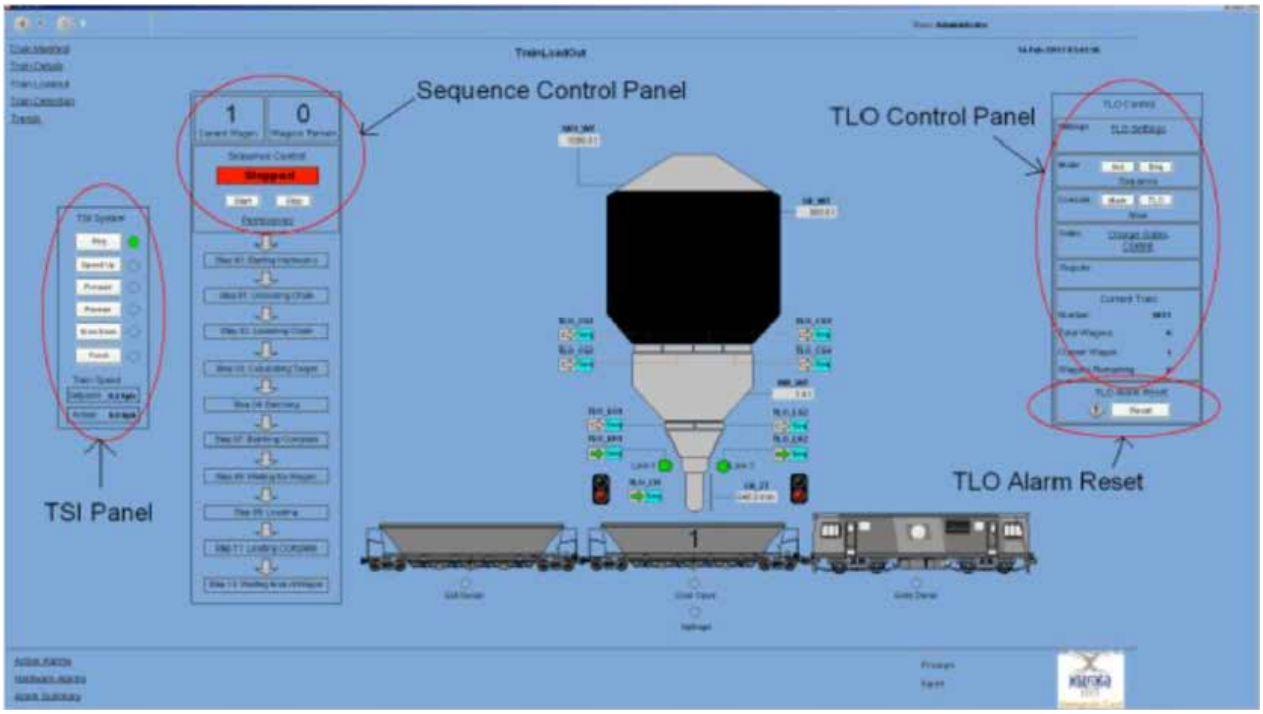


Figure 15: Container handling equipment at railway terminals

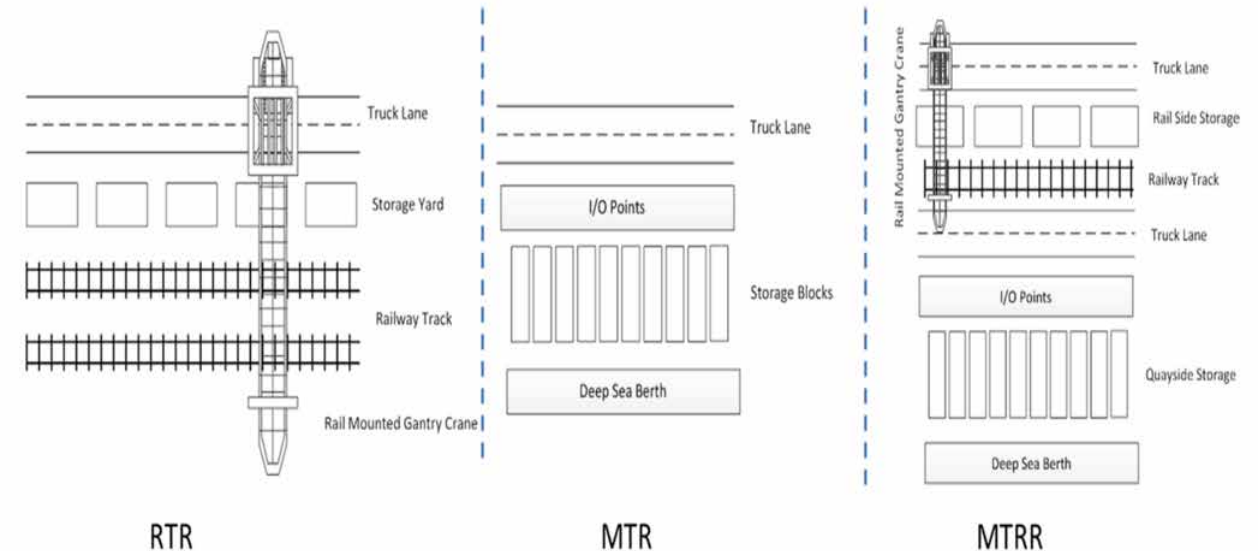
Source: Peter Hodgkinson, UN ESCAP presentation on Concepts and methods for designing and operating dry ports

Different innovative intermodal solutions are implemented for container transshipment between road and railway transport to achieve automated loading/unloading (one-man-operated), such as the ContainerMover system, the MOBILER, the BOXmover Side Loader and so on. These innovative solutions open various options for transshipment and intermodal services, enable optimization of loading/unloading processing and reduction of processing time.

The processes of organization, optimalization and automation of container handling depend on the location of the railway container terminals and their linkages to other intermodal nodes. The railway container terminals could be located at inland interchange hubs between railway and road traffic (RTR); at seaports (with direct on-dock railway connection)(MTRR); or nearby seaports (with off-dock railway connection through inter-terminal transport

between the seaport and railway terminal) (MTR); and similarly, at or nearby inland water (river) ports.

Figure 16: Types of container terminals with railway connection



Railway terminal with road connection

Maritime terminal with road connection (off-dock rail connection at RTR)

Maritime terminal with both road and on-dock railway connections

Source: Qu Hu, Bart Wiegemans, Francesco Corman, Gabrie Lodewijks, Integration of inter-terminal transport and hinterland rail transport (Fig. 1). Available at: https://doi.org/10.3929/ethz-b-000333808

Even though automation of MTRRs could significantly increase their efficiency, the overall effect will still be limited because regardless of the level of automation, presently there are not many fully functional MTRRs. It is not very common for existing seaports to have railway tracks that could accommodate full length trains close to the stacking yards and adjacent to the quaysides. Furthermore, available capacities of railway facilities at MTRRs are often very limited and in most of the cases located about 500 metres to 2 kilometres away from berths.[53]

At MTRRs there is a need for multiple handling of containers (typically 3 lifts per container to/from stacks), which represents significant competitive disadvantage for railways in comparison with road transport where typically only one lift per container to/from container stacking yard at the seaport is needed.[54]

There is already existing potential for full automation at seaports with road connection. Such ACTs at MTRs could also support railway intermodal linkages through efficient inter terminal transport to the existing or new railway terminals (e.g., RTRs). The optimization and automation of railway terminals should not be considered in isolation, but as a part of larger intermodal system.

53. ESCAP, 2018, Regional Framework for Development, Design, Planning, and Operations of Dry Ports of International Importance. Available at: https://www.unescap.org/sites/default/files/Regional%20Framework%20for%20upload%20V1.pdf

54. *Ibid.*

The concepts for optimization of intermodal freight transport by development of hub railway terminals (RTRs) with dedicated hinterland - seaport linkages (e.g., MTRs or MTRRs) have been tested and promoted. Such optimization does not include only introduction of technological solutions but institutional and organizational changes as well. The role of hub RTR is to optimize sorting of containers according to their destination (corresponding seaport or next railway destination) and enable configuring of dedicated block container trains.

Use of intelligent gate systems

Entry and exit inspections on arrival and departure of trains are standard operational procedures at railway stations and terminals. Using intelligent gate systems can automate the commercial and technical inspections, accelerate arrival/departure processes, reduce related operative expenses and increase security of railway operations.

The intelligent gate systems enable information gathering of the rolling stocks and automatic detection of damages or possible defects. The intelligent inspections could be achieved with different components depending on different needs and situations, such as cameras, illuminators (light), RFID antennas and tags, scanners, wheel sensors and other sensors (e.g., overheating, chemical leaking, etc.).

The Visy Train Gate system uses OCR and RFID to streamline rail operations and automatically verify trains and cargo as they pass through the gate.

Box 4: Examples of intelligent train gate systems

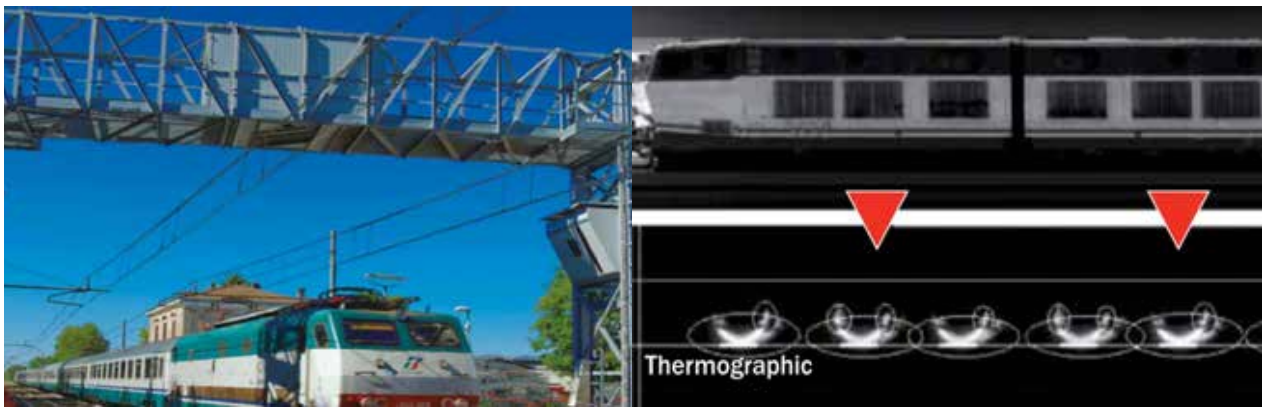
Visy's automated train gate solution for identifying and tracking trains and commercial containers/cargo is scalable and available in many configurations. The system uses OCR, RFID and other technologies to streamline rail operations and automatically verify trains and cargo as they pass through the gate. It is applicable at ports, intermodal and train terminals, remote gate facilities and border crossings.

Source: Visy website: https://www.visy.fi/products/visy-train-gate/

Hitachi Train Conformity Check System (TCCS)™

The TCCSTM system automatically detects 'irregular conditions' that affect rolling stock. The system analyses the data acquired from its subsystems and detects possible defects and hazardous conditions such as: violation of three-dimensional profile limits, overheating of rolling stock components, and high-resolution images to verify the failures. The TCCSTM system can integrate several subsystems: tracking of composition and displacement, 3D laser scanning, thermographic scanning, analysis, high resolution imaging and RFID. The web server-based operator interface (HMI) makes it possible to access more comprehensive self-diagnostic information, interface external systems and associate alarms

Figure 17: Hitachi Train Conformity Check System (TCCS)™



Source: Hitachi Rail STS website: http://sts.hitachirail.com/sites/ansaldosts/files/brochures/sts_tccs_ing_2019_0.pdf

The intelligent gate systems have potential to improve efficiency of railway and terminal operations by reducing manual processes and re-entering of data in railway/terminal IT systems. The intelligent gate systems could automate the commercial and technical inspections, accelerate arrival/departure processes, reduce related operative expenses and increase security of railway operations. The use of such systems increases visibility of container/train information to relevant third parties. Furthermore, use of intelligent gates and their integration with other smart technologies applicable at railway terminals may support optimization and automation of operations at intermodal terminals.

Automation of train formation / marshalling and automatic coupling

Modern railway stations and marshalling yards use sophisticated signalling and remote-control systems to track occupancy of sorting tracks and distance/speed of rolling stock with various wayside sensors/devices. To further increases performance, reliability, functionality and safety of railway operations, new solutions are being developed, including automated brake tests[55] and use of small automatic shunting robots

55. For more details see EU, Automated Rail Cargo Consortium (ARCC) project, 2018, WP 1: Automated Train Operation, Deliverable 1.3: Automated Brake Test. Available at: https://projects.shift2rail.org/download.aspx?id=be0d0127-61ee-4bd6-90c0-ef4f98658f05

and fully automated shunting locomotives.[56]

Currently manual handling is still needed during train preparation including manual coupling. However, advanced digital automatic coupling (DAC) is being developed and designed to achieve automatic connection of brake pipes and connection of power lines.

Figure 18: Examples of DAC prototypes under development

Source: TIC Presentation on the White Paper: The Intelligent Freight Train (sl.17) (Combined Transport Digital Forum, 2019)

Use of automatic couplers and automation of shunting can increase safety by avoiding dangerous manual work involved in this process, facilitate railway operations, reduce operational costs, improve efficiency, productivity and quality of rail freight services, increase competitiveness of rail freight transport and contribute to energy savings.

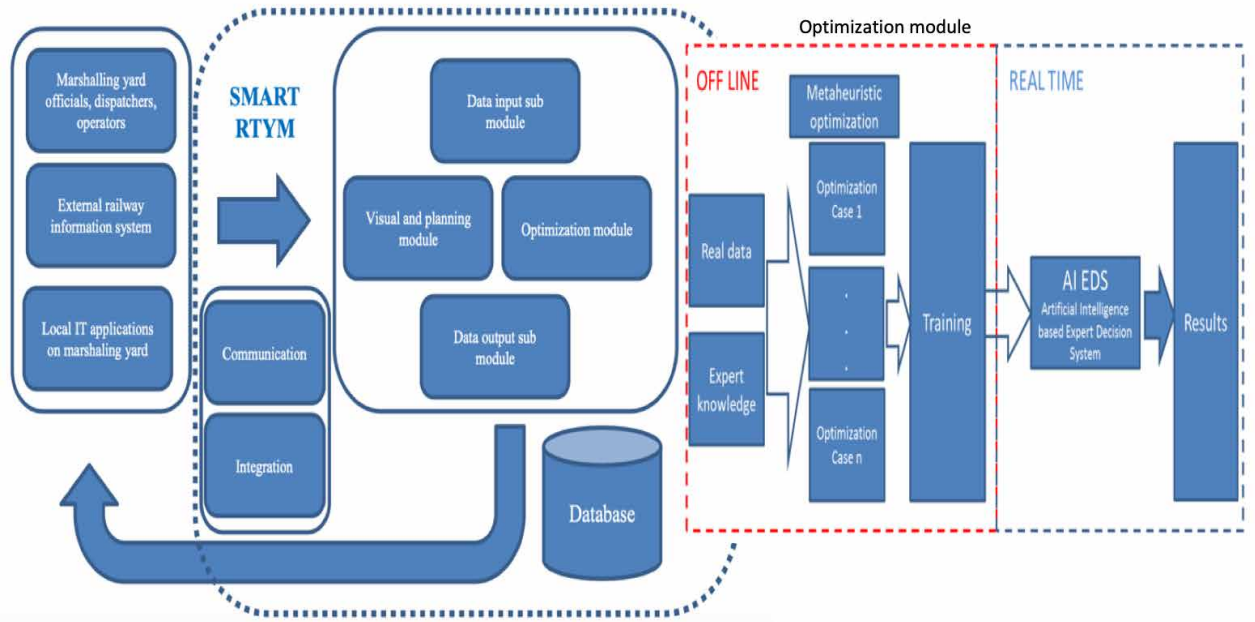
State-of-the-art terminal/ yard IT systems

The state-of-the-art terminal/yard IT systems are implemented at several seaports and dry ports (e.g., in China, Europe and America) to provide real-time solutions for efficient terminal operation. Those modern IT systems address real-time container handling and may include modules for optimization of intermodal processes using data linked with tracking technologies for the movement of cargo/containers, loading/ unloading equipment, and transport means (tracks, freight wagons) at the terminal. For example, Deutsche Bahn DB (Germany) uses multiple IT applications such as DXC's Rail Cargo Management Solution (RCMS) for train formation, cargo management and operations at marshalling yards.

The concept of real time marshalling yard management system has been developed in recent years. EU supported several projects to achieve real time optimization of marshalling process, including the Smart (Smart Automation of Rail) Project (2017-2019), OptiYard (Optimized Real-time Yard and Network Management) Project (2018-2019), and FR8RAIL III (Smart data-based assets and efficient rail freight operation) Project (2019-2022).

56. See the examples from Germany and Austria, presented in Ernst Lung, Austrian Federal Ministry for Transport, Innovation and Technology, Nov 2017 (updated in Jan 2019), Innovation in Rail Freight (p. 21-23). Available at: https://www.alpconv.org/fileadmin/user_upload/fotos/Banner/Topics/transport/AlpineConvention_TransportWG_InnovationRailFreight_012019.pdf

Figure 19: Concept solution for SMART Real-time Yard Management (RTYM) systems



Source: EU SMART Project, 2017, D6.1 Architectural design of the information system for supervision and management of marshalling yards (fig.5.2) (left) and D4.2 Overall framework architecture and list of requirements for real-time marshalling yard management system (fig.4.9) (right).

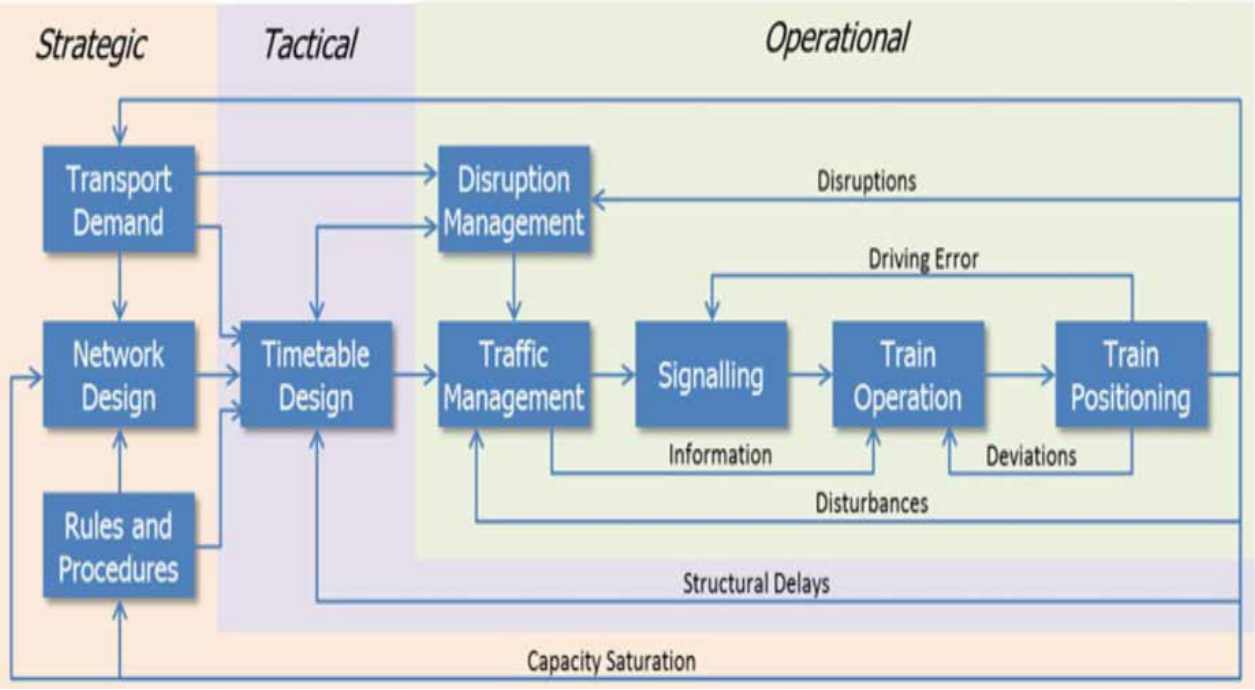
The smart railway operations envision fully automated terminals/yards of the future, with a range of specific solutions for automated loading/unloading, intelligent gate systems, fully automated train formation / marshalling with automatic wagon coupling and use of state-of-the-art IT solutions. Current developments in implementation and research of such solutions for full automation of terminals/yards strongly indicate that such concept is becoming more mature and viable option that is possible to achieve.

The general trend for automation is expected to grow in future, however it should be noted that investing in upgrading and building fully automated terminals/yards is considered costly. Therefore, developing such solutions need to be tailored to the specific needs of the railways and their customers. It requires careful deliberation with regard to investment costs, effects on efficiency gains and opportunities for expansion of railway market (e.g., due to increased competitiveness of railways in comparison of other modes of transport). In evaluation of options and search for optimal solutions for automation of railway terminals/yards, the effects on safety and sustainability that automation provides should be considered as well.

A2. Advanced traffic management system solution

Advanced railway traffic management systems could efficiently manage train control system (e.g., signalling, automatic train protection, automatic breaking and speed control) with new and adaptable communication technologies (e.g., GSM-R, LTE/5G, WiFi, SatComm) and advanced train positioning systems. Overall railway traffic system consists of several interlinked sub-systems. Thus, smart solutions for management systems could be with train operations.

