Strategy for the EU integration of the Ukrainian and Moldovan rail systems

11 July 2023

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Executive Summary

The European Union has shown unity and strength in response to Russia´s unprovoked and unjustified invasion of Ukraine. This response has been multifaceted, including the reception of refugees, humanitarian aid, economic assistance, support for the Ukrainian armed forces and the approval of several packages of sanctions on Russia. The war has severely impacted the Ukrainian economy and the traditional sea-based logistic chains.

As part of this sustained effort, Communication COM (2022) 217 'An action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with the EU' defines short, medium, and long-term measures to unlock the existing logistics potential and serve as enablers of Ukraine's post-war trade and support the reconstruction of the country. Together with short-term measures, the Communication foresees two medium- and long-term measures: increasing the infrastructure capacity on the new export corridors and developing new infrastructure connections.

Due to the ramifications of current conflict, it can be expected that a major economic transformation will take place in Ukraine and Moldova which will further strengthen EU integration, with stronger cross-border ties and improved social cohesion and economic development.

Rail transport can play a key enabling role in this transformation. Once hostilities cease and the situation stabilises, the production and industrial sectors will strive to adapt to a changed environment. New logistical chains will develop, with increased opportunities for high-value, container transport, effective logistics and on-demand services.

The rail sector is well placed to provide a competitive, environment and climate friendly transport offer, a prerequisite for future investment. There are, however a number of technical challenges to overcome, in particular in relation to infrastructure where there are differences in rail gauge (1520mm in Ukraine and Moldova vs. 1435mm in the EU). There are also other technological aspects affecting cross border interoperability and capacity, with rolling stock related issues posing a major obstacle.

Within this context, DG MOVE engaged JASPERS in September 2022 for the development of a pre-feasibility study for a new EU standard-gauge rail corridor connecting Poland (Krakow), Ukraine (L´viv), Romania (Iasi) and Moldova (Chisinau). The study scope subsequently expanded to a strategy for the integration of the Ukrainian, Moldovan and EU railway networks, with the primary objective of creating a system that is interoperable, adaptable to anew economic landscape and competitive with other transport modes.

Extensive stakeholder engagement was a defining feature of the study, with this report representing the culmination of efforts from all participants. Among others, this involved ministries, rail infrastructure managers and operators, customs and border control bodies from Ukraine, Moldova and all member states involved. The strategy identified the main transport relations: towards (1) Katowice and beyond to Vienna/Bratislava and Southern Germany, (2) Warsaw and beyond to northern Germany, North Sea, and Baltic ports (3) Danube and Black Sea ports and (4) Northern Adriatic ports; following the TEN-T corridors proposed to be extended to Ukraine and Moldova, North Sea – Baltic, Baltic Sea – Adriatic Sea, Rhine – Danube and Baltic Sea – Black Sea – Aegean Sea. Due to the cost, expected demand, and line capacity considerations, priority was given to connections via Poland. A key study objective was to maximise use of existing assets, such as transhipment facilities at the Ukrainian and Moldovan EU borders, as well as the two existing 1520mm corridors in operation inside the EU (linking to Kosice and Katowice, in Slovakia and Poland, respectively).

A number of options, ranging from full transformation into 1435mm gauge to modernisation of the current 1520mm gauge network, were assessed. A principal conclusion and recommendation of the study is to develop a new backbone 1435mm gauge network, to be operated in conjunction with the existing 1520mm network, on the following basis:

- The 1435mm gauge system would focus on higher speed transportation (international passenger, IC, and container/platform wagon freight), with the 1520mm system catering for lower-speed transport (local and regional passenger traffic and heavy bulk)

- The development of a 1435mm backbone network in the two countries would be implemented in a phased manner, from West to East, with the largest urban agglomerations eventually connected to the new 1435mm corridors to support future economic development

- For each line, the required configuration is defined (1435mm only, 1520mm only or both). This is based on a number of factors including:
    - Cost
    - Combined network-wide operational aspects (1435mm and 1520mm systems)
    - Time for project development and implementation
    - Ensure capacity of the current 1520mm gauge system during implementation and operation of the new lines.