Figure 20: Overall railway traffic system



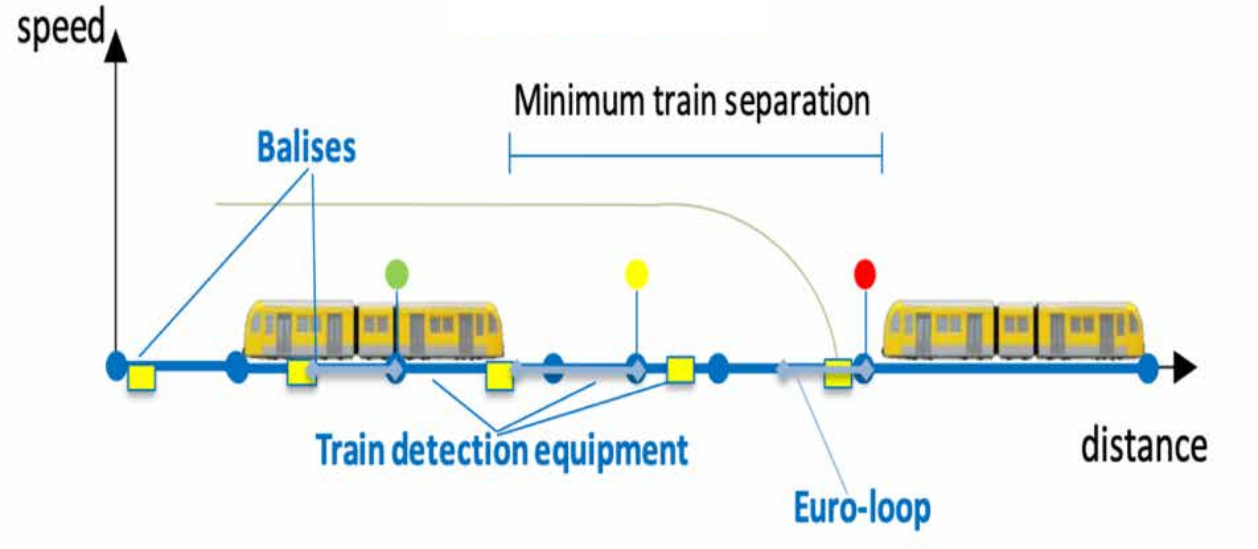
Source: Rob Goverde, March 2020, Global Railway Review: Trends and developments in the automation of heavy rail operations. Available at: https://www.globalrailwayreview.com/article/97734/trends-developments-automation-heavy-rail/

Existing advanced traffic management systems

At European level the ongoing major industrial project on development of European Railway Traffic Management System (ERTMS) has established itself as a worldwide standard. Similar systems have been developed in other countries based on the ERTMS standard including the Chinese Train Control System (CTCS). ERTMS level 1 and 2 (correspondingly CTCS level 2 and 3) are currently the commonly used modern traffic management systems in railway systems.

The ERTMS Level 1 controls the speed of the train based on the movement authority (MA)22 received by the standardized trackside transponders (Eurobalise), automatic braking will be activated if the maximum speed allowed is exceeded. The MA is determined by the control centre based on the train positions detected by the train detection equipment. It is also possible to create an infill loop (Euroloop) for the train to constantly receive updated information, which increases the system performance. Chinese CTCS Level 2 uses similar equipment, but the MA is computed by the on-board unit equipment rather than the balises.

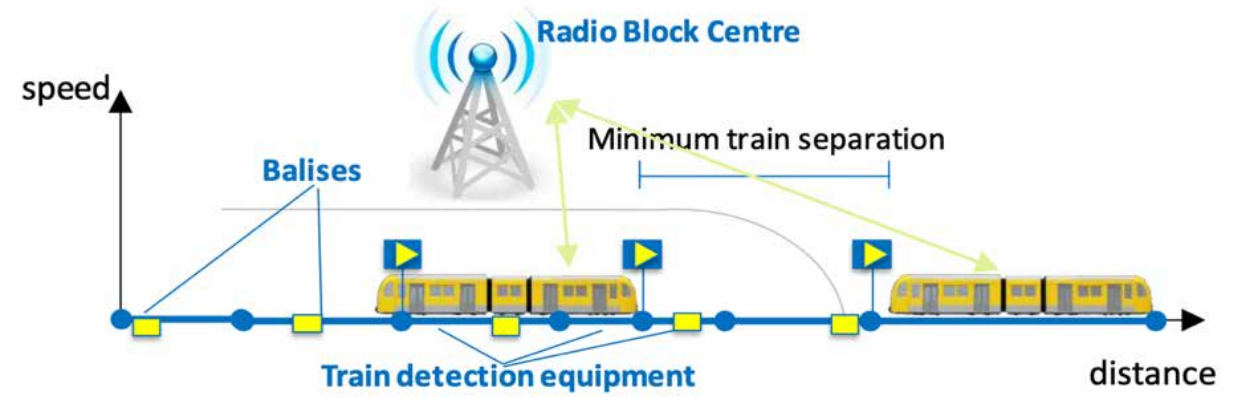
Figure 21: ERTMS/ECTS Level 1



Source: MOVINGRAIL Project, 2019, D4.1: Market Potential and Operational Scenarios for Virtual Coupling, (Fig.8 p.16)

The European ERTMS Level 2 and Chinese CTCS Level 3 systems have similar radio-based communication architecture. The communication of variable data (e.g., new MA) is provided between the radio block centre (RBC) and GSM-R equipment/ on-board data radios. Additional information (e.g., on train position) could be received on board via balises.

Figure 22: ERTMS/ECTS Level 2



Source: MOVINGRAIL Project, 2019, D4.1: Market Potential and Operational Scenarios for Virtual Coupling, (Fig.9 p.17)

The ERTMS Level 1 and CTCS Level 2 are generally used in conventional traffic which uses main line railways, while the ERTMS Level 2 and CTCS Level 3 are suitable for high-speed lines. The train control systems on the levels elaborated earlier are implemented throughout Europe, China and many other countries in the world which use similar advanced traffic management systems. Those previously elaborated train control system

levels use movement authority on fixed blocks defined as sections of tracks between two fixed points which cannot be used by two trains at the same time.

Development of solutions for future advanced traffic management systems

A moving block technology is a key element of the ERTMS Level 3 and CTCS Level 4 systems. This concept, which is still under development, is based on accurate and continuous supply of data about position of the train to the control center done directly by the train. With the ability of the train to continually monitor its own position, it will no longer be necessary to have fixed blocks, and the train itself could be considered as a moving block. The communication of the train report positions to the radio block centers (RBC) and broadcast of movement authority (MA) from the RBC to the train will be done via GSM-R equipment.

For the ERTMS/ECTS level 3 (and Chinese CTCS Level 4), it is necessary to have operational train integrity monitoring (TIM) supported by innovative on-board train integrity solutions capable of autonomous train-tail localization, wireless communication between the tail and front cabin, and safe detection on train interruption.

Figure 23: ERTMS/ETCS Level 3

Source: MOVINGRAIL Project, 2019, D4.1: Market Potential and Operational Scenarios for Virtual Coupling, (Fig.11 p.18)

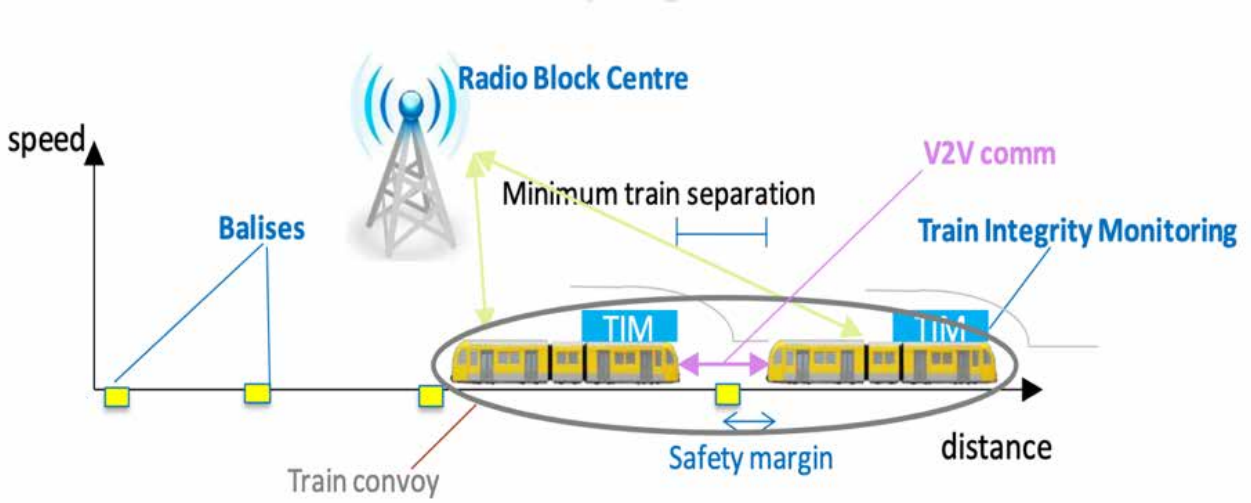
Further options for development of advanced traffic management technologies based on the concept of virtual coupling are being explored. The concept of virtual coupling technology envisions separation of trains by means of relative braking distance needed to slow down to the speed of the train ahead. To implement this concept, it will be necessary to have operational vehicle to vehicle (V2V) communication to exchange information on speed, acceleration and position and Automatic Train Operation (ATO).

Research indicate that virtual coupling has a potential to outperform moving block in terms of infrastructure capacity, system

stability, energy consumption and travel demand[57]. However, presently the virtual coupling technology is still not sufficiently mature, therefore it is necessary to further continue with the research and to enhance coordination for development of advanced traffic management and control solutions for the future.

Currently the GSM-R is used for train control systems (e.g., ECTS, CTCS etc.). A new future railway mobile communication system (FRMCS) based on 5G, Wi-Fi or even satellite is being developed as a part of future global rail traffic management system with larger data coverage and higher data transfer opportunities.

Figure 24: Concept of Virtual Coupling



Source: MOVINGRAIL Project, 2019, D4.1: Market Potential and Operational Scenarios for Virtual Coupling, (Fig.12 p.20)

Another important element of an advanced traffic management system are smart solutions for safe train positioning that use Global Navigation Satellite Systems (GNSS) (e.g., GPS, Galileo, BeiDou) and multi-sensor positioning systems (e.g., accelerometers, odometer sensors) which are able to boost the quality of train localization and integrity information, while reducing the need for conventional trackside detection systems (balises, track circuits and axle counters)[58].

Advanced traffic management systems allow faster and automated exchange of information, faster railway operations, and more efficient use of the network and the rolling stock. Having advanced traffic management system is an essential requirement for development of rapid and especially high-speed railway transportation. Existing advanced traffic management systems (e.g., ERTMS level 1 and 2 and CTCS level 2 and 3) already offer considerable benefits and provide significant advantages with regard to increased speed and capacities at the railway networks.

57. MOVINGRAIL Project, 2012, D4.2: Cost-Effectiveness Analysis for Virtual Coupling. Available at: https://projects.shift2rail.org/download.aspx?id=ab67e947-bf8c-4f8b-bd51-6143e4b02118

58. For more details regarding research on safe train positioning see Shift2Rail projects under Innovation Programme 2, Technical demonstrator TD 2.4 - Fail-Safe Train Positioning at Shift2Rail website: https://projects.shift2rail.org/s2r_ip_TD_r.aspx?ip=2&td=21651fb7-7047-4093-932a-79f4ca9c9652

Current developments in project implementation and research regarding smart solutions for future advanced traffic management systems are seen as promising even though they require high level of more mature technological innovations. Significant investment will be required to widely deploy such advanced traffic management systems and their development is considered as a long-term goal for the railways of future. Cooperation in research for design of compatible solutions could strengthen the efforts to reduce development costs and accelerate deployment of advanced traffic management solutions on global level.

B. Smart railway maintenance

Condition-based maintenance is a maintenance governed by monitoring the condition of the railway components (e.g., of a wagon, locomotive or infrastructure). By comparing real-time condition values of the observed parameter against critical parameter threshold, the current condition of the railway component could be described, and necessary maintenance could be scheduled.

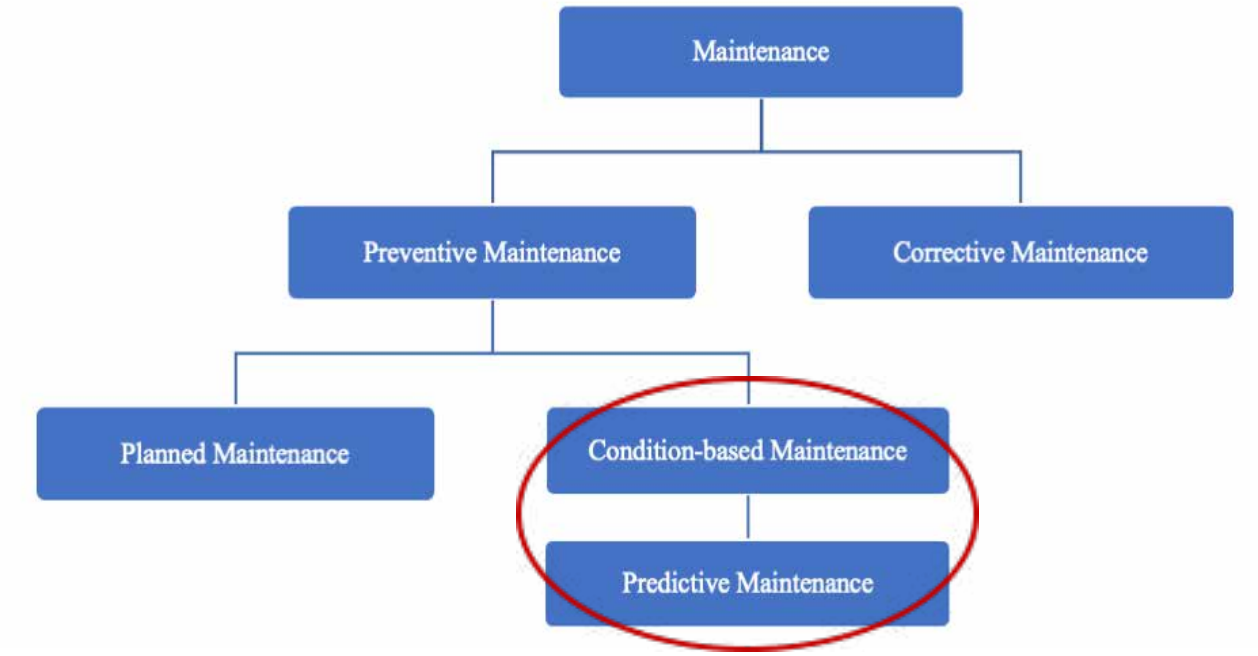
Predictive maintenance is a maintenance that incorporates condition-based monitoring as presented above. It could provide a forecast on future condition of a railway component using advance analytics with real-time conditions data, historical data and future usage estimation. Thus, the system is able to make a failure prediction with optimal timing for maintenance (e.g., using artificial intelligence and machine learning).

Railway maintenance strategies

Railway management systems with several railway maintenance strategies are designed to assure running of well-functioning, reliable and safe railway operations.

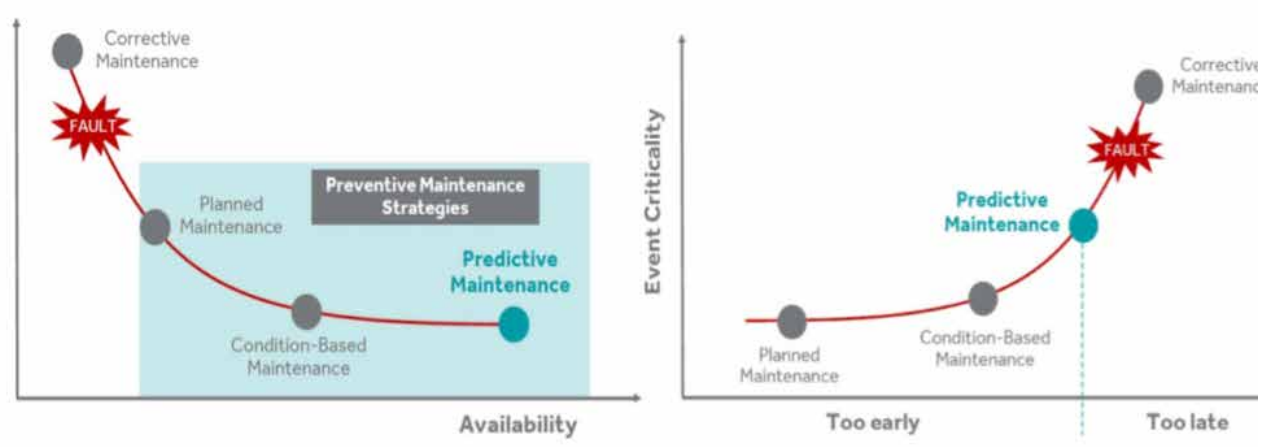
Compared with corrective maintenance where the railway assets are restored when they are broken, preventive maintenance strategy mitigates degradation from the usage of railway components, and significantly reduce probability of failure by restoring the railway assets before they are broken.

Figure 25: Types of maintenance strategies and operations



By using condition-based maintenance, the potential for optimization of maintenance timing is much higher compared to planned maintenance. Condition-based maintenance can lead to an overall reduction of at least 10 to 15 per cent in maintenance costs, (with additional 5 to 10 per cent reduction if predictive maintenance is implemented).[59]

Figure 26: Optimization of maintenance timing



Source: FR8Rail Project, 2018, WP2: Conditional Based and Predictive Management, Deliverable: D 3.6 Wayside Condition Monitoring Impact Analysis. (Figure 8-3, p. 50)

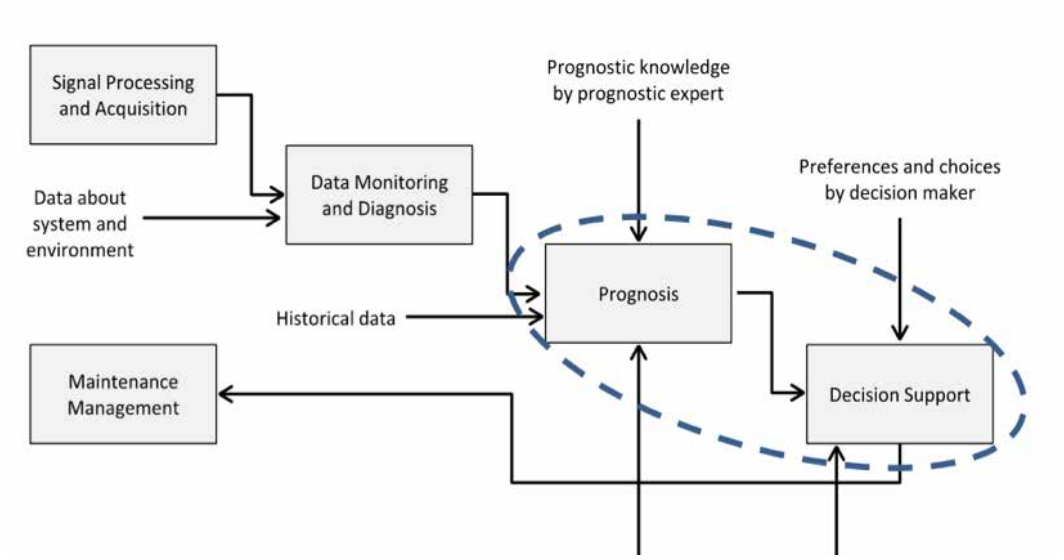
Condition-based and predictive maintenance model

Main characteristic of condition-based and predictive maintenance model is a dependency on data for monitoring conditions of railway components and optimization of maintenance operations. Sensor and scanning technologies have made it possible to monitor the conditions in real time, including acoustic sensors, optical fibre sensors and laser scanners.

Condition-based and predictive maintenance general model, as presented in Figure 27, has several interconnected functions. Enhanced capacities for prognosis of future conditions and extended decision-making support with optimization of processes distinguish predictive maintenance systems.

59. As evaluated by McKinsey, December 2017, The rail sector's changing maintenance game. Available at: https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/the-rail-sectors-changing-maintenance-game

Figure 27: Condition-based and predictive maintenance model



Source: EU SMART Project, 2019, WP2: Deliverable D2.3: CBM-Model Case Study Reports (Fig.1, p.12)

Signal processing and data acquisition functions provide digitalized data (e.g., heat, vibration, sound, rotational speed and axle stress) from sensors to measure condition of railway components. Data monitoring functions enable detection of the condition of railway components by comparing the data received from data manipulation with expected values. Health assessment and diagnosis determine if (and how much) the condition of the monitored component is degraded. During the analysis and prognosis phase, trend analysis is conducted based on the collected data and prediction models are created by experts or artificial intelligence. Based on developed prediction models future health status and the remaining useful lifetime (RUL) of railway component is determined. During the decision support phase, recommended actions are generated based on received alerts and reports on future health status / RUL.

Condition-based maintenance and predictive maintenance systems could increase the availability of wagons, reduce disruptions in using of railway infrastructure, and reduce maintenance cost. However, developing such sophisticated models with high reliably to predict degradation of specific railway components is demanding, since the complexity of entire system has to be taken into account.

Case studies on condition-based and predictive maintenance solutions

Railway companies in several countries in Europe and Asia have been working on development of conditions-based and predictive maintenance solutions (e.g., French railway (SNCF), German railway (DB), Swiss railway (SBB), Japan railway etc.). The case studies presented in this part provide brief elaboration of some of those solutions.

Predictive Maintenance at French railway (SNCF)

The French railway (SNCF) implemented condition-based maintenance since 2014, which enabled adapting the scheduling of maintenance in accordance with the conditions of individual trains and elimination of routine preventive maintenance.

The trainsets are preinstalled with sensors and equipment that could connect with mobile networks (e.g., using 3G or 4G technologies) to transmit large volumes of data. The data is then analysed by the SNCF rail experts and maintenance decisions are made. Implementation of condition-based maintenance at SNCF has contributed to reduction of train maintenance costs by 20 per cent, reduced shunting and maintenance centre visits by 30 per cent and increased availability. The system also improved reliability with number of breakdowns reduced by half.

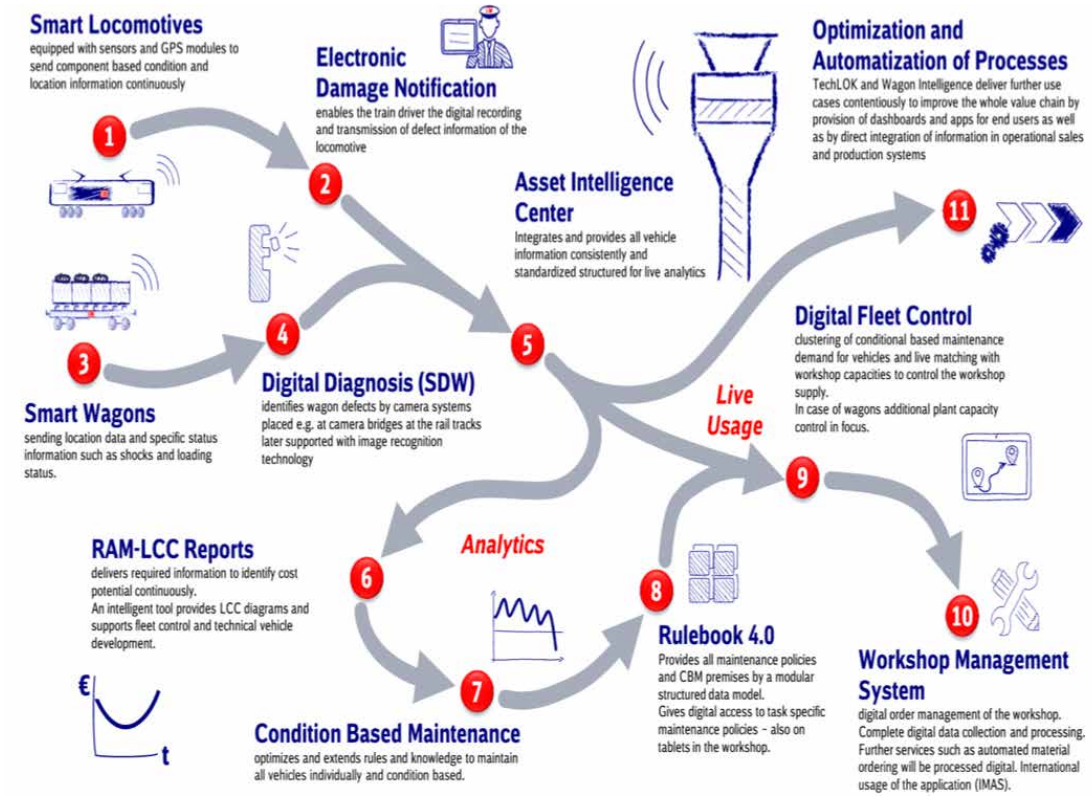
Predictive Maintenance at German railway (DB)

The new DB maintenance strategy starts from the implementation of rolling stock real-time monitoring to condition-based maintenance, at last to predictive maintenance. Under DB Asset and Maintenance Digitalization (AMD) program, variety of different digitalization projects have been undertaken.

For example, the TechLok project and DB Wagon Intelligence project were lunched to make early assessment of the condition of locomotives/ wagons and make the right conclusions for maintenance. The digital remote points diagnostics system identifies potential faults before they occur and reports abnormalities.

The DB cooperates with many manufactures to develop condition-based and predictive maintenance system. One of the projects is Siemens' Railigent solution, which is connected with the Siemens' Internet of Things (IoT) platform and other third-party applications (e.g., SKF on condition-based maintenance of bearings) to achieve data transmission and condition monitoring.

Figure 28: DB Asset Management Digitalisation concept



Source: J. Pieriegud, 2018, Digital Transformation of Railways (p.31) (DB Cargo 2017)

C. Smart train driving

The automatic of train operation (ATO) is a solution that provides support for automation of driving function (e.g., starting, accelerating, braking, and stopping) that is used in conjunction with the safety automatic train protection (ATP) function of train control systems. The ATO solutions work well with modern communication-based train control (CBTC) systems that use advance train positioning technologies, continuous communication between on-board and trackside devices with real time connection to traffic management system. The ATO functions are non-safety related and enable optimization of driving functions. The automation of train driving may range from partial to fully automated, that enables driverless and unattended human-less train driving.

Grades of automation in train operations

Automation of train operations could be divided in several levels, referred as grades of automation (GoA), that indicate the extent of sharing of responsibilities between the staff on the train (e.g., driver) and the train control systems.[60]

If the driver has full responsibility of the train operations, then such level is referred as manual on-sight train operation (GoA0). The responsibility of the train operations declines as the GoA level increases. Advanced GoA2 solutions for mainline operators are already available and tested, while potential upgrades to mainline GoA3/GoA4 solutions may be expected in future.

Figure 29: Grades of automation in train operations

Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of disruption
GoA1	ATP* with driver	Driver	Driver	Driver	Driver
GoA2	ATP and ATO* with driver	Automatic	Automatic	Driver	Driver
GoA3	Driverless	Automatic	Automatic	Train attendant	Train attendant
GoA4	UTO	Automatic	Automatic	Automatic	Automatic

ATP - Automatic Train Protection, ATO - Automatic Train Operation, UTP - Unattended Train Operation

Source: International Association of Public Transport (UITP), 2019, Statistics Brief 2018

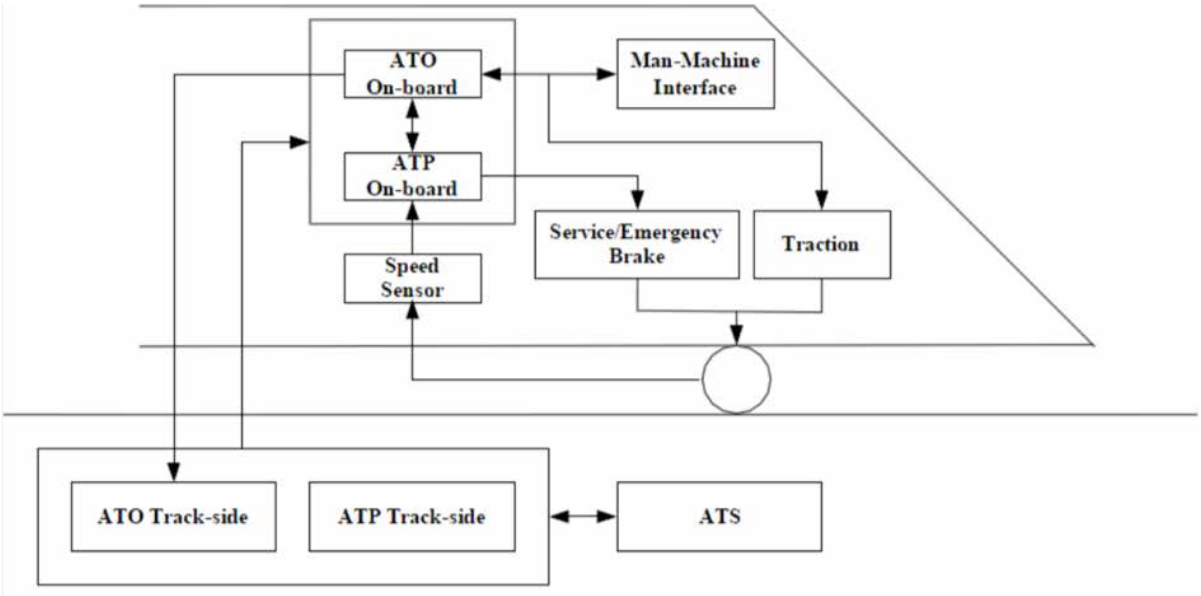
60. The grades of automation (GoA) are defined with the standards of International Electrotechnical Commission (IEC) such as: IEC 62290-1:2014: Railway applications - Urban guided transport management and command/control systems, Part 1: System principles and fundamental concepts and IEC 62267:2009: Railway applications - Automated urban guided transport (AUGT) - Safety requirements

Architecture and functional requirements of automatic train operation (ATO) system

To implement automated train driving it is necessary to employ an automatic train operation (ATO) system, which is able to control traction and braking systems, and to establish the optimum speed for maximum energy savings.

Basic ATO system architecture for GoA2 semi-automated operations is presented in Figure 30. For GoA3/4 fully automated driverless or unattended train driving operations more complex and additional requirements are envisioned. They include logical components such as perception component to sense the physical railway environment in place of a driver.[61]

Figure 30: Basic architecture of ATO system (GoA2)



Source: EU ASTRrail Project, 2018, Deliverable: D3.1 State of the Art of Automated Driving Technologies (Fig.17, p.49)

Technologies for automation of train driving and obstacle detection systems

Automation of train driving is data-driven activity and accordingly the technologies employed are related to collection, communication and processing of relevant data. For example, tachometer provides train speed data and odometer provides data about train position.

Train positioning could be supported by global navigation satellite system (GNSS) systems (e.g. GPS, BeiDou, Galileo) and mobile positioning systems that employ wireless communication technologies. Each technology that could be implemented in localization functionalities for automation of train driving has its own characteristics and different strengths depending on the conditions and specific situation. Therefore,

61. Development of ATO over ECTS GoA3/4 specification is ongoing under EU X2Rail Projects. Preliminary Specifications have been developed under EU X2Rail-1 Project: Deliverable D4.3

it is recommended to consider combining several sensor technologies to better exploit their strengths, mitigate their weaknesses and provide maximum reliability.[62]

Obstacle detection systems

To implement higher levels of automation of train driving it is crucial to employ obstacle detection system (ODS) for detection of unexpected obstacles on the track. Perception sensor technologies are key element of obstacle detection systems and they can include a range of active sensors (e.g., RADAR, LiDAR) or passive visual cameras (e.g. stereo camera, omnidirectional camera, infrared camera).[63] While laser sensor technologies (e.g. LiDAR) have advantage of more accurate measuring of distance to the obstacles, vision cameras provide more detailed information about surrounding environment, thus combining different technologies may be needed.

EU developed and tested an ODS prototype with multiple sensors and cameras in 2018 and 2019, it showed promising results but also limitations. Once obstacle detection systems technologies become sufficiently mature, they could be integrated with automated train operations to support full automation of train driving.

Examples of automation of train driving

GoA4 with unattended train driving (AutoHaul system) was tested in 2018 and become fully operational in 2019 in the Rio Tinto iron ore train in Australia. The locomotives are installed with on-board modules to exchange data (e.g., speed and position) with the control centre. The implementation of the system indicates significant potential to improve productivity, increase system flexibility and reduce bottlenecks.[64]

Automated train operation (ATO) is implemented in high-speed railway systems in China that run in several intercity railway passenger lines. The high-speed railway ATO has improved transport efficiency, reduced driver labor intensity and ensure the safety of passengers on the trains that run up to 350km/h.

In recent years ATO over ETCS on GoA2 level on mainline networks has been tested by several European railways. For example, ATO over ETCS was tested in December 2019 by Dutch Railway (NS) in cooperation with CAF Signalling on passenger trains running on high density lines. The NS is planning to test different functionalities of the ATO over ETCS in future.[65]

The main benefits of automation of train driving are demonstrated with improvement of operations, efficiency of scheduling and increased energy efficiency and cost savings. Optimized driving enabled by automation can increase the capacity of the railway network, enable higher punctuality, and contribute to reduced journey time. Use of automation of train driving eliminates bottlenecks and increases the safety level of train operations.

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62. EU ASTRrail Project, 2019, D3.2 Automatic Train Operations: implementation, operation characteristics and technologies for the Railway field. (for more details see precise train localization p.44-49) Available At: https://Projects.Shift2rail.Org/Download.Aspx?Id=05cc6d2e-E9a8-4565-Bb1e-Bd03271a322e

63. *Ibid.* (for more details see detection on unexpected obstacles on track p.49-56)

64. Railway Gazette International, January 2019, Rio Tinto completes AutoHaul autonomous train project. Available at: https://www.railwaygazette.com/australasia/rio-tinto-completes-autohaul-autonomous-train-project/47822.article

65. CAF Signalling website news, December 2019. CAF Signalling, Success in the ATO Test On ETCS in NS of Netherlands. Available at: https://www.cafsignalling.com/en/caf-signalling-success-in-the-ato-test-on-etcs-in-ns-of-netherlands/

D. Smart railway border crossing solutions

D1. Electronic information/data exchange for facilitation of border crossing by rail

To initiate and complete railway movement across borders it is necessary to meet operational requirements of the railways involved, as well as regulatory formalities of border agencies (e.g., Customs and other) in the countries along international railway transport corridors. Presently, at most border crossings in the region the processes follow manual and paper-based information flow. Information is exchanged by telephone, faxes, emails and manual hand over of documentation, which results in delays and inefficiency at the border crossings. Electronic exchange of information between railways and among railways and control agencies can significantly enhance the efficiency of processes at the border crossings.

Railway to railway electronic data interchange

Electronic exchange of information between railways (e.g., advance information on consignment note; estimated time of arrival; list of the wagons to be handed over to the next railways) could streamline the organization of the processes at railway border crossings. Multilateral and/or bilateral arrangements between railways on electronic data exchange are necessary to set the parameters and rules for such interchange that is aimed at simplification and acceleration of border crossing procedures.

The advanced automated information systems support efficient organization of railway transport and provide a communication interface between railways and their clients, business partners and other railways undertakings. They are consisted of multiple sub-systems and applications employed on national and international level to provide web-based client services, to facilitate and optimize railway transport operation planning, to digitize processing of railway transport documentation, to automate traffic control, to support transport operations at railway stations and to enable cross-border data exchange. The advanced automated information systems could obtain necessary information and railway transport documents in electronic format and minimize inefficient manual data entry input at departure, at border-crossings and at destination railway stations.

There are three main system solutions for electronic information exchange in international railway transport as follows:

- Solutions based on EU Telematics Applications for Freight - Technical Specification for Interoperability (TAF-TSI) in European Union and corresponding OTIF Telematics Applications for Freight - Uniform Technical Prescription (TAF-UTP).
- Solutions based on OSJD SMGS agreement and bilateral electronic data interchange (EDI) agreements; and
- Solutions developed under the CIS Council for Railway Transport (CIS CRT) (e.g. the automated system MESPLAN, managed by the IT center of the CIS CRT used to develop the monthly consolidated freight loading plan at international level).

The TAF-TSI / TAF-UTP standards enable development of solutions for exchange of railway freight transport electronic messages between railway undertakings, infrastructure managers, wagon keepers and other stakeholders. Under TAF-TSI

information is exchanged on: consignment note data; allocation of railway infrastructure capacity (path request); train preparation; train running forecast; movement of wagon and post trip data. The exchange of railway freight transport electronic messages based on TAF-TSI standards is operationalized by various IT solutions (applications and products) developed by several organizations.

Box 5: IT tools that support TAF TSI processes and functions

- ORFEUS – Rail Data, enables electronic exchange of railway consignment data
- International Service Reliability (ISR) – Rail Data, offers exchange of movement information for wagons in international traffic
- Common Components System (CCS) - Rail Net Europe (RNE), offers Common interface, Central Reference File Database and Certification Authority
- Path Coordination System (PCS) - RNE, for international path request coordinationTrain Information System (TIS) - RNE, supports international train management
- HEROES (H30) - HIT Rail, for advance information exchange on train composition
- Rolling Stock Reference Database RSRD2 – International Union of Wagon Keepers (UIP)

The CIS CRT and OSJD SMGS EDI solutions are based on United Nations/Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) standards. The OSJD supports railway electronic information exchange by providing a guidance with numerous OSJD Leaflets on Coding and Informatics. Among other, the OSJD leaflets provide details on harmonized rules on exchange of data on movement of trains; library of standard electronic messages for international freight traffic under SMGS conditions in the UN / EDIFACT standards; Model Agreement on electronic data interchange between the national information systems for freight traffic; principles of organization of information security in the interaction of digital telecommunications networks; recommendations on the use of technology of the trusted third party to ensure the legal relevance of electronic documents in a cross-border communication; typical technical specifications of cross-border cooperation between public key infrastructures used by railways.

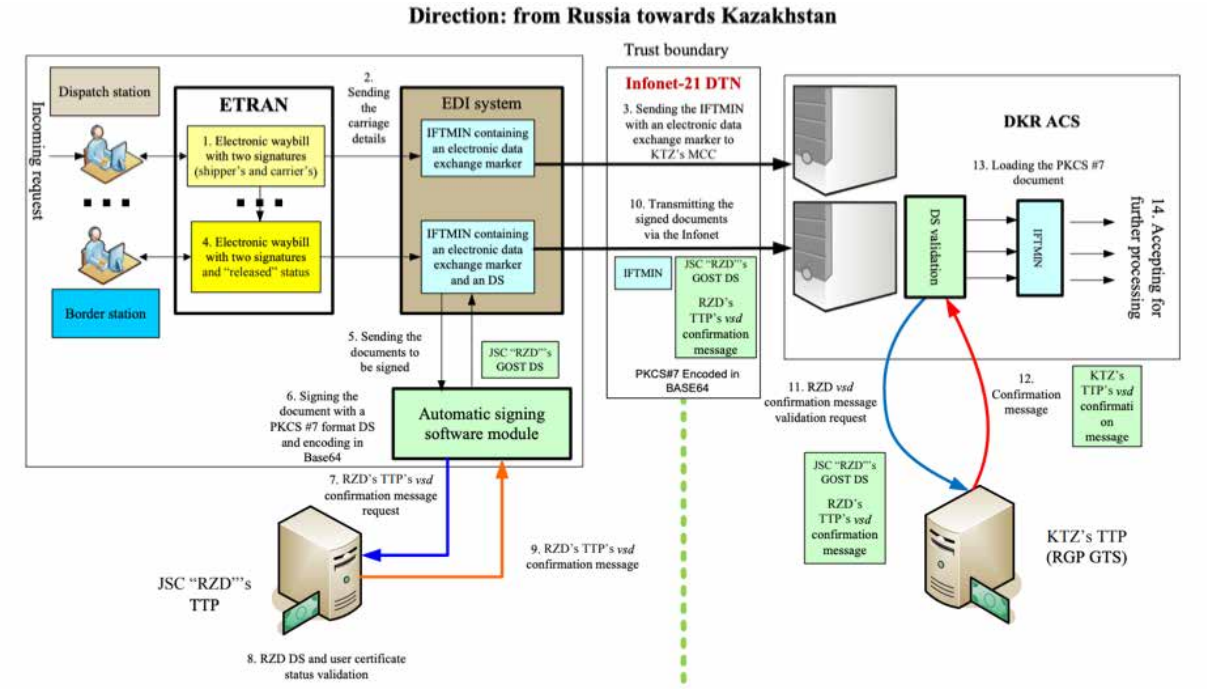
A set of electronic messages are mutually exchanged between national information systems of several OSJD railways in the processes of admission and handing over of trains at interstate border-crossing points that allows tracking of wagons and goods along the whole network. Facilitation of cross-border operations is supported by electronic exchange of train handover sheets between the CIS and the neighbouring countries using Automated Traffic Control System (ASOUP) message 4770, and /or UN/EDIFACT message IFCSUM. In both cases, initial train handover sheets data are being communicated 2-3 hours before the actual crossing of the border. The communication process between the railway information systems employs the internet network as

well as data transfer systems "Infoset-21" and HERMES.

The level of electronic data interchange development and percentage of electronic and paperless document processed varies between different railway administration that are implementing EDI projects. Such projects usually start with signing of EDI agreement between the railways, and gradually further implemented with establishing adequate information systems, infrastructure for exchange for electronic documents with mutual recognition of the electronic signatures, paperless electronic document processing for movement of empty wagons, and finally paperless electronic document processing for transport of goods. While some railways managed to cover almost 100 per cent of freight turnover with paperless transactions (e.g., for the freight traffic between Russia and Belarus) other are continuously working on increasing of EDI usage.

Many challenges remain to harness the full potential of electronic exchange of information along the international railway corridors. The differences in documentary requirements, classification codes and various electronic exchange solutions across different railway transport regimes (e.g. COTIF or OSJD) impede seamless data exchange flows and may burden border crossing processes, increase time and costs, crate delays and negatively affect the quality and competitiveness of railway transport. To address such challenges, it is necessary to enable e-interoperability for electronic information exchange between railways.

Figure 31: Cross-border exchange of electronic documents between JSC RZD and AO NK KTZ



Source: OSJD Leaflet R 941-4: Typical technical specifications of cross-border cooperation between public key infrastructures used by railways operated by member countries of the OSJD (Fig.9 p.41). Available at: **https://osjd.org/api/media/resources/11242**

Electronic information exchange between railways and control authorities

Completion of regulatory formalities at railway border crossings requires information and processing of transport related documents that have to be exchanged among the railways, Customs and other government agencies (e.g., border security guards, immigration, sanitary and phytosanitary, veterinary and food safety agencies). Providing those information and documents in advance and in electronic format, would result in much more efficient organization of border crossing regulatory formalities.

Advanced systems for electronic information exchange among railways and control agencies support efficient organization of both railway transport and control formalities. Such systems provide a communication interface between IT systems of railways, Customs and other control agencies. Ideally, the available railway transport related data should be electronically transmitted and reused for processing at Customs and other regulatory IT systems with minimized inefficient manual data entry inputs. The immediate benefit of electronic information exchange among railways and control agencies is making the regulatory controls more efficient. That will allow further optimizing of railway processes at border crossings, avoiding unnecessary delays and increasing reliability of railway transport.

However, the benefits of electronic information exchange among railways and control agencies cannot be fully harnessed without harmonization with regard to Customs and other border crossing formalities in a larger context along international railway corridors. Harmonization of Customs and border crossing formalities for international railway transport should include harmonization of information needed with regard to:

- Submission of advance electronic pre-arrival information (e.g., with regard to cargo declaration) and organization of Customs and other border crossing regulatory formalities on arrival of goods in Customs territory; and

- Implementation of Customs transit procedures (including potential regional Customs transit), and simplification of Customs transit procedures for railways as authorized economic operator (AEO).

The WCO standards and recommendations instruments (e.g., WCO RKC, WCO SAFE Framework of Standards, WCO Data Model) support such harmonization and provide important guidance for harmonized Customs requirements (e.g., recommendations on data elements, time limits and responsibilities).

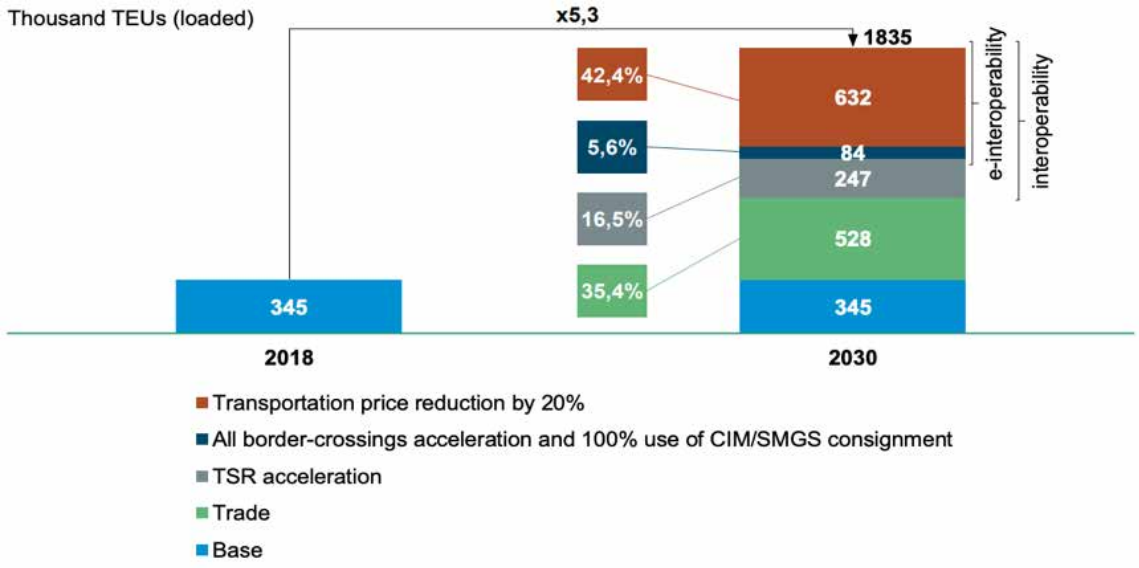
Expected challenges for linking electronic information systems of national railways, Customs and other control agencies include differences of the level of automation and computerization; lack of harmonized data requirements (e.g., railway transport documents and Customs declarations); legal requirements for authentication and acceptance of paperless electronic documents; complexity due to extensive regulatory requirements from multiple authorities.