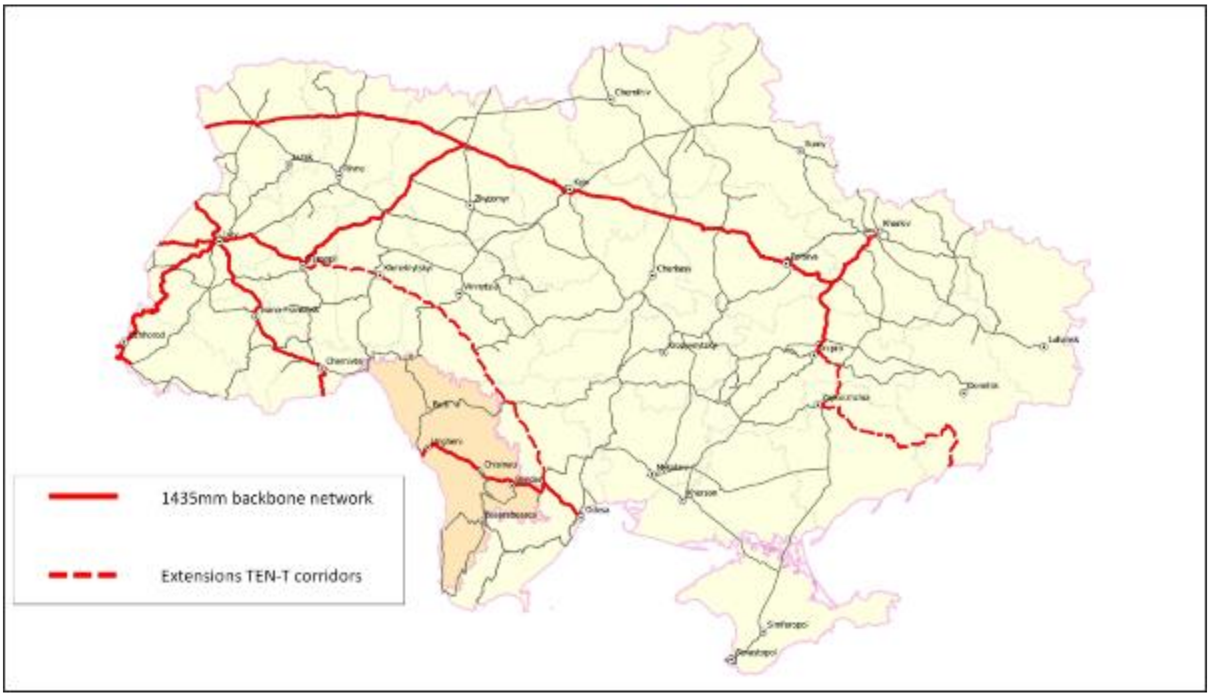


Figure 1: Proposed 1435mm gauge backbone and future extensions

The proposed new 1435mm gauge network identified by the study and the transport corridors resulting from it have informed the updated EC proposal for the extension of the TEN-T network into both countries. The study defines measures related to rail infrastructure, operation and organisation. It also identifies required implementation steps to successfully develop and operate the new network, including further strategic and feasibility studies and other necessary activities. Importantly, there are also proposals for key non-linear infrastructure, such as requirements for marshalling yards, workshops, and transhipment facilities. Further necessary legal and organisational improvements, as well as the necessary investments in rolling stock and maintenance equipment, are also considered.

The study applied best-practice planning methodology, with due consideration for existing data constraints and uncertainty inherent to the current situation. While an update of the study will be required in due course, to account for any relevant geopolitical, economic and demand developments, it is likely that the concept defining the study proposals, i.e. the development of a dedicated backbone 1435mm gauge system operated in conjunction with the existing 1520mm one, will remain.

Considerable efforts will be required to implement the strategy within Ukraine and Moldova. Neighbouring EU countries who participated in the study will also play a crucial role to ensure the success of the initiative Continued multinational stakeholder engagement will be required to ensure an effective and coordinated integration, resulting ultimately in a resilient and high-capacity integrated railway system.

1. Background

The European Union has shown unity and strength in response to Russia´s unprovoked and unjustified invasion of Ukraine. This response has been multifaceted, including the reception of refugees, humanitarian aid, economic assistance, support for the Ukrainian armed forces and the approval several packages of sanctions on Russia. The war has severely impacted the Ukrainian economy and the traditional sea-based logistic chains.

As part of this sustained effort, Communication COM (2022) 217 'An action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with the EU' defines short, medium, and long-term measures to unlock the existing logistics potential and serve as enablers of Ukraine's post-war trade and support the reconstruction of the country. Together with short-term measures, the Communication foresees two medium- and long-term measures: increasing the infrastructure capacity on the new export corridors and developing new infrastructure connections.

DG MOVE has engaged JASPERS for the development of a pre-feasibility study for a new EU standard-gauge rail corridor connecting Poland (Krakow), Ukraine (L´viv), Romania (Iasi) and Moldova (Chisinau) based on a Scoping Paper, which guides the development of the pre-feasibility study. The European Commission approved the JASPERS assignment on September 6, 2022.

The scope of the assignment was extended after discussions on the interim reports with relevant stakeholders. There was widespread agreement among stakeholders that a strategic study assessing overall EU integration for the Ukrainian and Moldovan rail systems would be more comprehensive and hence beneficial for both countries. Therefore, the scope of the study has been adjusted accordingly. With agreement of DG MOVE, non-TEN-T lines could also be considered allowing for further optimisation of the rail network configuration.

According to the scoping paper, the objective of the pre-feasibility study is to develop and assess operational alternatives and their associated requirements: infrastructure (gauge, siding requirements, power supply system, signalling, multimodal & transhipment terminals, logistic centres, etc.), rolling stock, maintenance requirements, customs operations, passport controls and other inspections.

The new corridors should contribute to the achievement of:

1) Integration of Ukraine and Moldova in the European transport area by improving connectivity with the EU and increasing the capacity of the new export corridors.

2) Increasing the resilience of the transport system and the logistic chains by reducing their vulnerability to exceptional events, such as the current blockade of Ukrainian ports following Russia's invasion of Ukraine.