With increased automation and digitalization introduction of smart solutions based on electronic information exchange between railways and among railways and control authorities is expected to continue. Establishing e-interoperability with use of unified electronic CIM/SMGS common consignment note and interfaces that connect different railway systems, logistics systems and the systems of control authorities will result in accelerated the border-crossing, reduced time for freight transport by rail, and accordingly contribute to transportation price reduction.

Benefits of e-interoperability along international railway corridors

Recent UIC study has analyzed Eurasian corridor development and employed transportation modelling for volume forecasting and analysis of the elasticity of the demand for rail freight transport in relation to multiple relevant factors (e.g., digitalization of processes, border crossing improvements, speed of transit). According to the modelling results, the e-interoperability could contribute to about 48 per cent of the increased Euro-Asian rail freight transit traffic by 2030. That includes: 42 per cent as result of transportation price reduction and 6 percent as result of border crossing acceleration and use of CIM/SMGS consignment note.

Figure 32: Estimation of interoperability and e-interoperability input to Euro-Asian rail freight transit traffic under "the best rail case" option



Source: UIC/IEC, 2020, Eurasian corridors: development potential Available at: https://uic.org/com/enews/nr/684/article/eurasian-corridors-development-potential

D2. Use of new technologies for efficient and secure border crossing by rail

Railway border crossing processes play a central role in facilitation of international railway transport. Inefficient railway inspections as well as inefficient regulatory controls may cause lasting and/or occasional delays. Delays caused by inefficient completion of border crossing formalities could lead to increased transit time for railway transport and reduced reliability, predictability and punctuality of freight trains.

New technologies could be employed to support efficient and secure border crossing, such as dynamic and automated inspections while the train is moving; non-intrusive inspections; electronic tracking of cargo and checking the integrity of containers/wagons with electronic seals.

Automated and non-intrusive inspections

The new technologies for dynamic and automated inspections, make it possible to collect data required for completion of required railway related inspections while

the train is in motion. The systems used for dynamic inspections could be individual (e.g., electronic dynamic weighing scales) or multifunctional intelligent gate systems with a range of components (e.g., cameras; illuminators; scanners; RFID, wheel and other sensor readers) and several technologies employed (e.g., detecting and imaging; video processing; optical character reding (OCR); laser and thermal scanning; and various sensor technologies.

Figure 33: Automated inspection system

Source: Lithuanian Railways, 2015 (Kena border crossing)

The data collected with dynamic and automated inspections may include identification of wagon/container numbers; checking of wagon weight (axle load); detection and calculation of loading gauge dimensions and automated check of oversized cargo; checking of other security and safety parameters of cargo and transport means (e.g., overheating, chemical leaking, open doors and other irregularities).

The dynamic and automated inspection systems could be installed directly next to the border line (or its proximity), at location between the border line and the railway border crossing station (if the railway station is not located next to the border line) or at the railway border crossing station itself. Installing dynamic inspection/control systems in vicinity of the railway border crossing allows recording the data as the train approaches to the railway border crossing station. The data recorded could be automatically transmitted to the control centre at railway border crossing station prior to the arrival of the train at the station.

The new technologies for non-intrusive inspections (NII), make it possible to organize regulatory controls and other formalities without disruption of railway processes, opening of containers/wagons

for conducting physical controls, or other manual engagement of control authorities in border crossing formalities. The systems and technologies used for non-intrusive inspections include systems based on X-ray and gamma-ray radiography for scanning of containers/wagons, radiation detectors, systems with thermal image technologies, electronic and video surveillance systems. The systems for non-intrusive inspections could also be dynamic (e.g., dynamic scanners that enable scanning while the train is in motion). Control authorities should define appropriate risk indicators for better targeting of controls with the use of non-intrusive inspection tools and significantly reduce the need for physical controls.

The data collected with the technologies for dynamic and automated inspections by railway stakeholders at border crossings could be also relevant for the regulatory controls of control authorities. Similarly, the railway stakeholders may require relevant information based on control results from non-intrusive inspections to better organize railway operations. Therefore, sharing of information based on dynamic, automated and non-intrusive inspections at border crossings should be encouraged.

Implementation of automated and non-intrusive inspection/control systems could significantly improve the efficiency of railway technical and commercial inspections as well as of regulatory controls. For example, at Kena railway border crossing the new technologies installed include dynamic weigh scales situated at main railroad lines, automated train and wagon commercial inspection system (AKAS system) and dynamic x-ray scanning system. The use of new technologies has significantly reduced the processing time on train handling (from 175 minutes to 50 minutes - for goods which are not subject to veterinary and phytosanitary control). The quality of inspections was improved, with decreased number of employees and significant financial savings with regard to the operational costs (Lithuanian Railways, 2015).

Electronic tracking for secure border crossing

The systems for electronic tracking with electronic seals (e-seals) make possible to have real time monitoring of railway transport movements, within a Customs territory of a country and/or across borders along international railway corridors. The systems for electronic tracking are using technologies such as satellite positioning systems, cellular communication systems, radio frequency identification (RFID) enabled e-seals, advanced web-based software and computer networks. The use of electronic tracking with e-seals could facilitate cross-border transport while addressing the security concerns of the control authorities. The e-seal combines physical seal to secure the cargo and mechatronic component to identify the status of the e-seal and enable checking of its integrity.

The use of e-seals that offer extended security may be:

- mandatory (e.g., for specific high-risk types of goods, that otherwise will be restricted to move under Customs transit procedure within or across the Customs territory);
- conditional (e.g., for granting greater simplifications in Customs transit such as authorized consignor/authorize consignee and self-sealing, waiver or reduction of transit guarantee requirements and facilitation of border crossing formalities); or
- voluntary (e.g., to demonstrate high level of cooperation with Customs authorities and offer higher security that may result in Customs facilitation and reduced Customs

control measures based on Customs risk assessment).

The integration between the e-seal and the electronic tracking system could be established: a) directly with the e-seals (if they are designed as multifunctional devices that include e.g. satellite positioning system (SPS) module and cellular communication system (CCS) module) and/or b) indirectly via additional device (tracking unit) that has its own SPS module, it is able to communicate with the e-seal (e.g. via RFID signals) to check their status, and further transmits the messages to the monitoring platform using its own CCS module. The monitoring platform is supported by web based electronic tracking application software to track the railway transport movements and the status of the e-seals. The electronic tracking could be organized in one country only or in several countries along international railway corridors.

Electronic tracking systems with e-seals in railway transport have been implemented in several countries in the region including India and Russian Federation.

The use of ECTS in India expedites Customs clearance and simplifies procedures. The Nepalese importers can turn around containers in 14 to 21 days, avoid paying demurrage and detention charges because cargo movement.

Box 6: Electronic Cargo Tracking System (ECTS) between India and Nepal

Using the concept of ESCAP Secure Cross Border Transport Model, the Customs authorities in India have started the ECTS pilot programme to facilitate the movement of traffic-in-transit of third-party imports for Nepal (by road and rail). The Nepalese traders (or their Customs brokers) (or transhipment agents) that wish to use the ECTS facility are required to register and use the website of the Manged Service Provider (Transecure).

Since April 2018, the ECST system provides a digitalized process for filing of electronic Customs Transit Declaration (e-CTD). Submission e-CTD is enabled through the ECTS web application, which is linked to the infrastructure for electronic sealing and GPS based tracking of transit cargo. Accompanied documents to the e-CTS are uploaded in PDF format (e.g., cope of invoice, packing list).

Printed copies of e-CTD are used to record the ECTS seal number affixed by Customs officer at departure and to accompany the transport to the Customs office of exit/destination. Un-sealing of the e-seal is carried out at the exit / destination railway station in India. Reconciliation/discharge of the transit is done automatically with a "trip-report" generated by the ECTS system and available to the Customs offices.

Source: India Customs Public Notice 33/2018; Transecure, 2019 Presentation on Transit of Nepal's Cargo through India (ECTS)

In addition to increased security the system for electronic tracking can also provide increased efficiency if the implementation of the system is accompanied by reduction of paper-based procedures, and simplification of Customs formalities (e.g., reduction or waiver of guarantee requirements, physical inspections). Simplified regulatory formalities could contribute to reduced transit time and lower overall costs (e.g., due to faster turnaround time, lower insurance costs, even though usually there are some additional costs for the use of e-seals). Developing electronic tracking systems also has some challenges that have to be addressed such as ownership/operator modes and costs for using of system, technical requirements and options on equipment to be used (in particular on cross-border level).

Similar electronic tracking systems (without Customs e-seals) that enable increased visibility could be used by railways to provide commercial services their customers. Such electronic tracking systems may provide information to the customers on location of their cargo; security of cargo (if non-Customs e-seals are being used), and condition of the cargo depending on sensor technologies employed (e.g., temperature, humidity, shock, load).

D3. Harmonized Customs transit formalities for international railway transport

Use of railway consignment note as a Customs document

The organization of railway operations and regulatory formalities at border crossings requires processing of different railway and Customs documents. When the cargo in international railway transport is crossing from one country to another there is a divergence of formalities with numerous railway transport documents, as well as Customs documents to be processed. Having multiple different railways and Customs documents along the international railway transport corridors increases complexity and contributes to delays. That is most evident in the case of transit where it is necessary to repeat processing of same/similar documents which may have many same/similar data elements at each border.

Having a common railway consignment note (e.g., CIM/SMGS) streamlines the transport processing across the border crossing. This railway transport facilitation could also be reflected as a Customs facilitation since it is possible to use the same railway consignment note (e.g., CIM-SMGS) as a Customs document (as recommended with Article 4 (7) of the Annex 9 on Facilitation of border crossing procedures for international rail freight of the International Convention on the Harmonization of Frontier Controls of Goods (1982)).

Railway consignment note (e.g., CIM-SMGS consignment note), could be used as a Customs document that is necessary to be submitted in accordance with Customs legislation for completion of border crossing formalities and procedures such as Customs transit by rail. This solution makes it possible to reuse already available railway data / documents, facilitate submission of Customs transit declaration, avoid the need for preparation of new Customs transit documents at each border crossing and reduce the involvement of intermediary parties (e.g., Customs brokers, forwarding agents) in Customs transit formalities.

Box 7: Simplification of Customs transit by rail in Europe

The Customs transit procedure by rail in accordance with EU Customs regulation and Convention on a Common Transit Procedure (1987 as amended) could be organized as:

simplified customs transit procedure with paper based CIM (or CIM/SMGS) consignment note as a Customs transit declaration, or

standard Customs transit procedure with paperless electronic Customs transit messages in the New Computerized Transit System (NCTS), (with paper based CIM (or CIM/SMGS) consignment note that serves only as a transport document); orstandard Customs transit procedure with paperless NCTS Customs transit messages, where the data from the electronic form of the CIM (or CIM/SMGS) consignment note is used to be processed as a Customs transit declaration by NCTS).

Presently with the European simplified Customs transit procedure, the rail operators are mostly using paper based CIM (or CIM/SMGS) consignment note instead of the standard paperless EU NCTS declaration. Customs processing of the paper-based consignment note is minimal, and the rail operators are required to make the records held at their accounting offices, available for Customs control purposes.

See more details at: European Commission, May 2019, **Transit Manual Amendment (Goods Carried by Rail)**

The railway consignment note could be in paper-based format only; dual paper-based and electronic format where consignment data could be electronically exchanged in advance (as elaborated in earlier) or in a fully paperless format (e.g., paperless electronic CIM-SMGS). Railway consignment note in any of these formats (paper-based, dual, paperless) could be applicable to be used as a Customs transit document.

Even though the railway consignment note is the main railway document that could be used for Customs document, the data available from other railway documents such as wagon list / container lists and other information available to the railways may be used under the same concept (reusing railways documents and data for processing of Customs transit formalities).

In Customs transit procedure the carrier (e.g., the railways or its representative) could be directly involved as a principal / declarant. The Customs transit declaration could be made by the railways or its representative that acts as principal/declarant. The WCO recommends that any commercial or transport document setting out clearly the necessary particulars (e.g., railway consignment note) should be accepted as the descriptive part of the goods declaration for Customs transit (WCO RKC, Specific Annex E; Ch.1 Customs Transit - Standard 6). The WCO has also identified the maximum data sets for Customs transit declaration with the WCO Data Model

If according to the Customs regulation the Customs transit declaration should be submitted in an electronic form, then the data elements of such declaration could be based on the data already

available in the railway consignment note. If a paper-based Customs transit declaration is required to be submitted (at the office of departure, transit offices and the office of destination), then it could be substituted by the railway consignment note and a separate Customs transit declaration should not be required.

The of use of the transport documents, such as railway consignment note, as a Customs transit declaration is allowed in the legislation of the Eurasian Economic Union, European Union, and several national Customs legislation in the region.

Box 8: Simplification of Customs transit by rail in Turkey

In 2016, Turkish Railways (TCDD Taşımacılık A.Ş.) was authorized by the Turkish Customs to use simplified procedures for the Customs transit procedure in transport by rail based on the provisions of Turkish Customs legislation and the Convention on Common Transit Procedure. For the simplified procedure for Customs transit by rail in Turkey in addition to the paper based CIM consignment note, there is an electronic data exchange with the Turkish Customs authorities.

The Turkish railways (or their representative) have to submit to the Customs authorities an entry summary declaration for the goods to be brought into the Customs territory of Turkey. Arrival notification has to be submitted upon arrival of the train. The entry summary declaration and arrival notification are submitted electronically to the Customs authorities at the border crossing. The Customs authorities have to approve the summary declaration and arrival notification following the comparison of the electronically submitted information with the information from the paper based CIM consignment note.

For the processing of Customs transit operation within Turkey (e.g., from the border crossing Customs office to the inland destination Customs office) electronic transit notice for each wagon has to be submitted by the railways, before departure of the train. The transit notice contains only minimal information: wagon number, CIM consignment note number, the planned shipment date, Customs office of departure, and Customs office of destination. The transit notice is submitted to the Customs IT system using electronic signature technology.

The information on accepted transit notice is also available at the departure and destination Customs offices. The registration number has to be written on the paper based CIM consignment note, which has to be labelled/stamped with a green pictogram that indicates a transport carried out under simplified railway procedure. Additional Customs transit declaration is not required. Future project activities of fully paperless electronic entry summary declaration are expected to reduce the time needed for Customs formalities for entry customs formalities from 3 minutes to 1 minute per wagon.

Sources: Turkish Customs (2018; 2019)

D4. Joint border controls and streamlined border crossing procedures

Railway border crossings are bottlenecks, where railways and other related stakeholders have to interact between themselves and with control authorities (Customs and other) to complete necessary formalities. Some of the factors that lead to inordinate delays are inefficient organization of border crossing operations, lack of coordination, exchange and processing of paper-based documents, lengthy and uncoordinated regulatory controls of Customs and other government agencies. Introduction of smart solutions such as electronic information exchange, new technologies for efficient and secure border crossing, efficient break of gauge operations, automation of loading/unloading, use railway consignment note as a Customs document are addressing those challenges.

Implementation of such smart solutions improve the level of coordination between the stakeholders and may contribute to reorganization of border controls and processes within the country (e.g., joint border controls and use of single window facilities) and across borders (e.g., with development of single stop joint border controls) that could further streamline the movement across borders.

Joint border control and use of single window facility within a country

Improved coordination and joint border inspections/controls at border crossings, organized between railways and regulatory agencies (e.g., Customs, border security and immigration, transport, sanitary, phytosanitary, veterinary, food safety and other inspections) are key requirement for increased efficiency of movements across the borders.

The railways in the region in general operate only in their own country, which requires change of locomotive/staff to be organized at one of the railway border stations as agreed between neighbouring countries. In accordance with legal requirements and operation rules, the handover process at that border interchange station consists of railway commercial and technical inspections.

Apart from jointly agreed handover process, the railways and regulatory authorities at the two neighboring border stations have separate border crossing procedures (railway and regulatory) and separately conduct inspections/controls (railway and regulatory). The railway inspections and regulatory controls are organized in sequential manner first at the exit border crossing station in one country (first stop) and then at entry border crossing station in other country (second stop).

Joint border inspections/controls within a country are organized at many existing border crossings. Coordination and joint border inspections/controls between railways and regulatory agencies within the country at each of the border crossing stops (separately in exit country and separately in entry country) could take different forms such as: a) transfer of control responsibilities and b) joint inspection teams.

To avoid large number of regulatory agencies at railway border crossing stations, it is possible to transfer some of the control responsibilities to a designated agency (e.g., Customs). Reduced number of control authorities at the railway border crossings increases the efficiency in organization of border controls.

The Customs and other control authorities (border security and immigration, transport, sanitary, phytosanitary, veterinary, food safety) can conduct control activities jointly, or independently and simultaneously, at one

location at the railway border crossing station (e.g., at station side-tacks, Customs yard, or at dedicated side-tracks for veterinary/phytosanitary control).

Railway and regulatory inspections could be coordinated and conducted jointly. Coordination and joint railway and regulatory inspections/controls could reduce delays and streamline the border crossing control process. Efficient coordination among railways and border control authorities may include exchange of information in electronic format and joint use of surveillance and control equipment.

Box 9: Joint border controls in the Russian Federation

Typical border crossing controls are organized under "single window" principle, where the Customs authorities are empowered for a first level examination of the documents in the field of sanitary-quarantine, veterinary and phytosanitary control.

Customs authorities coordinate with other relevant state control authorities if additional controls (other than first level examination of documents) are required.

Initial inspection on arriving train is organized jointly with a commission that includes Customs, border guards and railway station staff.

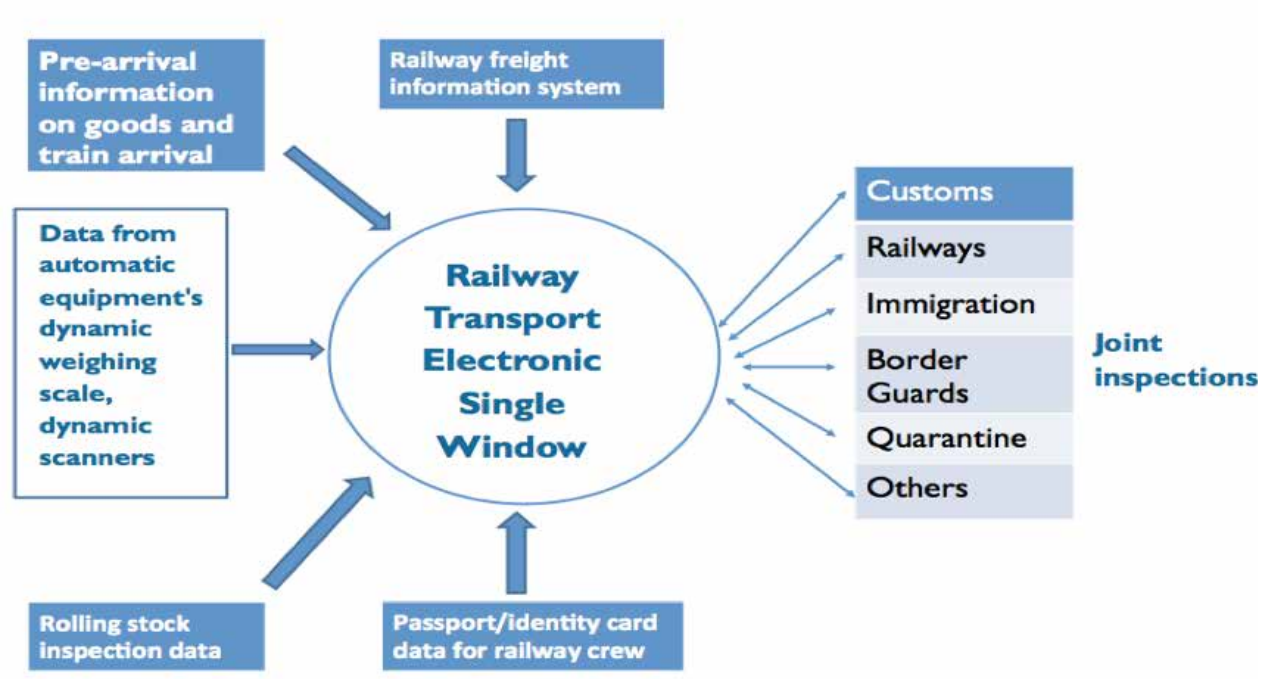
Source: ESCAP (2018) Study on Border Crossing Practices in International Railway Transport

Use of single window facility for railway transport facilitates and enhances coordination of railways, other related stakeholders and regulatory authorities. The railway transport electronic single window could use modern technologies and a neutral platform to receive and store relevant information from multiple sources e.g., railways, freight forwarding agents, consignors/consignees, automatic control equipment and dynamic scanners employed at border stations. The system should support interconnection with multiple information systems such as those of railways, Customs and other government agencies and expedite their formalities to release transport means and goods at the border crossing.

Introduction of railway transport electronic single window and linking railway information systems with the systems of other regulatory agencies, would lead to more efficient information exchange. In particular, it would alleviate the need for resubmission of similar information and contribute to smooth cross-border operations and a reduction in delays at railway border crossings. It would also aid risk management and, accordingly, enhance the efficiency of the controls conducted by Customs and other government agencies.

If there is already developed national single window facility in the country, linking railway information systems in order to support railway border crossing processes could be considered. The railway transport electronic single window primarily supports joint border crossing controls within the country (and potentially it could be expanded to support coordination of border crossing formalities on cross-border level).