Importantly, analysis informing this report investigates aspects beyond the corridor object of the study, given their importance for a successful integration of the Ukrainian and Moldovan rail system into the EU transport system. For this reason, this deliverable and the work that follows will include considerations about the general rail network and operations in both countries. This includes an assessment of the logistic paths towards the main Origins and Destinations relevant for Ukraine, Moldova, and the European Union.

2. Geopolitical context and revision of the TEN-T Guidelines

As part of the responses of the EU to the current geopolitical situation, in July 2022 the Commission proposed to amend its December 2021 proposal[1] on the revision of the TEN-T Regulation.

Since December, Russia's war of aggression against Ukraine has redefined the geopolitical landscape, highlighting the EU's vulnerability to unforeseen events beyond the Union's borders as well as the connectivity gaps with its Eastern neighbours. The major impact on global markets, such as global food security, has underlined that the Union's internal market and transport network cannot be viewed in isolation when it comes to Union policy. Extension of TEN-T standard infrastructure and policies towards EU's neighbours is needed more than ever before.

Commissioner for Transport Adina Vălean observed: *"By extending four European Transport Corridors to the territory of Ukraine and Moldova – including the ports of Mariupol and Odesa – today's proposal will help improve the transport connectivity of these two countries to the EU, facilitating economic exchanges and better connections for people and business alike. These corridors will also be a key priority in rebuilding the transport infrastructure of Ukraine once the war ends. Our efforts to facilitate the export of grains from Ukraine via the Solidarity Lanes have also demonstrated the importance of interoperability in the transport system, reinforcing the need to increase convergence within the EU network, making it more resilient and strengthening the internal market."*

Responding to the request within the *Solidarity Lanes* communication, designed to help Ukraine's agricultural produce and other goods to reach world markets through the EU and – in the longer term – to better integrate the Ukrainian and Moldovan's economy with the EU one, the proposal extends four European Transport Corridors to Ukraine and the Republic of Moldova.

The difference in gauge, leading to complex and costly transhipment operations at the borders prevents the full interoperability between the respective EU, Ukrainian and Moldovan networks. The proposal includes measures to migrate rail lines, when economically justified, to the European standard track gauge. This also applies to non-standard track gauges within the EU; the difficulties at the Ukraine border have highlighted how this lack of interoperability makes the rail network in Ukraine and Moldova vulnerable**.**

The proposal is to extend the following TEN-T corridors to Ukraine and Moldova, as shown in the figure below: North Sea – Baltic (red), Baltic Sea – Adriatic Sea (dark blue), Rhine – Danube (light blue but in Ukraine overlapping with dark blue) and Baltic Sea – Black Sea – Aegean Sea (purple).

[1] The Council agreed a negotiating mandate ('general approach') for the draft regulation on the EU guidelines for the development of a trans-European Transport Network (TEN-T) in December 2022. Link: [Trans-European transport network: Council agreement paves way for greener, smarter and more resilient transport in Europe (europa.eu)]

Figure 2.1: Proposed rail TEN-T Corridors in Ukraine and Moldova. Source: TENtec on the basis of Council General approach, December 2022

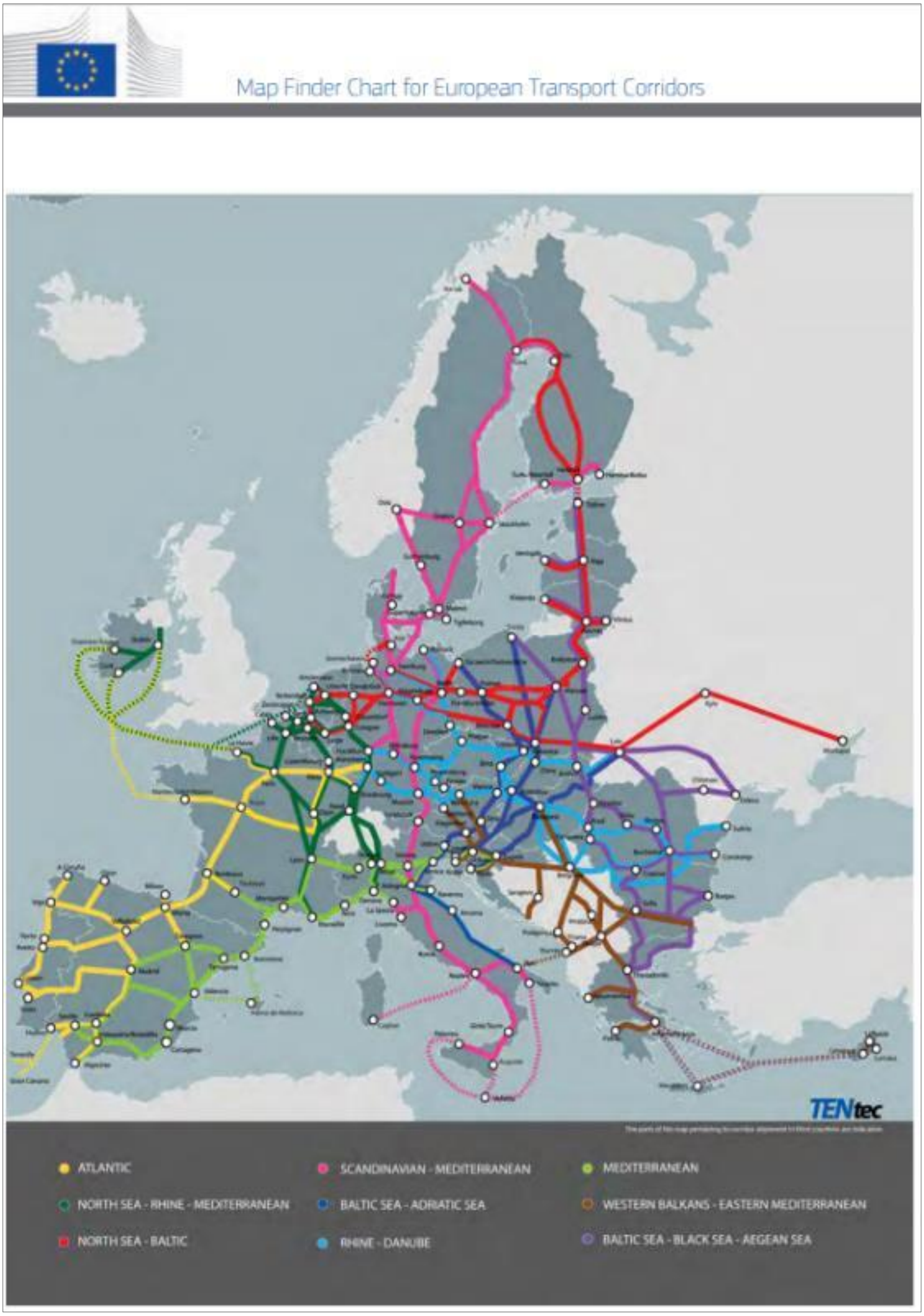


Figure 2.2: TEN-T Corridors. Source: Council general approach, December 2022

The full extent of the proposed extension of the TEN-T rail core and comprehensive network to Ukraine and Moldova is shown in the figure below.

Figure 2.3: TEN-T rail core and comprehensive network in Ukraine and Moldova[2]. Source: TENtec

This strategy considers this new geopolitical and policy framework.

[2] Discussions between the Commission and Ukraine and Moldova are ongoing with a view to modify the maps reflecting the latest geopolitical developments and its impact on the traffic flows. High level agreement on the revised TEN-T network in Moldova and Ukraine will be ready for signature in 2Q of 2023. Link: [Trans-European transport network: Council agreement paves way for greener, smarter and more resilient transport in Europe (europa.eu)]

3. Methodology

3.1 Methodology

The methodology, discussed and agreed with all study stakeholders, is summarised below:

- The initial step is the **analysis of the current situation** and identification of key findings regarding EU integration of the Ukrainian and Moldovan rail systems. The key findings are then **summarised** following a **SWOT** analysis format. The main conclusions of the analysis, the key findings and full SWOT table are presented in chapter 4.

- The analysis of the current situation is followed by the **definition of objectives**. **General objectives** result from the relevant EU and national policies, while **specific objectives** are formulated based on the outcomes of the analysis (i.e., translating the findings in the SWOT into objectives).

- Once objectives have been defined, the study deals with the **definition and appraisal of options**. The options analysis was **performed independently for each element or parameter** of the decision-making process. With this methodology, a long list of options and sub-options. For certain elements and parameters, which are either defined by policy requirements or should be developed in line with the existing network to ensure compatibility, there is no need to develop an options analysis.

- In addition, **for the implementation of 1435mm gauge (EU gauge) corridors** in Ukraine and Moldova **an analysis of alternative routes was developed**. As each train-path consists of several network sections, alternative routes for each relevant Origin Destination pair could be identified. Therefore, groups of network sections and alternatives combining several train paths were developed, to identify the preferred alternative for each case.

- To **select the preferred option for each section of the assessed alternatives**, an appraisal was conducted against **criteria related to the general and specific objectives**. The selected option, while not being critical for any of the criteria, should be in line with the highest number of criteria, ensuring strong alignment with the study objectives.

- The final step was the **definition of measures** for the integration of the Ukrainian and Moldovan rail systems in the EU. Measures are defined in terms of infrastructure, operation, and organisation.

Long term strategies require careful monitoring of impacts and potential reconsideration of further development steps. This study outlines the strategic aspects to be monitored and proposes potential alternatives. The strategy will present a staged development of the integration of the Ukrainian and Moldovan rail systems into the EU transport system. The staged development already started with the improvement of the transmissibility of BCPs (Border crossing points) between Ukraine/Moldova and the EU, and the projects already under development.

For the development of this study, JASPERS was supported by Egis Poland Sp. z.o.o. (Egis) for specific tasks and areas drawing on their international experience, including experience in Ukraine and Moldova. The main areas of Egis support have been:

- Development of the implementation cost estimate for the rail modernisation options

- Support to JASPERS in the analysis of the current situation, with a special emphasis on logistic, organisational and legal aspects, rolling stock and description of the existing rail networks

- Identification of relevant measures for the strategy in the logistic, organisational and legal areas

3.2 Main rail functionalities in the study

In the presented methodology, it was essential to establish the most relevant functionalities in relation to the current and anticipated demand and operations between Ukrainian, Moldovan, and neighbouring EU rail systems. This was accompanied by the identification of other important local and regional functionalities (within the countries), which may significantly overlap with or constrain international traffic. Functionalities will be used to inform key stages of the study, including the analysis of the existing situation, option definition and appraisal, and development of measures.