Figure 34: Single window facility for railway transport



Source: ESCAP, 2018, Draft framework for enhancing efficiency of railway border crossings along the TARN and beyond

More comprehensive regulatory single windows solutions may include all modes of transport and additionally it could be linked/integrated with digital logistics platforms that cover business-to-business (B2B) transport related information exchange. Some of the B2B data could be re-used for electronic information exchange between busines and government agencies (B2G, G2B) (e.g. Customs, transport authorities).

D5. Single stop joint border crossing and seamless movement of trains across borders

Single stop inspections at joint border crossing is a solution where only one common border station between the neighboring countries is designated as a joint border control checkpoint. The arrangements on joint border crossing station are normally part of bilateral agreement that details formalities for organization of railway processes and control procedures (e.g., customs, sanitary, food safety, veterinary, phytosanitary inspections).

At the designated joint border crossing station, the change of locomotive/staff will be organized. The railways and control authorities from both countries may conduct the necessary inspections/controls jointly at a common inspection area or independently (sequentially or in parallel) at other dedicated inspection areas located at the joint border crossing station (e.g., only at exit or at the entry border crossing station).

If the border crossing is a break-of-gauge point, then all break of gauge operations (e.g., transshippment of containers and/or change of bogies) should be organized at the same joint border crossing station as well. The trains do not have to stop at the other border station at all.

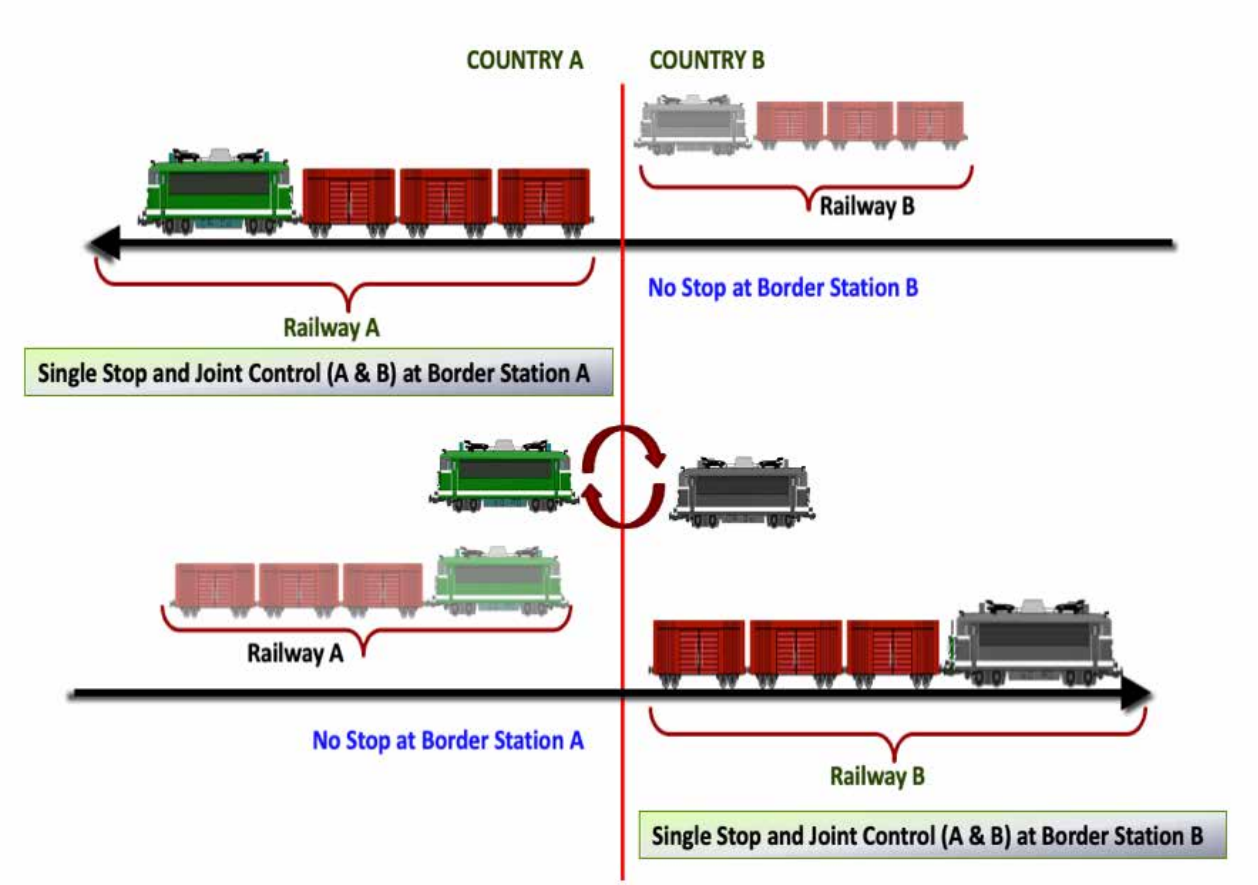
Joint border railway stations are very rare, despite the huge potential they offer for streamlining of border crossing procedures

and reduction of time to cross the borders by rail. An example of single stop border crossing is Padang Besar in Malaysia (for passenger railway transport only), where all railways and regulatory controls are conducted (Customs and immigration) and the passenger trains do not have to stop at the border crossing in neighboring Thailand.

Potentially it could be possible to organize crossing the border without stopping at the border stations. In such case it will be required to have common regulatory procedures and controls organized only at departure and destination stations, in parallel with operational procedures for railway traffic management. The trains do not have to stop at the border stations at all. The railway undertakings should be able to operate on the networks on both neighboring countries in this case.

The solution for crossing the border without stopping may be achievable for the unions of countries which are developing common railway transport area and have common Customs territory. Such arrangements are very demanding to made and therefore extremely rare and limited. For example, for some railway border crossing movements between Norway and Sweden there is no need for the trains to stop at the border at all. Customs authorities from both countries are empowered to perform Customs control on behalf of each other. Such control will take place at the first inland station in Norway or in Sweden where the train must stop.

Figure 35: Joint border crossing stations with single stop inspection (at entry)



E. Smart railway customer orientation

E1. Mobile application for railway freight- Rail SUGAM[66] (case study of Indian Railways Smart User Group with Advance Mobility)

Rail SUGAM is a mobile app of India Railways developed for ease of doing business for railway freight customers.[67] It is designed to meet the immediate requirements of potential as well as existing customers and those having interest in knowing more about freight operations and performance of India Railways.

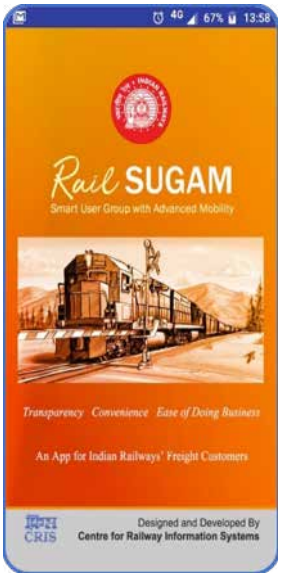
The application promotes use of railway transport services and also improves customer confidence by providing easy to use interface for accessing relevant information.

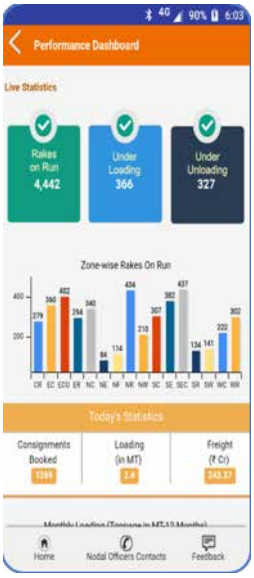
The application dashboards and data views provide information on multiple Indian Railways freight aspects including performance, terminal handling details, contact details of concerned officers and many more features including tracking and tracing the position of the goods in transit over Indian Railways network.

The main features of the app are:

- Booking information - that provides interface to key information helpful to users for booking their goods through Indian railway (IR)
- Freight terminals - that provides details of operational terminals for handling goods traffic
- Indent status - that provides details on the status of specific orders and other important IR freight information
- Rake allotment - that enables freight customers to access details on pendency of iron ore and coal indents and allocations/ allotment plan for same as generated through IR system
- Freight Performance - which is a dashboard on performance of IR's freight business
- Consignment tracking - that provides tracking and tracing of position of the goods
- Other external links - that offers links to other freight related websites

66. Adapted from the Smart Railway Solution Case Study prepared by ESCAP Transport Division, based on the information provided by Mr. Amit Kumar Jain, Centre of Railway Information System of the Indian Railways.
67. The App was developed during 2018-2019 by the Center for Research in Railway Information System (CRIS) an IT arm of Indian Railways

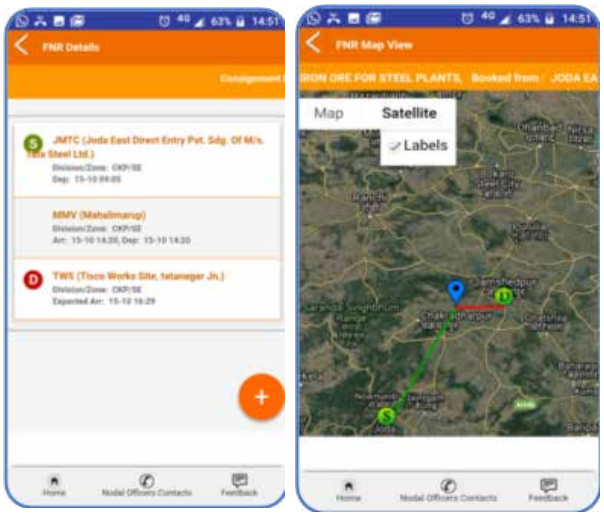




The booking related information can be accessed by user through the option including:

- Freight calculator - that provide users with an approximate freight amount to be charged for transporting their goods through Indian Railways at the time of enquiry
- Freight rates - that provides a list of rate slabs and distance wise slabs for each commodity allowed to be booked for transport through Indian Railways
- Booked route information - that helps users to know the shortest and rationalized routes open on Indian Railways for carrying customer's goods
- Terminal details - that provides detail of all loading / unloading terminals across IR that can further be viewed on Google Map view

The consignment tracking feature enables freight customers to track and trace the movement of their consignments booked and being transported through Indian Railways on geospatial view on interactive Google map. Through this feature, customer can not only know the last reported location of the consignment but can keep track on its expected time of arrival (ETA) at destination.



The App facilitates first mile and last mile connectivity, because it is bundled with features which provide details on logistics service providers at various goods handling locations over IR network. The App provides details and contacts of service providers including truckers, warehouse service providers, labor service providers.

The App was developed by the Center for Research in Railway Information System (CRIS) in cooperation with freight customers intending to respond to their major requirements. Vast amount of digital data maintained centrally at existing freight operations information system has been used in app development. The App has been presently downloaded more than 6,000 times and it is extensively used by the customers of railway freight related business.

F. Smart railway investing

F1. Green bonds, sustainability bonds and green loans

Green bonds, sustainability bonds and green loans are debt instruments (bonds / loans) that can be used to borrow money under obligation to repay the specific amount at specified date in future, together with interest. The green (or sustainability) financial instruments have to be exclusively applied to finance or re-finance (in partial or in full) new and/or existing eligible green projects (or combination of both green and social projects).

Green bonds can be issued by various issuers (e.g., multilateral development banks (MDBs), governments or corporations, for example railways) usually with fixed interest rate (coupon rate) for a different tenor (e.g., 5 years, 10 years, or longer). The underwriters (e.g., banks) work closely with the issuers to determine the bond-offering price, to administer bond issuance and sell them to investors. External reviewers may provide independent opinion on alignment of the green bonds with specific guidelines or standards and provide verification and certification. Investors (e.g., institutional investors such as insurance companies and pension funds or private investors) are buying bonds to generate return.

Green loans are given by the borrower (e.g., development bank, commercial bank), with fixed or variable rate in one or more tranches. The green loans are given to lenders (e.g., to the corporations such as railways) to finance eligible green projects. In similar way as with the green bonds, the green loans could be subject to external review and certification to assure alignment with specific guidelines and standards.

Green / Sustainability Principles and Standards

- ICMA, Green Bond Principles (updated 2018),
- ICMA, Sustainability-linked Bond Principles (2020)
- LMA, Green Loan Principles (2018)
- CBI, Climate Bonds Standard (Version 3.0) (2019)

Currently, there are many differences with regard to defining and labelling of green bonds, sustainability bonds and green loans. Voluntary principles and standards in this regard have been developed and promoted by international associations and initiatives (e.g., International Capital Market Association (ICMA), Climate Bonds Initiative (CBI)). Common principles and standards support more harmonized approach in development of regulations and recommendations on national and supranational level.

For example, European Union has adopted taxonomy regulation as a framework to facilitate sustainable investment and issued recommendations on EU green bond standard.[68] ASEAN has issued green bond standards and sustainability bond

68. For more details see European Commission website on EU taxonomy for sustainable activities: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en, and EU Green Bond Standard https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-green-bond-standard_en

standards.[69] At national level, the People's Bank of China released an announcement on the issuance of green financial bonds, the National Development and Reform Commission published a Guidance on green bond issuance, and Securities Regulatory Commission issued guiding opinions for supporting the green bonds.[70] Large number of national polices from the countries around the world are developed with regard to green financial markets.[71]

The financial policies, guidelines and regulations on national (or supranational level) clarify the approach for issuance of green / sustainable financial instruments; provide issuers guidance on the key components in launching credible green / sustainable financial instruments; aid investors to monitor and evaluate the impact of their investments; and help government to support issuance of such financial instruments in accordance with their environmental and sustainable policies.

The wide use of green / sustainable financial instruments in the financial sector can re-orient investments towards more sustainable transport solutions such as clean railway transport.

The four core principles related to green financial instruments (green bonds / green loans) are:

- Use of proceeds, in eligible green projects (e.g., energy efficiency; pollution prevention and control; clean transportation) that provide clear environmental benefits, which will be assessed and, where feasible, quantified by the issuer / borrower

- Process for project evaluation and selection, that requires issuer / borrower of a green financial instrument to clearly communicate to the investors / lenders: the environmental sustainability objectives; the process by which it is determined how the projects fit within the eligible categories and related eligibility criteria

- Management of proceeds, with accountability and high level of transparency (that may be supplemented by use of an auditor or other third-party external review)

- Reporting, that provides readily available up to date information on the use of proceeds (annually and as necessary in case of material developments)

The CBI has developed land transport criteria that provide the requirements that must be met for land transport projects to be awarded Climate Bonds Certification.[72] The railway criteria recommend automatic eligibility (e.g., for electric and zero direct emissions transport) or conditional eligibility based on mitigation requirements such as reduction of emissions and universal emission thresholds. Dedicated fossil fuel transport is excluded from certification.

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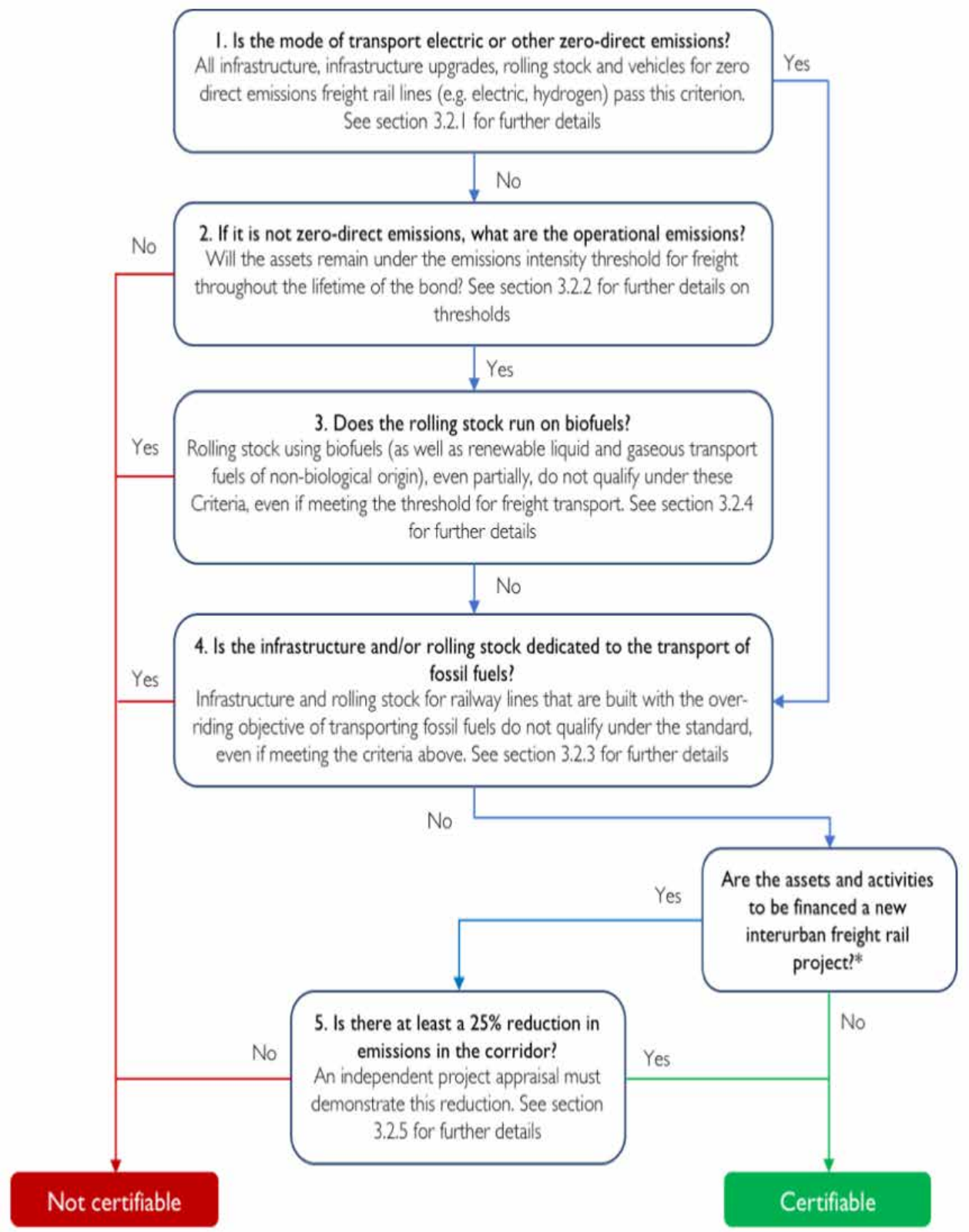
69. For more details see ASEAN Capital Markets Forum (ACMF) website: https://www.theacmf.org/initiatives/sustainable-finance/asean-green-bond-standards (for ASEAN green bond standards) and https://www.theacmf.org/initiatives/sustainable-finance/asean-sustainability-bond-standards (ASEAN sustainability bond standards).

70. For more details see ADB, 2020, (Hao Zhang), Regulating Green Bonds in The People's Republic of China: Definitional Divergence and Implications for Policy Making. Available at: https://www.adb.org/sites/default/files/publication/562076/adbi-wp1072.pdf

71. Over 100 Green bond policies of different type (e.g., guidelines, special documents, regulations) are identified by Climate Bond Initiative. For more details see: https://www.climatebonds.net/policy/data

72. CBI, 2020, The Land Transport Criteria for the Climate Bonds Standard and Certification Scheme (Version 2). Available at: https://www.climatebonds.net/files/files/CBI%20Transport%20Criteria%20document_13%20Oct%202020.pdf

Figure 36: Certification requirements for railway networks and freight rail rolling stock



Source: CBI, 2020, The Land Transport Criteria for the Climate Bonds Standard and Certification Scheme (V2) (3.7, p.18).

Railway transport is included in CBI Climate Bonds taxonomy that identifies assets and projects needed to deliver a low carbon economy consistent with COP Paris Agreement. Cross cutting assets such as ICT that improves asset utilization, intermodal facilities, smart logistics solutions are also included.[73]

Figure 37: CBI Climate Bonds taxonomy for freight rail and cross cutting assets

	Asset type	Asset specifics	2 degree compliant	Screening indicator	Certifiable
FREIGHT RAIL 	Trains	Rolling stock for electrified freight rail	●	Fossil fuel freight must not be more than 50% of the freight transported (in tonne/km)	●
		Rolling stock for non-electrified freight rail	●	(i) Fossil fuel freight must not be more than 50% of the freight transported (in tonne/km) (ii) Transport meets universal gCO2/t-km (tonne-kilometre) threshold	●
	Infrastructure	All infrastructure for electrified freight rail	●		●
		All infrastructure for non-electrified freight rail	●	Eligible if the associated rail is eligible	●
CROSS CUTTING		ICT that improves asset utilisation, flow and modal shift, regardless of transport mode (public transport information, car-sharing schemes, smart cards, road charging systems, etc)	●	Must deliver substantial GHG emissions savings on either a passenger/km or a tonne/km basis	●
		Intermodal freight facilities	●		●
		Terminals to improve journey times	●		●
		Smart freight logistics	●		●
		Multi-modal logistics hubs	●		●
		Integration of transport and urban development planning	●		●

Source: CBI, 2020, Climate Bonds Taxonomy (p.8).

The green bond market continues to expand and reached on global level a total of 259 USD billions in 2019 out of which over 100 USD billions are certified climate bonds (Asia-Pacific share in 2019 was 64.5 USD billions). About 20 per cent overall green bond market

73. CBI, 2020, Climate Bonds Taxonomy. Available at: https://www.climatebonds.net/standard/taxonomy. For more details on low-carbon transport criteria see CBI website: https://www.climatebonds.net/standard/transport

and about 50 per cent of certified volume of has been allocated to transport (about 50 USD billions). Substantial part of it was dedicated to low-carbon transport in various rail projects and expansion of metro lines around the world (e.g., in China, Japan, Russian Federation, France, Germany, USA, Chile etc.).[74]

Box 10: Examples of Certified Green bonds in Railway Transport

French Railways SNCF is one of the rail industry leading issuers of green bonds. From October 2016 until April 2020 the SNCF has issued nine green bond deals with total value of 7 billion EUR. At 31 of December 2019 the SNCF green bond represented 11 precent of total SNCF depth. The green bonds have been issued with various tenor ranging from 10 to 100 years. Eligible green projects financed by SNCF include investments related to maintenance, upgrades and energy efficiency of the rail system (renovation of tracks and traction power supply infrastructure and signalling system upgrades of 100 per cent electrified part of the network) and investments related to new rail lines and rail lines extensions which ensure access to the network and the efficient movement of people and freight.[75]

Russian Railways ("RZD") issued first certified climate green bond deal in May 2019 (EUR 500 million, with 8 years tenor and 2.2% coupon rate) and second in March 2020 (CHF 250 million, with 6 years tenor and 0.84% coupon rate) through its Irish subsidiary, RZD Capital, which exists primarily to access offshore debt financing for the parent. The proceedings from the green bonds are allocated towards re-financing of acquisition of electric locomotives and electric trains "Lastochka" (Swallow) which are used in suburban and intercity long-haul passenger transportation.[76]

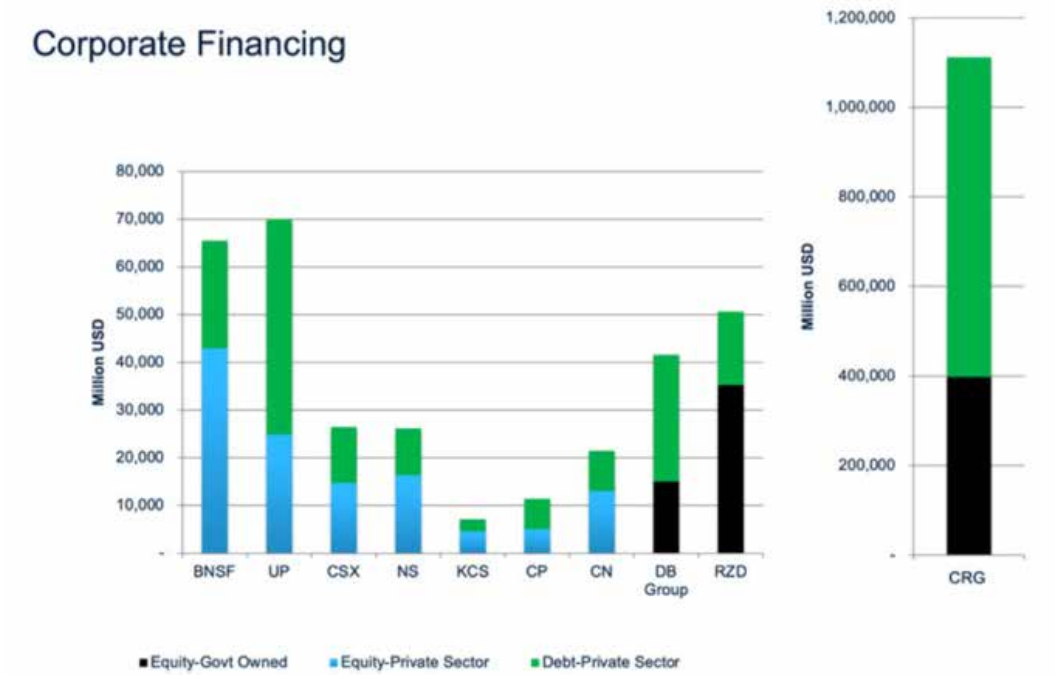
It should be noted that green bonds are still only small part of overall railway debt financing. In financing of their dept the railways in many countries depend on the sovereign financing, raised through their governments. However, the railways are increasingly looking to the private sector for needed investment. Some railways manage to raise their entire financing from the private sector (e.g., North American freight companies), while others such as Deutsche Bahn (DB), Russian Railways (RZD) and China Railway Group (CRG) – mix sovereign and corporate financing. Their stock is owned by the government, while debt is borrowed from the private sector.

74. CBI, 2020, Green Bonds Global State of The Market 2019. Available at: https://sotm.climatebonds.net/modules/custom/cbi_sotm/bonds-view/assets/cbi_sotm_2019_vol1_04d.pdf

75. For more details see SNCF Green Bonds webpage: https://www.sncf.com/en/group/finance/green-bonds and CBI SNCF information at: https://www.climatebonds.net/certification/sncf

76. For more details see RZD Green Financing website page: https://eng.rzd.ru/en/9653 and CBI RZD information at: https://www.climatebonds.net/certification/Russia_Railways

Figure 38: Railway Corporate Financing



Source: Global Railway Review Railway, Nov 2020 (M. Lawrence and H. Goetsch), Financing – expand your scope, you'll need it.

Government/intergovernmental funds and public private partnerships

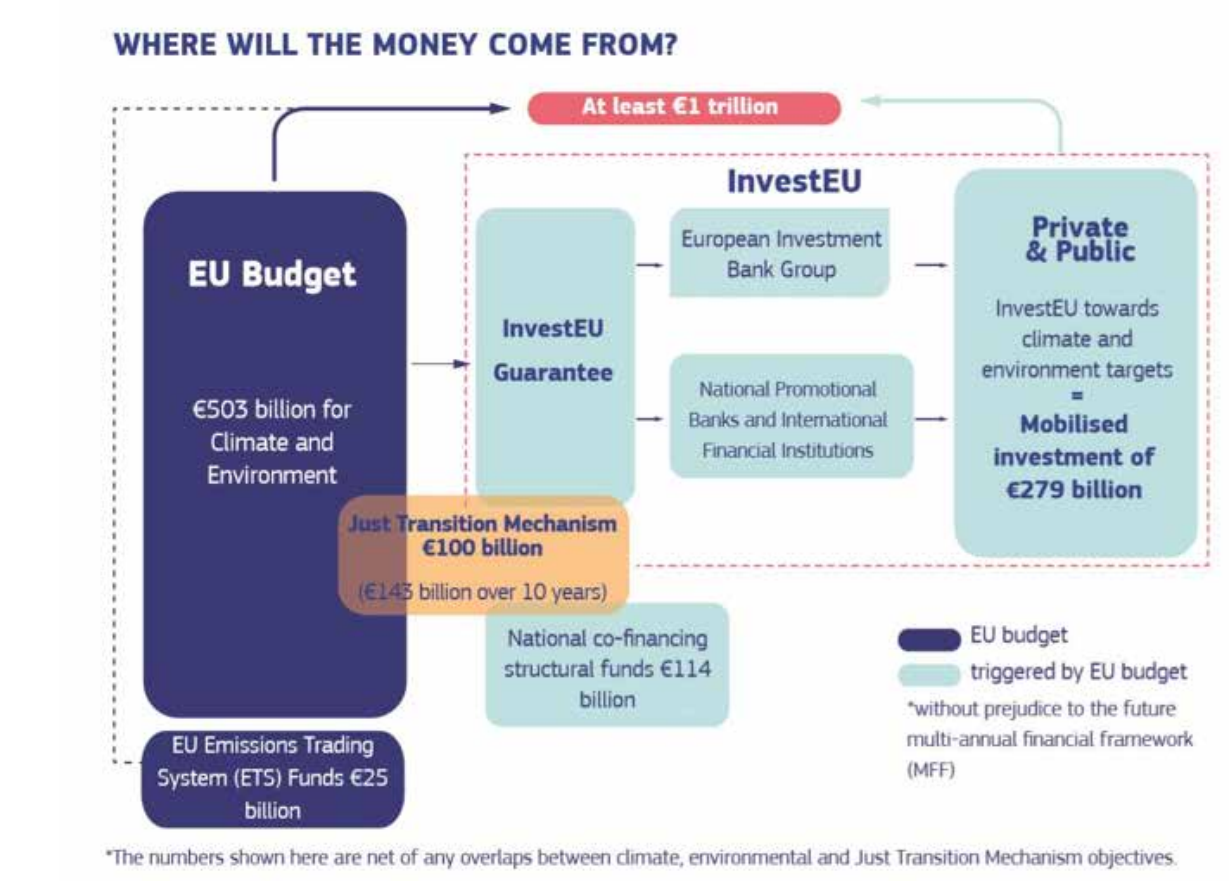
Governments are increasingly involved in the development of green economy that includes support for funding of green projects. Governments, and intergovernmental organizations partnering with multilateral development banks are mobilizing funds for development of large transport infrastructure projects. In some instances, special green funds are being established, that may be directly supported from the budget, or via other green financing mechanisms. The railways are more and more in the centre or national sustainability policies and they are in position to benefit from governmental/ intergovernmental funds and grants.

For example, for financing of the European Green Deal,[77] a European Green Deal Investment Plan (EGDIP), has been developed with aim to mobilize at least one trillion euros to support sustainable investments over the next decade. The plan envisages increasing the resources devoted to climate action under the EU budget and leveraging additional public and private financing. Around half of the amount of for financing of European Green deal projects would come directly from the EU budget. About a quarter of the total amount is expected to be triggered via European Investment Bank and the rest should be covered by just transition mechanism that will focus on the social and economic costs of the transition in the most impacted regions and finance projects; and co-financing from the EU Member states.[78]

77. The European Green Deal was launched by the 2019 Communication of European Commission as a roadmap to reach a carbon neutral economy in the European Union by 2050. For more details see: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

78. European Parliament Briefing, April 2020, (European Parliamentary Research Service) European Green Deal Investment Plan. Available at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/649371/EPRS_BRI(2020)649371_EN.pdf

Figure 39: Financing for European Green Deal



Source: European Commission, 2020, The European Green Deal Investment Plan and Just Transition Mechanism explained. Available at: https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_20_24/QANDA_20_24_EN.pdf

Considering the lower environmental impact of the railway transportation compared to other modes of mass transportation the railway related projects contribute to reaching the goals of the European Green Deal, such as accelerating the shift to sustainable and smart mobility. Therefore, it is expected that the railways will be able to benefit from dedicated funds and financial support program of the European Green Deal Investment Plan.

Public-private partnerships (PPP) are frequently used methods to increase a project viability and attract private capital. The PPP are project delivery mechanism with financing component that may be focused on green projects. The PPP on railway projects may be used for construction of railway lines, terminals, port links etc. under different forms such as concessions and build, operate, transfer schemes (BOT). PPP are more used for passenger and especially urban rail projects with clear revenue base

F2. Geographic Information Systems (GIS)

Modern geographic information systems (GIS) combine hardware, software to collect, manage, analyze and display all types of geo-referenced information. The value of GIS in all areas of activities in terms of planning, process management and important strategic

decisions is explained by its key features. GIS integrates many data types, giving information about geographical location. Geodata, unlike data of any other type (tabular, text, graphical), acquire a spatial configuration, providing the user with new opportunities for their interpretation. Analysis of data based on their mutual location reveals hidden and spatial relationships of qualitative and quantitative characteristics of all kinds of objects.

GIS provides a universal form of presenting information in the form of geographic visualizations (maps). This is particularly important for products developed for international collaboration or for a broad user audience. With a common visual language, GIS allows for the integration and presentation of multiple types and datasets into a single system of relationships. Converted into geodata, the information becomes visible, making it much easier to understand and opens up new opportunities for comparison and interpretation.

GIS-based maps are interactive, i.e., provide the user with the ability to interact with visual content . It can be developed for an unlimited number of users, as well as for solving complex industry tasks by a narrow team of specialists.

GIS as a data collection and storage system provides tools and architecture to simplify the process of accumulation and unification of information from different sources. In this aspect, the capabilities of geoinformation technologies are constantly growing and practically unlimited, covering a huge range from collecting historical data to recording events in real time. Depending on the specifics of each specific data set, the collection can be performed using different methods: manual mode by the system operator, automated mode using a single form of entering information that can be sent to representatives of various departments and organizations and in fully automatic mode from fixation devices such as sensors, cameras, updated digital databases, etc.

Geodata forms a "mirror" of the real world, thus serving as a basis for digital modelling and forecasting. Flexibility of settings allows to take into account many factors, to play all sorts of scenarios, to compare the results. GIS and models based on them are an indispensable tool for strategic planning, risk assessment and search for optimal solutions.

GIS a widely used solution for both rail and non-rail organizations. It is used by development banks and subregional organizations: Asian Development Bank[79], Islamic Development Bank[80], the World Bank[81], ASEAN[82] and many others. Such systems are also widely created within railway companies: Russian Railways[83], Indian Railways[84], etc.

In addition to map representation of processes or data, GIS allows using of interactive dashboards to observe changes by places / objects or regions under specific circumstances or under various alternatives.

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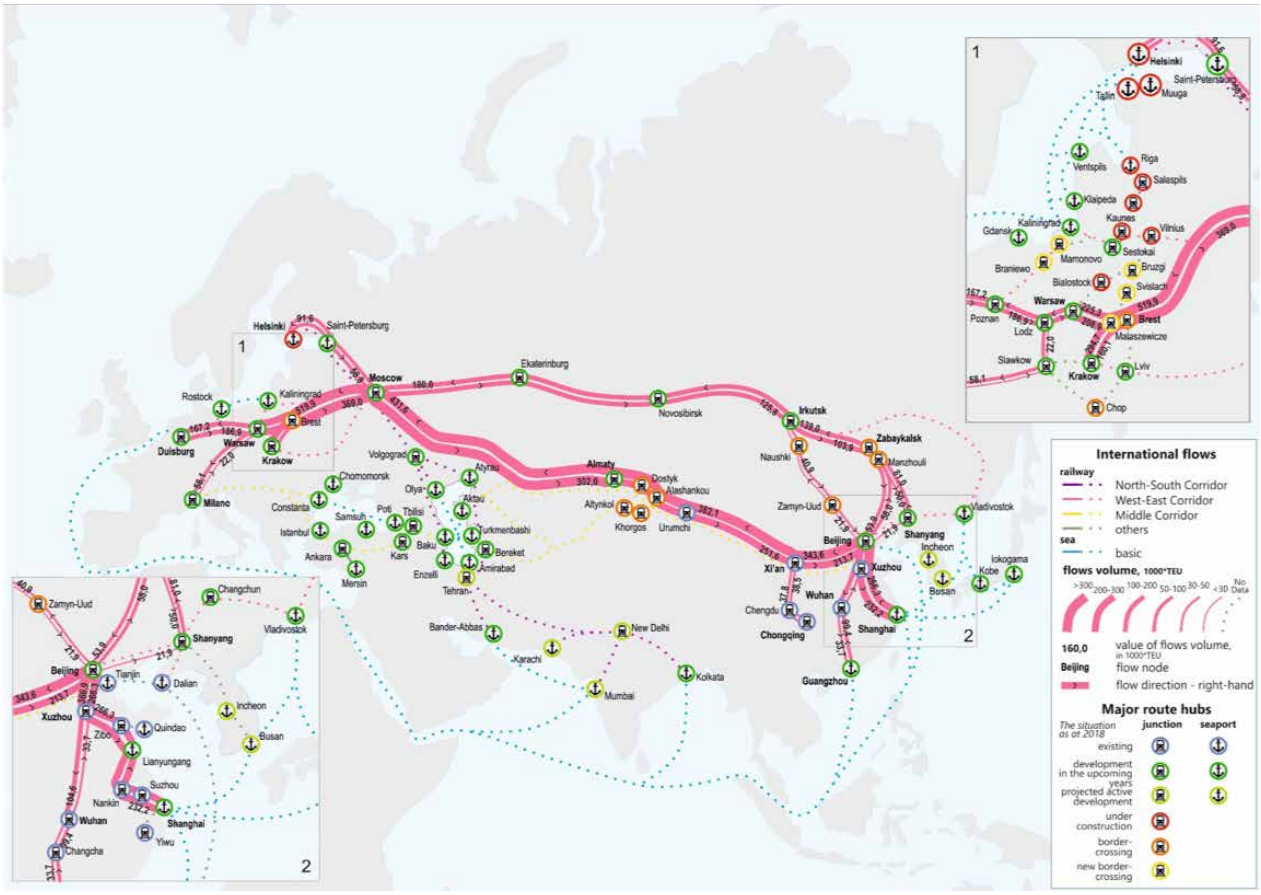
79. https://www.adb.org/sites/default/files/publication/148901/space-technology-and-gis-applications-adb-projects.pdf
80. https://www.isdb.org/fr/node/38408
81. https://datacatalog.worldbank.org/data-type/geospatial
82. http://www.asean-gidatabase.org/gidatabase/
83. http://www.vniias.ru/geoinformatsionnye-tekhnologii
84. https://www.geospatialworld.net/blogs/indian-railways-to-use-gis-portal-satellite-imagery-and-gps-to-monitor-manage-its-assets/

Figure 40: Using GIS for a UIC Study "Eurasian corridors: development potential"[85]



F3. Railway transport modelling

Transport modelling is a smart decision-making tool which allows for transport planning (for infrastructure, operation, technologies and other issues). It can also facilitate setting up investment and development priorities as well as testing new routes, services, charging schemes and solutions. In addition, planned changes in railway sector against macroeconomic conditions and their changes can also be simulated.

For purposes of modelling all features of railway network and its performance, as well as of networks of other transportation modes (if necessary) are represented in a digital form. To adjust the formulas and relevant mathematical laws, the model self learns based on historical data. Modern technologies allow self-learning (machine learning) models. Thus, self-learning algorithms are programmed to refine their own performance, and that requires enough of processing capacity.

Transportation modelling allows decision-making based on objective mathematical formula without engagement of human factors and subjective preferences. Still most subjective factors, including political risks and other constraints, may be considered within models.

85. https://uic.org/IMG/pdf/uic-iec2020_eurasian-corridors-development-potential_exec_summary.pdf

Basic structure of model

Transportation modelling can be done through use of transport data along with either fixed or variable macroeconomic data. Following basic blocks of data are necessary for rail freight transportation model development:

- graph of transportation network (GIS) with basic features like transportation speed
- historic trade data
- trade forecast
- historic data for the transportation network: existing and previously existing flows, allocation by routes
- transportation tariffs and prices (market prices)

In the first case rail system will be considered as fixed within the model, without the ability of the model to evaluate effects and changes under new economic conditions. This approach is often used by transportation companies. It can be applied for short-term planning.

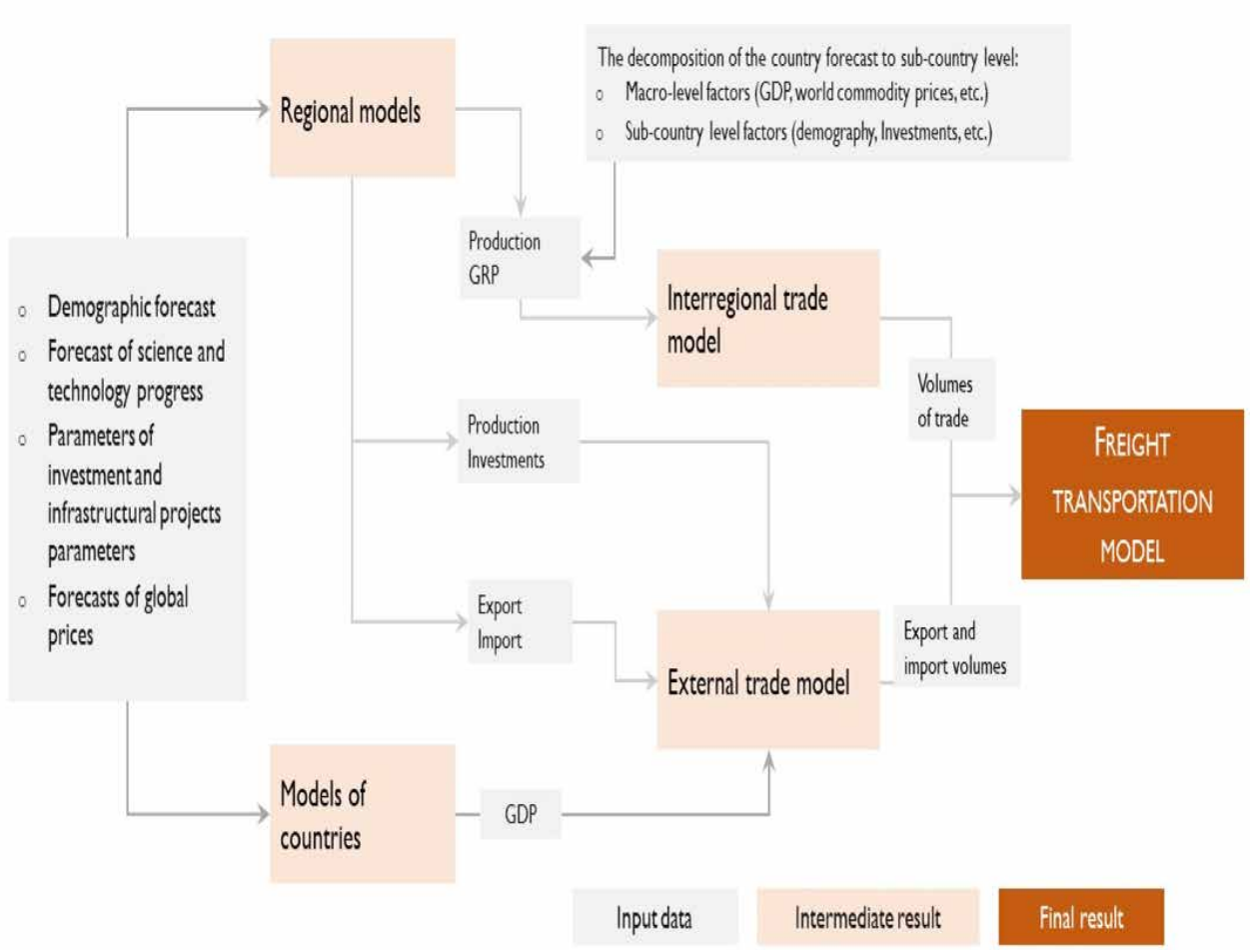
In the second case macroeconomic data is considered as fixed. Such approach may be used by organizations that provide macroeconomic forecasts themselves (banks, ministries, etc.) and that use transportation models as an illustration for some projects. It can be applied for short to long-term planning, but it does not allow consideration of several economic scenarios to evaluate top and bottom opportunities of railway transportation.

The third case is most adoptive to variable conditions and can be used to set up investment priorities under different scenarios for any term of planning. Such approach is in high demand of governments and businesses for strategic planning and risk assessment. Below the most complex third option is considered for further description.

The quality of data impacts the accuracy of forecast with more detail's accuracy increases . Some specific tasks, such as modelling of flows of the exact type of cargo, requires high accuracy, whereas more general issues, such as modelling of general (or by groups of commodities) freight flows allocation for transcontinental routes may be based on lower accuracy.

In comprehensive transportation models freight flows forecast is a result from trade (macroeconomic) forecast.