The definition of relevant functionalities takes into account the current situation of rail transport in Ukraine and Moldova, and the constantly changing, volatile and uncertain conditions, and environment. Therefore, proposals may differ from classical definitions used in other transport studies.

Regarding the identification of future measures, the relevant functionalities anticipated by the study are assigned to each of the sections assessed, which is intended to inform the required technical specifications and timing concerning an eventual, seamless transition to the European system.

The results of this exercise are presented below, separated for passenger and freight segments.

3.2.1 Passengers

The following functionalities have been identified as relevant regarding rail passenger traffic:

Passenger International

Due to the different track gauge in both Ukraine and Moldova, long distance passenger traffic has been further split between national and international.

International passenger traffic will be characterised by a very low number of stations, with trains ideally stopping only in the country capitals and a number of major regional centres (e.g., L'viv in UA), with a relatively high operational speed (between 120 and 200 km/h currently foreseen).

Passenger National

National (or long distance) passenger traffic has a very similar profile to international passenger traffic. The operational speeds are similar, and the number of stations should also be limited.

Regional and local passenger

Unlike for international and national passenger traffic, speed is of lower relevance for regional and local traffic. In this case, frequency and regularity of services, reliability, and a denser network of stops and stations optimising regional and local accessibility are the most relevant aspects to be considered.

Regional and local traffic will typically overlap with long distance functionalities in and around major urban rail nodes (e.g., L'viv, Kyiv, Odesa, Chisinau), where it will be imperative that strategic capacity is safeguarded, while simultaneously accommodating a high quality local rail offer to potential passengers within the functional areas[3] concerned.

Passenger Night Trains

The use of night trains as an alternative to short and middle-distance flights is again becoming a reality in the EU in the recent years. This has been and remains a relevant functionality in Ukraine, since distances between major regional centres are suitable for such services. In Moldova, night trains could also gain relevance for international traffic.

Night trains should provide comfortable and convenient travel, with suitable speed profiles, limited interruptions and convenient departure and arrival times. Depending on the trip purpose, the possibility to transport passenger's cars may also be provided.

3.2.2 Freight

To define the relevant functionalities for rail freight, the outcomes of the analysis performed, as described in the next chapter of this study, were carefully considered.

In this case, unlike for passengers and for the purpose of this study, a division between international, long distance and local/regional segments is not considered. Instead, rail freight is divided between slow (heavy) and fast categories. The main reason for this classification is that the two categories generally imply the use of different type of rolling stock, usually with different axle load requirements. **It is important to note here that lack of specialised freight wagons has been identified by the study as one critical issue for improved trade and integration.**

An important consideration relates to the fact that freight with a homogeneous speed profile (without excessive braking, stopping, and waiting for overtaking) implies higher operational capacity, higher average commercial speed, and overall, more cost-efficient train operations, particularly on single track lines present in the study area. Thus, opportunities to increase capacity and lower operational disturbance exist by, where feasible, merging only fast freight with passenger traffic.

Freight Slow/heavy

This freight is generally transported with specialised rolling stock, such as hopper wagons, and requires high axle loads. The speed profile is low, with maximum speeds below 100 km/h.

Slow/heavy trains are normally carrying low value goods, which are not time sensitive in themselves and that, due to their heavy weight and shipment cost sensitivity, cannot be containerised. Examples of this category are coal, ore, timber, and some agricultural products.

Freight fast

Fast freight in this study is assumed as that which is transported in containers or can feasibly be containerised (platform wagons). The speed profile of freight container trains is higher and can be similar to the speed profile of passenger traffic. Axle load requirements for this type of traffic are lower than for heavy freight.

This functionality often relates to higher value freight, but certain categories of lower value freight, such as certain types of grain, liquid bulks, etc., can also be containerised by using containers with large liner

[3] The functional area of a city includes the municipalities that gravitate towards it on a regular basis. In most cases it can be defined by the commuter traffic patterns. A specific municipality can gravitate towards two or more different cities and would then belong to the functional area of all of them.

bags within platform wagons. Two important additional categories within the freight fast functionality would be car transport and intermodal semitrailer transport.

3.3 Limitations

One of the main limitations of the pre-feasibility study is that it is based on the available existing information and data, as it is not possible to conduct on-site surveys and analysis.

This study has been developed under constantly changing and uncertain conditions and environment, due to the ongoing war in Ukraine. This has made it impossible and impractical to reliably forecast demand in a traditional manner, hence the relevance of the different nodes and corridors in the study area.

Focus is therefore aimed at operational and technical aspects likely to affect integration, understanding of the existing infrastructure and operations, technical engagement with key stakeholders and selective use of demand and other available information.

Likewise, due to the limited time and data available for the development of this study, it has not been possible to assess important aspects, such as identification of the rolling stock needs and estimate of the O&M cost. However, those aspects have been identified and studies covering them have been proposed for the next stages of development.

4. Analysis of the current situation

4.1 Infrastructure

4.1.1 Ukraine

4.1.1.1 Key network features

The table below summarises key rail network features, which are described more in detail in the following chapters.

Component	Data
Operational length of the main tracks	19 790 km (excluding temporary occupied territory)[4]
Length of double-track rail line sections	6 767 km
Length of single-track rail line sections	12 975 km
Track gauge	1 520 mm, about 350 km in 1 435 mm and about 400 km in narrow gauge 750mm
Electrified network	9 926 km (47.3 %)
Number of rail stations	1 447
Number of rail stops	2 268
Number of rail road crossings	4 198

Table 4.1: Ukrainian rail network features. Source: Ministry of infrastructure in Ukraine and Egis

4.1.1.2 Track gauge

The overwhelming majority of the network utilises 1520mm track gauge. However, there are currently several sections of 1435mm track gauge, mainly in the vicinity of the PL/HU/SK/RO borders (lines in Western Ukraine were initially built to standard gauge):

- Chop – Bat'ovo – Korolevo – Diakove (103 km): rail line with a 1435mm connection going from Bat'ovo to Mukachevo (26 km) – double track at loop stations
- Hlyboka-Bukovynska – Vadul-Siret rail line (6 km)
- Stariava – Khyriv (9 km) rail line
- Mostiska – Mostiska II Border (9 km) rail line
- Kovel – Yahodyn (60 km) rail line[5]

Various 750mm gauge rails operate in Ukraine, mainly as industrial or children's rails.

[4] Total length of Ukrainian rails was 28 000 Km at the end of 1997.

[5] 1520mm and 1435mm gauge tracks are running in parallel on this section.

In Hungary, from 1945, and in Slovakia, from 1947, the Hungarian and Slovak railways joined the 1520mm gauge rail network towards Ukraine at Záhony (Hungary) and Cierna nad Tisou (Slovakia). A spacious transfer station was built for transferring goods between 1520mm and 1435mm gauge freight trains, both in Záhony and in Cierna nad Tisou. For technical reasons, it became necessary to build and operate a four-rail dual-gauge track on a short distance (1435mm and 1520mm gauge together).

The two longest 1520mm railway lines in the EU are in Poland and Slovakia, connecting to Ukraine:

- Polish PKP Broad Gauge Metallurgical Rail Line (PKP LHS) which connects Silesia (ending in Slawkow terminal in Zaglebie Dabrowskie – 25 km from Katowice) and the Polish/Ukrainian border Hrubieszow/Izov. This is the westernmost 1520mm gauge track in Europe with a length of circa 400 km

- 1520mm rail line connecting the U.S. Steel factory in Kosice (Slovakia) to Ukraine, near Uzhhorod. The length of this line is 88 km

4.1.1.3 Track characteristics

The Ukrainian network mainly comprises Rail R65 and R50 types. Standard rail length ranges between 12.5 m and 25 m, with joints and two joint bars or fishplates bolted through the web of the rail.

Rail type R50 is not compliant with TEN-T requirements regarding axle load. With 51.50 kg/m weight, it is used on some mainline sections with 200 m length, but mainly on siding areas and marshalling yards. Rail type R65 complies with the TEN-T axle load standards.

Rails are usually laid on monobloc reinforced concrete and wooden sleepers, with a varying density / spacing depending on the alignment[6]. Different types of fastening systems are applied, with heterogeneous use.

Different standard and special-type turnouts are used on the Ukrainian rail network. The switches are classified based on the tangent of crossing angle, using the following designations:

- 1/6 – Tg 0.16: 25 km/h, the most common switch in marshalling yards and sidings

- 1/9 – Tg 0.11: 40 km/h, the most common switch on station sidings

- 1/11 – Tg 0.09: 60 km/h, used on main tracks

- Double slip /single slip, also installed at station sidings

On main lines, turnout support is provided with concrete sleepers. Other turnouts on sidings and marshalling yards are mostly built on wooden sleepers.

The Ukrainian rail network mainly comprises tracks with design speed below 120 km/h (92.8% of total track length). The country’s high-speed network is underdeveloped and consists of a limited number of sections (2 900 km) operated at a maximum speed of 160 km/h. Most of the higher-speed sections have a maximum speed of 120 km/h, which is significantly lower than in other European countries.

[6] 1840 per km on straight and curved tracks with R ≥1200m and 2000 per km on tracks with R ≤ 1200m, according to the current regulation.

4.1.1.4 *Track condition*

In general, the Ukrainian rail infrastructure company (JSC UZ) has been affected by lack of financing and investments for a long period, with the following results:

- No regular refurbishment and modernisation of fixed assets
- Technical and technological deficiencies compared to European rail systems
- Lack of own sources for the renewal of fixed assets
- Absence of state support to follow the innovative development of the rail industry
- Low level of attractiveness for investment
- Difficulties to repair war damage to track infrastructure and equipment
- Incompatibility of technical equipment with modern requirements
- The maintenance program not fulfilled according to identified needs (due to the lack of funds). JSC UZ lacks efficient railroad machinery for track maintenance

More than 30% of track length of JSC UZ network needs immediate repairs. Multiple track defects are observed on the Ukrainian network, which combined with heterogenous track condition, leads to numerous speed restrictions. In 2015 the line length subject to speed reduction to 40 km/h was approximately 300 km, whereas currently it is assessed to be more than 5 000 km.