Figure 41: Simplified structure of a macroeconomic model used for transportation modelling

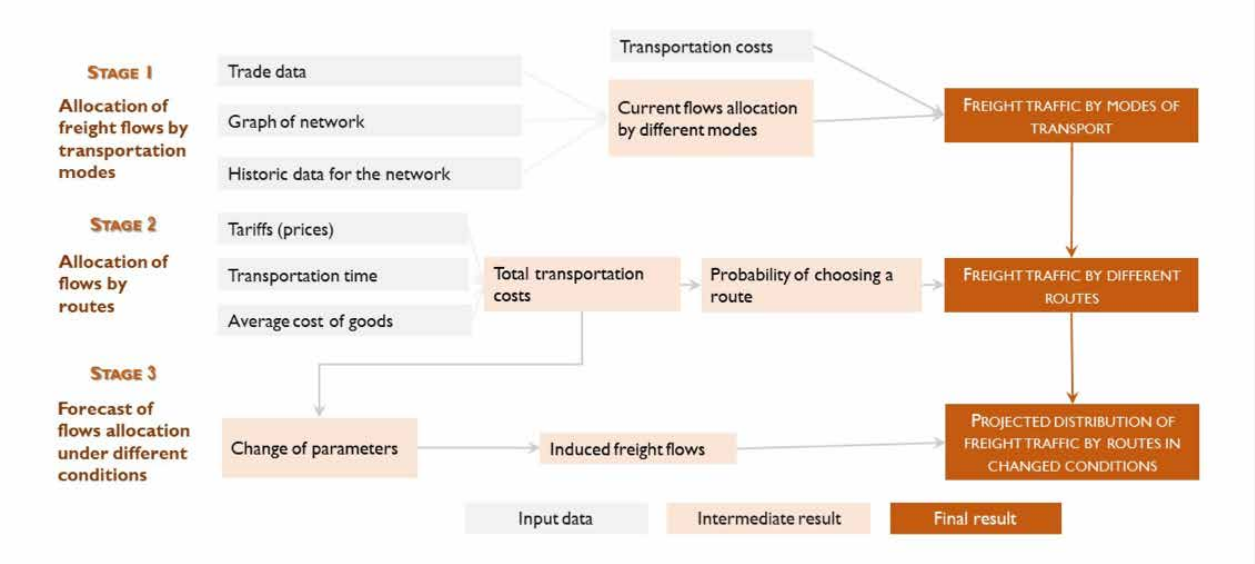


Source: Infrastructure Economic Centre

Macroeconomic module results in definition of total freight flows between countries and between regions within one country for the specified period. Such forecast may only consider groups of countries, separate countries and, if necessary, regions within one country. Forecast of interregional trade is crucial for larger countries, such as China, India, the Russian Federation, etc.

Freight transportation model provides information of allocation of these flows by specific modes of transport, by routes between countries or within one country, as well of changes in allocation of these flows under impact of various factors and condition.

Figure 42: Simplified structure of a freight transportation model



Source: IEC

Thus, macroeconomic module of the model provides the total volumes and freight transport module provides details on allocation of these volumes by routes.

Another link between macroeconomic data and freight transport data is information on average cost of goods, especially for models considering detailed forecast for specific commodities. The cost of goods is defined by market prices and it is extremely important to calculate total transportation costs, which are the core element of freight transport model.

Total transport costs are formed of transport price + frozen capital assets[86] for the period of transport:

- total transport costs differ for various types of commodities
- total transport costs for the exact types of commodities should be considered for high-quality models.

86. Commodities cannot be used during the period of transportation: the higher value added are the goods, the higher is the importance of transportation speed, to make these assets parts of production chain as soon as possible

Data set and data collection

Standard data sets, defining the accuracy of forecast, can be proposed.

Figure 43: Standard data set for macroeconomic module of the transportation model

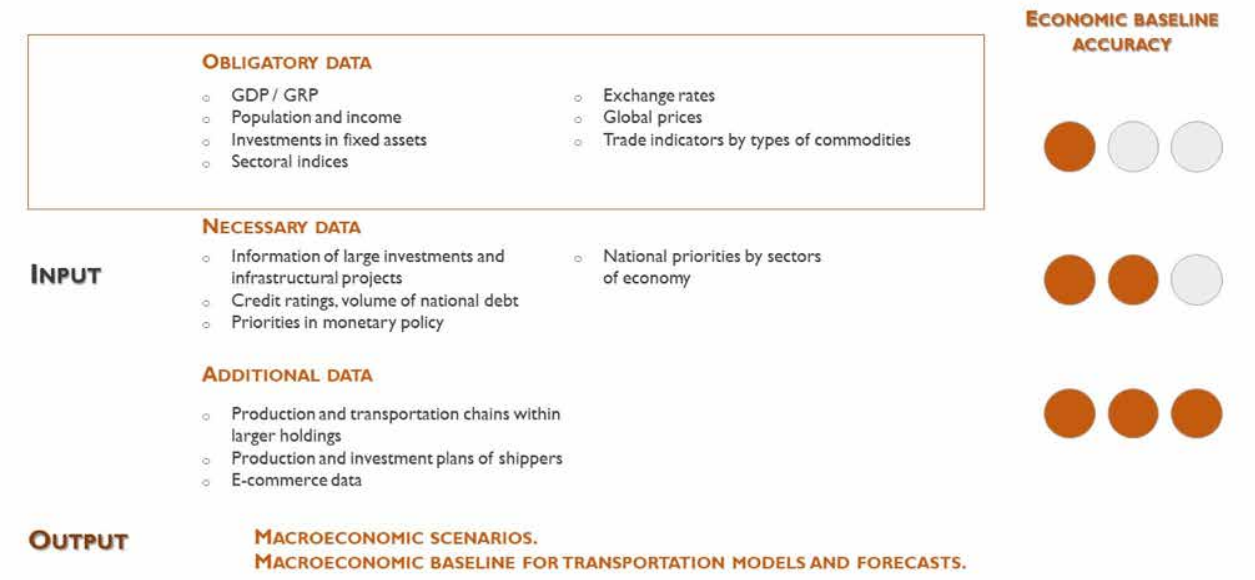
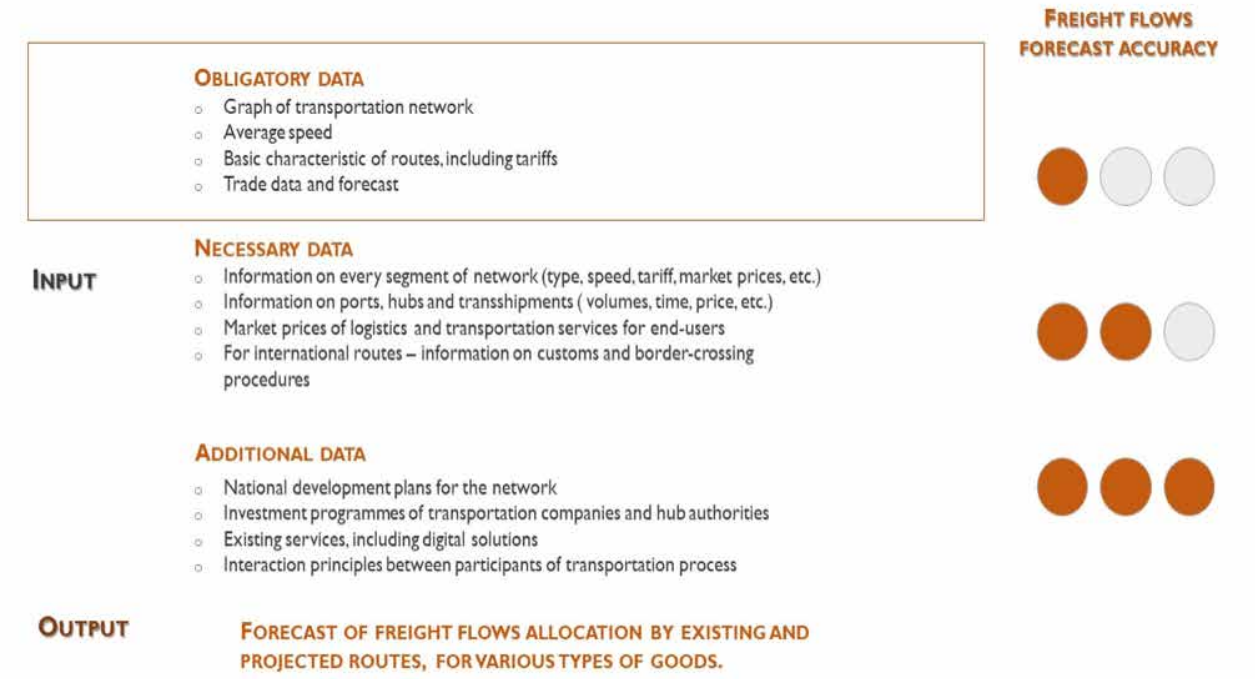


Figure 44: Standard data set for freight module of the transportation model



While data sets for the highest modelling and forecasting accuracy and complex and specific for each country, data collection for basic accuracy can be simplified:

- by establishing national data collection and transport statistics systems
- by using automated data collection by using API (application programming interface) to collect data from different statics forms of various authorities and organizations.

Implement a uniform approach to transport statistics may be recommended to subregional organizations and all countries that are part of international transportation corridors. Automated data collection may result in 35-times increase of efficiency in comparison to manual collection.

Setting up a model

GIS as a base part of modelling and decision-making. Graph of transportation network – representation of network as a system of segments and nodes with their characteristics – is the key element of a transportation model. Otherwise, the allocation of flows by routes and theirs parts cannot be forecasted.

Geographically linked data on transportation network is usually presented in a form of a GIS – Geographic Information Systems. GIS are used to store, manage and analyze data that can be (a) easily visualized in a form of maps, and (b) analyzed as spatial data revealing territorial patterns and relationships.

For transportation models it is the shipping route that matters. If several networks of various transportation modes are used, the model can provide the segmentation of route by different combinations of transportation modes (e.g., truck + rail + sea + truck) with detailed information for each segment.

In some cases, geographically visualized information may already be a tool for decision-making without any further analysis. It is also important that existing GIS usually held either by international organizations or by national authorities, are already a good base for constructing comprehensive transportation models.

The models are based on mathematical and logical algorithms. Some of them are widely known and used, some of them may reflect the specificity of the exact corridors / countries / regions. In this case special coefficients may be added or adjusted.

One of the modern smart solutions for transportation modelling is the use of machine learning to elaborate self-learning algorithms and models. In this case, a mathematical model is based on sample data (historic network performance) and predictions, or forecast, are made by using automatically detected patterns from large amounts of data and by applying known rules to the data for processing. The more data is put into the model and tested, the more accurate is the modelling due to machine learning.

There are different types of software that allow creation of transportation models software for general purpose and software for professional use. The first type represents platforms that assure data management, scenarios management and visualization. Such platforms do not propose (a) any pre-set of data; (b) any specifically pre-taught algorithms for regional cases; (c) any

combination of economic and transportation modelling. At the same time, they offer a simple use and a variety of existing transportation algorithms. This type is more suitable for small to medium transportation companies and for modelling within closed transportation systems (one country without considering international links and trade changes).

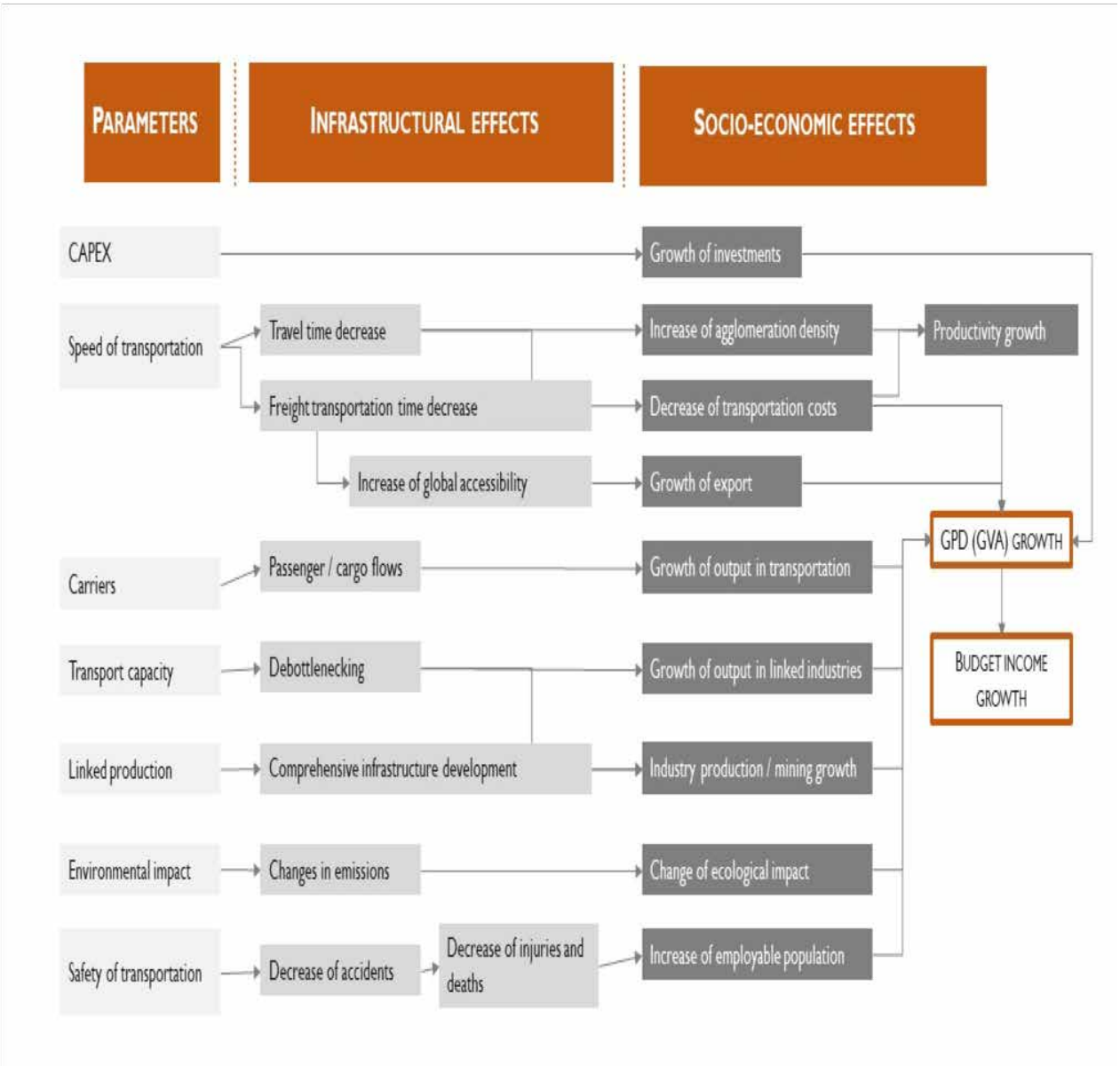
The second type is usually used as a part of consultancy services and require additional support from the software providers. These models have got (a) built-in data or automatic collection mechanisms; (b) self-learning algorithms; (c) macroeconomic and transportation modules working together; (f) in some cases – additional module for effects assessment arising from transportation projects and enhancements. This type is suitable for modelling of freight transportation by corridors and regions and for use by authorities focused on setting up national or international priorities.

Effects assessment

One of the key benefits of combined macroeconomic and transportation models is an opportunity to assess socio-economic effects from transportation projects or even small enhancements. Over the recent years many countries have elaborated reference systems for evaluating investment projects. With modelling it is possible to assess direct and indirect effects from railway developments.

This module is available only in models for professional use, and, despite automation, it requires consultancy assistance to test and adjust the algorithms and results for each specific case.

Figure 45: General scheme of effects assessment within transportation modelling



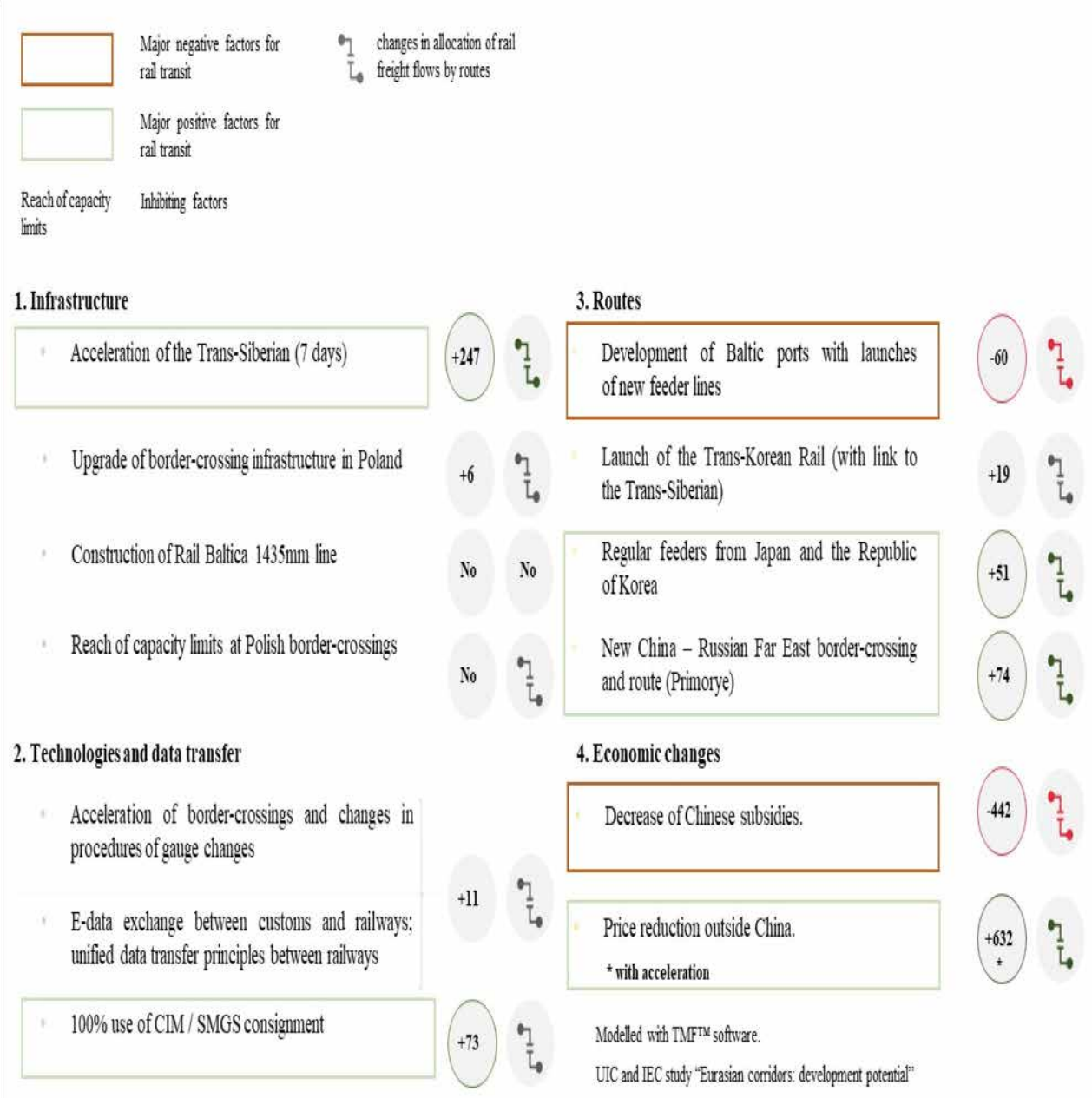
Source: Infrastructure Economic Centre

Use cases for different stakeholders

In 2020 UIC released "Eurasian corridors: development potential" study based on modelling of the impact of various (economic, technological, operational, institutional and political) factors on Euro-Asian freight flows in 2030. This study shows an opportunity of modelling for decision-making process.

Key usability of modelling is resource optimizing, including large investments planning at both national and international levels. In addition, modelling can be used to evaluate the impact of various factors on specific project or process (transportation)

Figure 46: Modelling of the impact of various factors on Euro-Asian freight flows in 2030



Source: UIC / IEC, March 2020, Eurasian Corridors: Development Potential. Available at: **https://www.shop-etf.com/en/eurasian-corridors-development-potential-report.html**

Conclusions

The Smart Railway Solutions elaborated in this study are meant to expand the knowledge of railway officials of the region on the options available for them to deal with the challenges posed by the pandemic.

The COVID -19 pandemic that started as health crisis quickly morphed into socio-economic challenge of humongous proportions- the effects of which would be felt for long time. As transport has been one of the worst hit sectors by pandemic, the crisis affords an opportunity for transport community to revisit approaches that led to transport development.

Generally, transport and economic growth has followed one and another. However, in its pursuit to support economic activities the rapid growth in transport had many negative consequences that have become quite apparent now. It is widely acknowledged that the business-as-usual approach to transport would have many unsustainable outcomes.

Therefore, efforts have been made by countries to increase the sustainability of transport in all its dimensions with focus on its social and environmental aspects. The increasing emissions from transport and its impact on climate change is well documented and needs an urgent response.

One of the potent ways to reduce emissions from transport is to shift towards more cleaner modes of transport. In this regards rail has clear advantage- however, to capitulate on its comparative advantage railways of the region have to further measures to make railway transport efficient, reliable and more greener- the smart solutions elaborated in this study could support the railways of the region in this direction.

Annexes

Annex 1. New container routes 2016 – 2020[87]

New container routes in 2016
1. Moscow - Shenyang and Guangzhou – Moscow route organized by RZD Logistics
2. Vladivostok - Karakul (Uzbekistan) was organized by FESCO
3. China (Tianjin) and Russia (Vorsino) via Mongolia route was organized by RZD Logistics and Swift Transport International Logistics
4. Moscow - Mumbai (International transport corridor «North-South") route was organized by RZD Logistics
New container routes in 2017
1. Russian Federation – Viet Nam – Russian Federation route was organized by RZD Logistics and Ratraco
2. Changsha - Budapest via Naushki and Brest route was organized by RZD Logistics
3. Daqing - Belgium via Zabaykalsk and Brest route was organized by RZD Logistics
4. Shilong - Europe via Zabaykalsk route was organized by RZD Logistics.
5. Changsha - Germany route was organized by RZD Logistics
6. Tigers Co launched a new rail freight service, called «Tiger Rail», offering customers a 16-day transit time both east and westbound, between Duisburg and Hefei, Chongqing, and Chengdu
7. Vorsino - Chengdu - Vorsino route organized by RZD Logistics
8. Austrian-based Rail Cargo Group (RCG) strengthened its China-bound operations with the launch of a monthly container train from the Italian city of Mortara to Chengdu. It is built on a recent pilot and now regular service from Lugo to Taiyan
9. Łódź in Poland and Chengdu in China, transiting via the Russian exclave of Kaliningrad was launched.
10. A new freight train service linking Warsaw with Ganzhou was launched.
11. UTLC JCS and Belintertrans-Germany LLC have launched a new container route between Poland and China via the Belarusian border crossing Kuznitsa/Bruzgi.
12. Freight forwarder Kuehne+Nagel's (KN) 'Eurasia Express' is the latest cargo service to link China and Europe. The new less-than-container-load service, taking 14-18 days, will make its way from Wuhan to Poznań, Duisburg and the Port of Hamburg via Russian Federation.

87. Sources: The Railway Gazette, Global Railway Review, Railway Pro, RailFreight.com, official Webpages of mentioned companies. The overview is based on analysis of press-releases, no additional check of facts was done by the authors of this study.

New container routes in 2018
1. Lodz - Chengdu. The route was organized by UTLC ERA and Belintertrans Germany.
2. Changsha - Tilburg. The route was organized by RZD Logistics and Hunan Xiangou Express.
3. The new railway line connecting Istanbul and the Chinese port of Lianyungang has now been established as a regular service. In November 2018 a block train departed from the Kazakh-Chinese logistics terminal in the east-Chinese port. The train will proceed along the Middle Corridor through China, Kazakhstan, Azerbaijan and Georgia before it enters Turkey, eighteen to twenty days later.
4. The transport operator DSV started a rail freight service to connect Zaragoza Sea Terminal in Spain with the Chinese region of Sinkiang. The train transports Spanish goods for the renewable energy industry and it stops in Germany and Poland to add more products.
5. A new railway route has been opened between the Chinese province of Hunan and Minsk, the capital of Belarus. It is the second rail freight route connecting the Central Chinese province to a European city.
6. A new railway service connecting the Austrian capital Vienna with the Chinese freight hub Chengdu was launched with the first train departing in westbound direction. It is the first direct railway service connecting Austria to the New Silk Road.
7. A new rail link has been launched between the Port of Caofeidian in the north of China and the Mongolian capital of Ulaanbaatar. The new rail freight service was officially opened by the government of Tangshan.
New container routes in 2019
1. Bremerhaven - Chongqing. The route was organized by Hellmann Worldwide Logistics and UTLC ERA.
2. Vorsino - Dongguan. The route was organized by RZD Logistics and Far East Land Bridge.
3. Ulanqab - Moscow. The route was organized by Cosco Shipping Lines.
4. Chengdu - Zhodzina. The route was organized by RZD Logistics.
5. Novosibirsk – China route was launched.
6. Chine - Hungary via Kazakhstan and Ukraine. The route was organized by Rail Cargo Group (RCG).
7. The first container train from Xi'an in China to Prague in Czech Republic. The journey took 11 days and terminated at the Ceska Trebov Terminal.
8. Kerry Logistics Network launched multimodal freight services between China and Pakistan operated by Lanzhou Pacific Logistics Corp. with transportation time of 13 days.
9. Agreement on regular twice a week freight services between Amsterdam and Wuhan were signed by Wuhan Asia Europe Logistics (WAE), NUNNER Logistics, Samskip, TMA Logistics and Port of Amsterdam.

New container route in 2020
1. RZD Logistics and Sinotrans have launched a transit container service from Shenyang in China to Enns in Austria via the Zabaikalsk border crossing between China and Russian Federation.
2. Maersk has launched its first rail service from Xi'an in China to Izmit in Turkey via Korgas, the Caspian Sea ports of Aktau and Baku, and the Baku – Tbilisi – Kars railway with a transit time of 18 days.
3. A cargo train from China's Lanzhou for the first time moved goods to Tashkent via China-Kyrgyzstan-Uzbekistan transportation corridor.
4. CEVA Logistics has launched a 'truck-rail-truck' service to keep freight moving between China and Southeast Asia to cope with COVID-19 restrictions and waits of up to four days for road traffic crossing the border between China and Viet Nam.

Annex 2. Key priorities of TARN member countries[88]

Country	Railway Network development -key projects
Azerbaijan	Rehabilitation of the track and structure of the Sumgayit–Yalama rail line (North South Railway Corridor)
Bangladesh	The current Five-Year Plan for the railway in Bangladesh projects the construction of 856 kilometers of new railway tracks, dual gauge double tracking of 1110 route kilometers, the rehabilitation of 725 kilometers of existing track and the construction of bridges and other railway infrastructure in order to improve operations.
Cambodia	Construction of the Bat Doeung (Northern Line) to Snoul line. This line, with a total distance of approximately 256 km, will connect the Cambodian and Vietnamese (Lock Ninh) railway networks and will pose as an integral part of the Singapore-Kunming Railway Link. Construction of a new railway link between Phnom Penh Station and the port of Phnom Penh. A direct connection to Laos via the proposed new railway line from Snoul to Voun Kam (Dong Kralor Border) with a total distance of approximately 273 km is being considered. Construction of minor lines from Phnom Penh Airport, Phnom Penh Special Economic Zone (SEZ), fuel stations, warehouses, sea and river ports as well as tourist zones and mineral locations is being studied.
India	Creation of Dedicated Freight Corridors (DFC) facilitated by the Dedicated Freight Corridor Corporation of India Limited (DFCCIL). The new DFC consist of two railway routes, the Eastern and the Western freight corridor, and runs at a total length of 3.360 kilometers. The Eastern DFC runs from Punjab to West Bengal and the Western DFC runs from Jawaharlal Nehru Port (Mumbai) to Uttar Pradesh. The corridors boast modern high-capacity railway freight infrastructure enabling considerable increases in productivity leading to significant reduction in unit transport costs. The project further builds on the recent success of the railway freight sector, which was able to improve freight volumes without substantial investments in infrastructure due to increased axle loads, reduced turn-around times, and reduced unit costs. The DFC are likely to further improve the IR competitiveness. Electrification of 3378 km of railways anticipated to be completed between 2021 and 2022.

88. According to official documents listed in the Table 1

Country	Railway Network development -key projects
Iran (Islamic Republic of)	RAI has outlined its future orientation in respect to passenger and cargo capacity and utilization in a section titled "Vision 2025". The ambitious outlook anticipates an increase in the railway routes to 20.000 kilometers, double-tracked routes of 5800 kilometers, 2000 electrified kilometers and the creation of 1000 kilometers of high-speed corridors. Important railway construction projects, particularly for international railway connectivity, include the completion of the Qazvin-Rasht-Astara (372 km) railway link, the Sangan – Herat (191 km) route to Afghanistan and the Chabahar Port – Birjand, Mashhad project (1330 km) which aims to connect the Central Asian countries to the Persian Gulf. High speed double track railway from Tehran to Mashhad (940 km), as well as a similar track from Tehran to Qom (140 km), the electrification of the Bafq – Bandar Abbas (600 km) and the electrification of the Garmsar – Gortgan route (404 km) will significantly contribute to the modernization of the railway network. These improvements will likely result in an increase in operational efficiency, service quality and international connectivity.
Kyrgyzstan	Construction of domestic railway network to connect North and South part of the country. Construction the China-Kyrgyzstan-Uzbekistan railway in the midterm.
Lao People's Democratic Republic (the)	A 409-kilometer railway connection between the Laotian capital Vientiane and Boten is expected to start operations in 2022. Vientiane – Thakhek – Mu Gia railway, connecting the capital of Lao PDR.The 455-kilometer-long passenger and freight line aims to transform Laos from a landlocked to a "land-linked" economy. The start of construction predicted to be between 2020 and 2025. A 220 km connection from the Laotian Thai border in Savannakhet to the Laotian Vietnamese border in Lao Bao. A pre-feasibility study on a railway route (463) from Thakhek to Vern Kham (Cambodian border) via Pakse has been completed in December 2012. Presently, a BOT investment is being considered. A Pakse – Vang Tao (26 km) railway is in the process of a pre-feasibility study. An extension of the existing Lao-Thai Railway project of 7.5 km from Thanaleng Station to Ban. Khamsavath (Vientiane Station) is under construction.
Malaysia	Electrification and double-tracking of the Gemas – Johor Bahru connection (192 km Up of the railway infrastructure between Rawang and Salak South. Strengthening and rehabilitation of tracks on the 528-kilometer-long single-track stretch from Gemas to the northeastern coast at Tumpat.

Country	Railway Network development -key projects
Myanmar	Upgrade of the 620-kilometer-long Yangon-Mandalay Railway line. Upgrade to the 490-kilometer-long Mandalay – Myitkyna railway line has completed its feasibility study and is currently processing the loan agreement. Thought to be completed in 2023 the USD 800 million project will be financed by the Republic of Korea's EDCF and Myanmar government funds. Bago – Mawlamyine link construction is ongoing. The Mawlamyine-Ye project the Ye-Dawei project are at the level of pre-feasibility study. The Dawei-Htee Kee project, is currently seeking technical assistance from development partners. The Mandaly-Muse project is at the feasibility studies stage conducted by CREEC.
Mongolia	2016-2020: Building a railroad from Ukhaa Hudag to Gashun Sukhait. Construction of the railway from Erdenet Ovoo to Bulgan. 2021-2025: Complete the construction of the railway from Erdenet Ovoo to Bulgan; Start the construction of Railways in the regions. 2026-2030: Complete the construction of Railways in regions.
Thailand	Construction of Northeastern high-speed rail line (Kunming - Singapore HSR) Bangkok - Nakhon Ratchasima - Nong Khai
Turkmenistan	Modernising railways in Turkmenistan, between Turkmenabat, Mary, Ashgabat and Turkmenbashi
Viet Nam	Until 2030 most of the focus of the railway sector is on the upgrade of existing lines. Modernization of the signaling and telecommunication system, replacement of outdated sleepers in order to reach the 2nd grade level in the National Standards classification and the rehabilitation of weak bridges are the focal points for renovation of the Lao Cai (connection to China) – Ha Noi line, the Ha Noi – Ho Chi Minh city line and the Yen Vien – Cai Lan line as well as the completion of urban railway lines in Hanoi and Ho Chi Minh city.

Annex 3. Key projects of TARN member countries in international railway transport[89]

Country	International railway links priorities and key projects
Azerbaijan	Boosting country's competitiveness in the Europe Caucasus-Asia and North-South transport corridors via construction of new links, launching new routes and services and connecting to existing corridors
Bangladesh	International railway connectivity, links to neighboring countries and notably India, are listed among key priorities for Bangladesh
China	Construction of cross border corridors and main corridors along One Belt One Road The Beijing-Tianjin-Hebei Integration Initiative Yangtze Economic Belt Initiative
India	Creation of Dedicated Rail Freight Corridors as an important element of national economic development- links with Bangladesh, Myanmar, Nepal, and Pakistan
Kazakhstan	Boosting transit trade along a key Central Asia transport corridor (more than 80 per cent of Euro-Asian transit traffic in 2019). Development of the North-South railway corridor (Kazakhstan - Turkmenistan - Iran) Development of the Transcaspian corridor (TITR)
Kyrgyzstan	Establishing railway links from China to Central Asia as a part of transit corridor
Russian Federation	Investments in transit increase Facilitation of cargo transportation via the Trans-Siberian railway with transit time decrease to 7 days (from the port of Vladivostok to Krasnoe at the Western border with Belarus) Logistics hubs development programme to ensure linkages between industrial centres (cargo generation) and transport network
Thailand	Making Thailand a hub for connectivity. Provision of efficient transport system, good level of service and accessibility to economic zones and communities. Ensuring connectivity with neighbouring countries.

89. According to official documents listed in the Table 1.

Country	International railway links priorities and key projects
Turkey	Active development of international links within TRACECA project, links with Trans-Caspian route via a recently launched Baku – Tbilisi – Kars connection. Large programme for the development of logistics hubs to ensure balanced cargo flows and to attract additional flows via Turkey.
Turkmenistan	Enhancement of transit via establishment of physical and non-physical connections with neighbouring countries, in North – South and East – West links. Hubs development programme.
Uzbekistan	One of the key priorities is integration into international transportation for increasing transit traffic.

Annex 4. Priorities and key projects of TARN member countries in shifting to rail[90]

Country	Priorities and key projects in shifting to rail
Bangladesh	General increase of modal share of railways is indicated as one of the priorities.
Kyrgyzstan	Increasing modal share of railways as a part of national and international connectivity for a land-lock country is considered.
Malaysia	Promotion of wider use of railway transport for passengers is considered.
Russian Federation	Modal shift is considered for railway freight transit, as well as for passenger transportation (thanks to construction of high-speed lines and to development of urban rail transportation).
Thailand	Upgrading the accessibility and increase the use of public transport, including railway transport. Increasing mobility in passenger travel and freight transport. Modal shift from road transport to alternative modes which provide lower transport cost per unit.
Turkey	Shift to rail in both passenger and freight services thanks to network development and adjustment of rail network and services to existing demand.
Viet Nam	General shift to rail to assure sustainability and social mobility is considered.

90. according to official documents listed in the Table 1

Annex 5. Key projects of TARN member countries in sustainability-focus[91]

Country	Key projects focus on sustainability
Azerbaijan	Introduction of greener technologies to ensure decrease in green gas emissions.
China	Implementation of use alternative fuels, new energy vehicles, green technologies in transport to cope with 1) traffic congestion and clogged cities; 2) high shares of carbon emissions; 3) noise and (urban) air pollution.New technologies widely tested for the rolling stock.
India	Investments in sustainability and green energy (solar, wind, water recycling, led, etc.) are considered with 100 days plan. Green financing is applied. New technologies for the rolling stock are applied.
Kazakhstan	Minimizing environmental impact by reducing emissions and implementation of energy-saving technologies.
Malaysia	Shift to rail for passenger transport as a path to increase the level if sustainability.
Russian Federation	Russian Railways issue annual sustainability reports and widely use green financing (green bonds).
Tajikistan	Development of measures to reduce transport and industrial emissions is officially considered.
Uzbekistan	Reducing emissions of auto and rail transport is an objective of existing programmes.

91. According to official documents listed in the Table 1

Annex 6. Key projects of TARN member countries in digitalization[92]

Country	Key projects on digitalization
China	Innovation driven promotion of IT and big data-based transport management and operation, online ticketing and vehicle and fleet automation
India	Implementation of the European Train Control System (ETCS) Level 2 an advanced radio based signaling and movement control system. Rapid advances in terms of digitalization are being made in terms of e-ticketing. A novel Passenger Reservation System (PRS), "New Generation e-Ticketing System" (NGeT) The effort towards digitalized ticketing has been widely embraced by railroad users, the mobile application Rail Connect Indian Railways alone caters to over one million daily passengers willing to reserve their train tickets from their phone. Indian Railways maintain its own satellite hub to enable the connection of remote locations for Freight Operation Information System (FOIS), Unreserved Ticketing System (UTS), Disaster management System and other emergency communication needs.
Kazakhstan	Digital transformation program to improve operational efficiency and investment attractiveness by development of IT technologies, big data analysis and other initiatives. Blockchain technology is being tested for international transit on the Trans-Caspian corridor.
Malaysia	Notable investments in modernizing the signaling, communication and electrification systems as well as the corresponding railway stations to the highest international standard. Particularly the EDT network on the West coast is one of the most progressive and technologically advanced railway systems in the region. Progress in digitalization of KTM is not limited to the railway infrastructure and operation but has aimed at improving customer satisfaction through electronic payment and ticket systems as well as on-board amenities such as e.g. on-board entertainment systems in business class.

92. According to official documents listed in the Table 1

Country	Key projects on digitalization
Russian Federation	Comprehensive digital strategy of Russian Railways adopted in 2019, including e-data exchange with other railways and non-rail authorities. In the course of the Long-Term Development Programme until 2025 Russian Railways has allotted RUB 168 bn (~ EUR 2,36 bn) to IT development. RUB 99 bn will go towards informatization, RUB 65 bn towards equipment and communication upgrades and RUB 4 bn towards the Intelligent Railway Transportation Management System (IRTMS). The overarching "Digital Railway Concept" encompasses funding for Digital Railway R&D, a smart system for the complete automation of freight train handling (Digital Railway Station), a standard system for train traffic control and automatic routing (Moscow Central Circle), an unmanned Smart Locomotive without the need for human input and a uniform automated system for locomotive stock control. For international freight transit automated data interchange among railways and customs is being successfully developed within INTERTRAN project (supported by UNESCAP). Use of blockchain technology is under tests as well.
Turkey	TCDD has invested in the digitalization of the railways business operation. This includes e.g. the development of a "Traffic Operation System", analytical tools for the evaluation of business operations and project planning, the development of various application on SAP Fiori to trace activities with mobile media, the allotment of funds for the procurement of Information Technology Equipment, Mobile Data and Internet Lines as well as streamlining administrative efforts by, for example, enabling digital signatures of pdf documents.Software solutions for interlocking systems, centralized traffic control and certification processes were introduced. For passenger services TCDD and TCDD Transport JSC have developed practical solutions for e.g. e-Ticketing, mobile applications for "Trenkarts" and "Instant Complaint Applications" via WhatsApp. Furthermore, high speed train costumers (YHT) are electronically sent a message providing the essential travel information.
Viet Nam	Investments in the improvement of the system have led the modernization of signaling systems on the whole network. Modern technology has been introduced. Most stations are equipped with an interlocking system and colour light signaling. Semi-automatic and automatic block systems have replaced the token method Automatic train control systems, automatic train protection systems and train location detection systems are being tested to improve operational safety, train speeds and running capacity of the railway network in the future The telecommunication system has seen been updated with modern hardware and optic fiber cables were employed for several route sections. These investments led to tangible improvements in the transmission and switching systems.

Annex 7. List and key features of Railway Smart Solutions

No	Area	Solution	Effects	National/ international applicability	Technical base requirements	Financial requirements	Special international legal framework requirements	Multi-agency (yes/no)	Fast solution (yes/no)	Direct effect on rail resilience	Usability during COVID-19 and at recovery phase
1	Border crossing	Automatic and non-intrusive inspections	Increase in speed of control procedures, less dependence on human factor and higher level of security	International	High	Medium	No	Yes	Yes	Yes	Very high
2	Border crossing	Bogies change at one side	Decrease of transportation time	International	Low	Low	Yes	No	Yes	Yes	Very high
3	Border crossing	Combined (joint) control procedures	Time economy and predictability	National	Low	Low	No	Yes	Yes	No	Very high
4	Border crossing	Electronic data interchange between railways and border agencies	Drastic decrease of transportation time and increase in reliability	International	High	Medium	Yes	Yes	No	Yes	Very high
5	Border crossing	Electronic interoperability	Acceleration of transportation, cost reduction, speeding up of control and border crossing procedures	National and international	High	High	Yes	Yes	No	Yes	Very high
6	Border crossing	Electronic tracking for secure border crossing	Increase in reliability of railways	National and international	High	Medium	No	Yes	No	Yes	Very high

No	Area	Solution	Effects	National/ international applicability	Technical base requirements	Financial requirements	Special international legal framework requirements	Multi-agency (yes/no)	Fast solution (yes/no)	Direct effect on rail resilience	Usability during COVID-19 and at recovery phase
7	Border crossing	E-seals with customs information to reduce checks	Important decrease in customs control time and increase in security level	International	Medium	Medium	Yes	Yes	Yes	Yes	Very high
8	Border crossing	Information exchange and simplification between railways	Increase in reliability and speed of international transportation	International	Low	Low	Yes	No	No	Yes	Very high
9	Border crossing	Non-stop border crossing (if no break of gauge)	Time economy and predictability	International	Low	Low	Yes	Yes	Yes	Yes	Very high
10	Border crossing	Simultaneous scheduled transshipment (container trains)	Time economy and predictability	International	Low	Medium	No	No	No	No	High
11	Border crossing	Standard time targets	Higher predicatbility and reliability	International	Low	Low	Yes	Yes	Yes	Yes	Very high
12	Border crossing	Use of combined rail consignment considered as customs document	Time and costs economies	International	Low	Low	Yes	Yes	Yes	No	Very high
13	Multi-use: decision-making	Geographic information systems (GIS)	Tool for both decision-making (capacity assessment) and customer informing	National and international	n/a	n/a	n/a	n/a	n/a	Yes	Very high

No	Area	Solution	Effects	National/ international applicability	Technical base requirements	Financial requirements	Special international legal framework requirements	Multi-agency (yes/no)	Fast solution (yes/no)	Direct effect on rail resilience	Usability during COVID-19 and at recovery phase
14	Multi-use: decision-making	Transportation modeling	High quality decision-making with decreased role of human factor	National and international	n/a	n/a	n/a	n/a	n/a	Yes	Very high
15	Railway customer orientation	Electronic sales	Promotion of shift to rail by increasing competitiveness of railways in comparison to sea and asssuring better market conditions for the market players	National and international	High	Medium	No	Yes	No	No	Very high
16	Railway customer orientation	Single window	Improvement of customer experience to promote shift to rail	National and international	Medium	Medium	No	Yes	No	Yes	Very high
17	Railway Financing	Green bonds	High quality decision-making with decreased role of human factor	National and international	n/a	n/a	n/a	n/a	n/a	No	High
18	Railway Maintenance	Predictive maintenance	Cost decrease and reliability increase	National	High	High	No	No	No	No	Low
19	Railway Operations	Automated traffic management system	Speed acceleration (a must have for high speeds), safety improvement	National and international	High	High	Yes	No	No	Yes	High
20	Railway Operations	Automation of terminals	Higher resilience	National	High	High	No	No	No	Yes	Very high

No	Area	Solution	Effects	National/ international applicability	Technical base requirements	Financial requirements	Special international legal framework requirements	Multi-agency (yes/no)	Fast solution (yes/no)	Direct effect on rail resilience	Usability during COVID-19 and at recovery phase
21	Railway Operations	Automation of train driving (automatic train operations, ATO)	Capacity, reliability, energy efficiency, flexibility, safety, and cost effectiveness improvement	National	High	High	No	No	No	Yes	High
22	Railway Operations	Estimated time of arrival (ETA)	Higher predicatbility and reliability, higher resilience	National and international	High	Medium	No	Yes	No	Yes	Very high
23	Railway Operations	Interoperability	Acceleration of transportation, cost reduction, improvement of safety	National and international	Medium	High	Yes	No	No	Yes	Very high