Lack of resources and investment severely constrains JSC UZ’s ability to refurbish and modernise its fixed assets. Main issues in relation to poor track condition can be classified as follows:

- Inadequate and/or absence of drainage leading to flooding
- Track components in poor condition, with geometry in good condition (alignment and level defects)
- The profile of tracks not maintained (rail’s corrugations, rail head’s surface defects with cracks, intrusion, shelling, etc.)
- Sleepers (old and second hand) and/or not well adjusted (squareness of the ties). Heterogeneity in track support (e.g., use of mixed wooden and concrete sleepers on a given section) can also affect track condition and lead to speed restrictions
- Ballast polluted and/or missed
- Elastic fastening missing, and crampon not adequate for modern tracks
- Absence of uniform track gauge
- Joints low and in poor condition
- Rail with excessive wear and/or important side wear, becoming worn down
- Weak rails and sleepers
- Turnouts in poor condition

Rail life span is conditioned by the overall tonnage catered for by the different lines and determined by established rules.

4.1.1.5 Traction power supply

Approximately 47% of JSC UZ rail lines are electrified, with the following breakdown:

- 5 325 km (52.8%) with 25 kV AC, mainly connecting Kyiv to L'viv (West part of JSC UZ rail network), Odesa (South part of the rail network) and Kharkiv (East part of the rail network)

- 4 763 km (47.2%) with 3 kV DC, mainly concentrated around Donetsk region, Kharkiv and Crimea area

In the period between 1991 and 2013, about 2 500 km of the rail network was electrified, but further planned electrification works are on hold due to lack of funds. DC electrification was implemented until 1964, followed by subsequent AC electrification until the 1980s. Of the electrified network, it is assessed that 67% of rail energy sub-stations and 65% of catenary network reached their service life. The traction power supply network is now in poor condition, in many cases reaching the life span of its electrification components (50 years).

4.1.1.6 Traffic management, signalling, communications

The Ukrainian network is generally equipped with the legacy Soviet signalling system, called "ALSN". The technology (interlocking) is based on relays. Only limited microprocessor equipment has been implemented to date.

The radio system for communication is based on analogue technology from the Soviet time, which works on 2 100 KHz frequency. Most of the equipment dates from 1960-80 with obsolete technology based on the use of HF and UHF radio systems. Gradually, JSC UZ has been introducing modern technology connected to the rail telecommunication network by fibre optic cables. JSC UZ is also considering introducing DMR (Digital Mobile Radio).

In general, due to lack of funds, JSC UZ is struggling to achieve regular maintenance of the current system. Moreover, due to obsolescence issues, spare parts are becoming less available.

4.1.1.7 Rail stations

JSC UZ is currently managing 1 447 and 2 268 rail stations and stops, respectively. On average the distance between 2 consecutive stops or stations is short, in the order of 6 km (the equivalent EU average is 8 km).

Stations are classified according to different types and sizes, with the lower categories comprising rather simple and small passenger facilities. There are issues to board and alight the trains at low level station platforms with access provided by a set of 4 steps with important vertical and lateral gaps between the steps and the platform edge.

Passenger information systems at stations are of the common type existing in many countries, i.e., based on electronic boards, where the train number, time schedule and platform number are provided. In terms of rolling stock, only the latest modern EMUs "Rotem-Hyundai" are equipped with on-board passenger information systems.

4.1.1.8 Civil structures

The Ukrainian rail network has 8 059 rail bridges, amounting to a total 210.4 km of length. Bridges are mostly based on reinforced concrete and steel structures, with high average age for many, indicating the likely requirement for major repair works. 34.6% of all rail bridges in Ukraine operated from 50 to 100 years, and 15% for more than a century.

Currently, 20.5% of rail bridges are showing defects resulting in speed restrictions.

4.1.2 Moldova

4.1.2.1 Key network features

The Moldovan rail network currently in operation comprises 1 126.2 km of main lines and 662.2 km of station tracks. Lines are mostly single-track with a 1520 mm gauge, with only 40 km of double track, as follows:

- Cornesti – Parlita on the Central Corridor (Ungheni – Chisinau)
- Abaclia – Basarabeasca on the Southern Corridor
- Chisinau – Revaca towards Bender

The axle load is 25 t, allowing standard trains of 57 units (although due to the bad condition of the network, rolling stock is operated up to 22.5 t). The rail network is not electrified. It includes 226 level crossings, 181 with automatic signalling, out of which 39 are fitted with rail barriers and another 37 with guarded rail signalling. The figure below shows the average speed on each corridor, as well as the maximum load per train. Lines in grey have limited use or are outside the state borders.

Figure 4.1: Overview of Moldovan rail corridors. Source: Moldovan rail company (CFM) and Egis

The backbone of the Moldovan network consists of three major rail corridors. The routes along these corridors are considered as Solidarity Lanes capable of supporting freight traffic from Ukraine when the Ukrainian ports on the Black Sea are blocked:

1. The **North corridor**, which connects with Ukraine through several BCPs, and serves the northern city of Balti and Ungheni, the most traffic-intensive border point with Romania in 2022 (to the route of Iasi and the Port of Constanta in Romania)
2. The **Central corridor**, connecting Ungheni to Chisinau and heading towards Ukraine (Odesa region) through Transnistria. This major corridor was considered as the backbone for extended TEN-T planning, however due to political and technical reasons, traffic with the Transnistria region is interrupted. A bypass solution has been adopted using southern routes, which gives increased importance to the connection between the central and southern corridors through the section Chisinau – Cainari
3. The **Southern corridor** is connecting the central network to the new route to the Odesa region through Basarabeasca station – a new section in the Ukrainian territory was rehabilitated to Berezyne station, to bypass the Transnistria region. To the south, the route reaches the Danube and Romanian border by Giurgiulesti Port and the Port of Reni in Ukraine. The corridor infrastructure is generally in poor condition and currently undergoing refurbishment, and the branch connecting to the border point of Cahul is no longer operational. Consequently, the only connection to Romania in the South (to Danube port facilities in Galati) is through Giurgiulesti

4.1.2.2 Track infrastructure

Track infrastructure is highly deteriorated due to the age of network sections and insufficient maintenance. This results in numerous speed restrictions, as illustrated in the table and figures below.

Line section	Total length of main line (km)	Total length with defects (km)	Total length without defects	% of track length with defects
LS-1 (Chisinau Line Section)	158.10	60.4	97.70	38.20%
LS-2 (Tighina Line Section)	169.70	36.5	133.20	21.51%
LS-3 (Basarabeasca Line Section)	371.60	174.3	197.30	46.91%
LS-5 (Balti Line Section)	231.20	82.7	148.50	35.77%
LS-6 (Ocnita Line Section)	195.60	76.8	118.80	39.26%
Total	**1 126.20**	**430.70**	**695.50**	**38.24%**

Table 4.2: Track defect % compared to total main line length. Source: CFM

Most speed restrictions are caused by defective sleepers, rails, and track bed. The critical sections are shown in the map below, showing that the nominal speeds of the Moldovan network are: 100 km/hour on the central route and between 60 and 80 km/hour on the southern and northern corridors. Many parts of the lines are limited to 40 or even 25 km/h instead of the original 80 or 100 km/h.

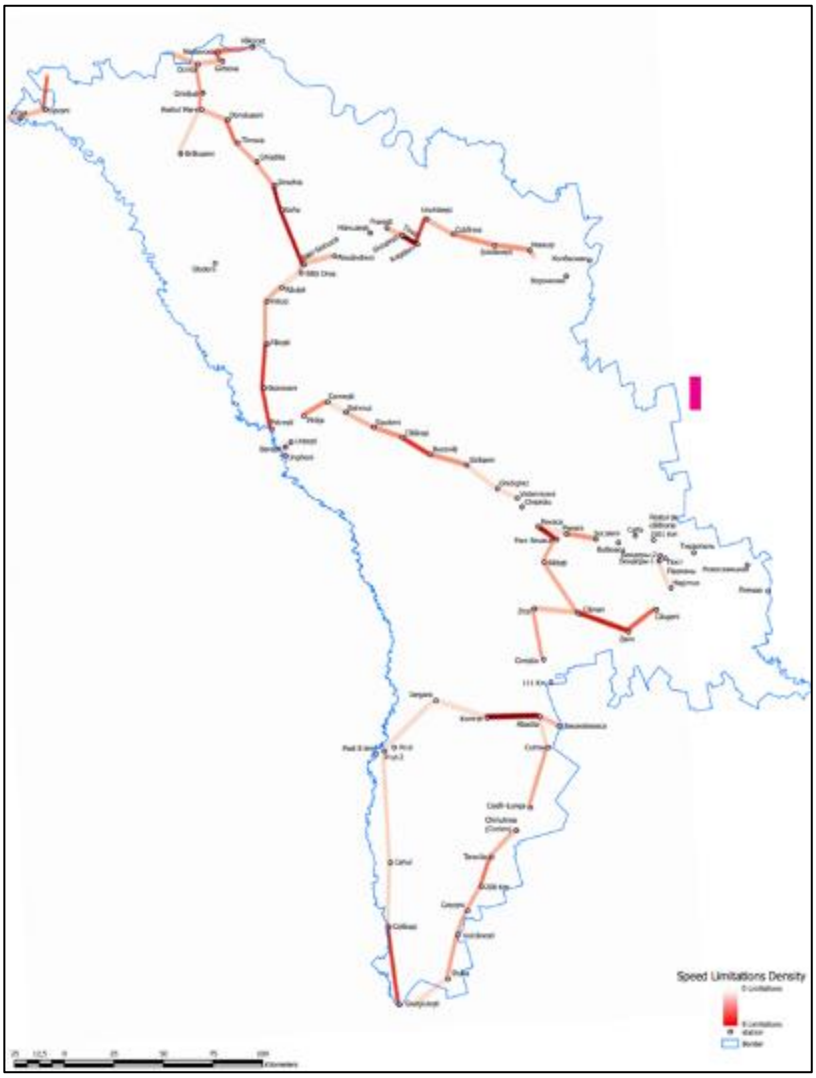


Figure 4.2: Speed limitations on the Moldovan network. Source: CFM year 2022

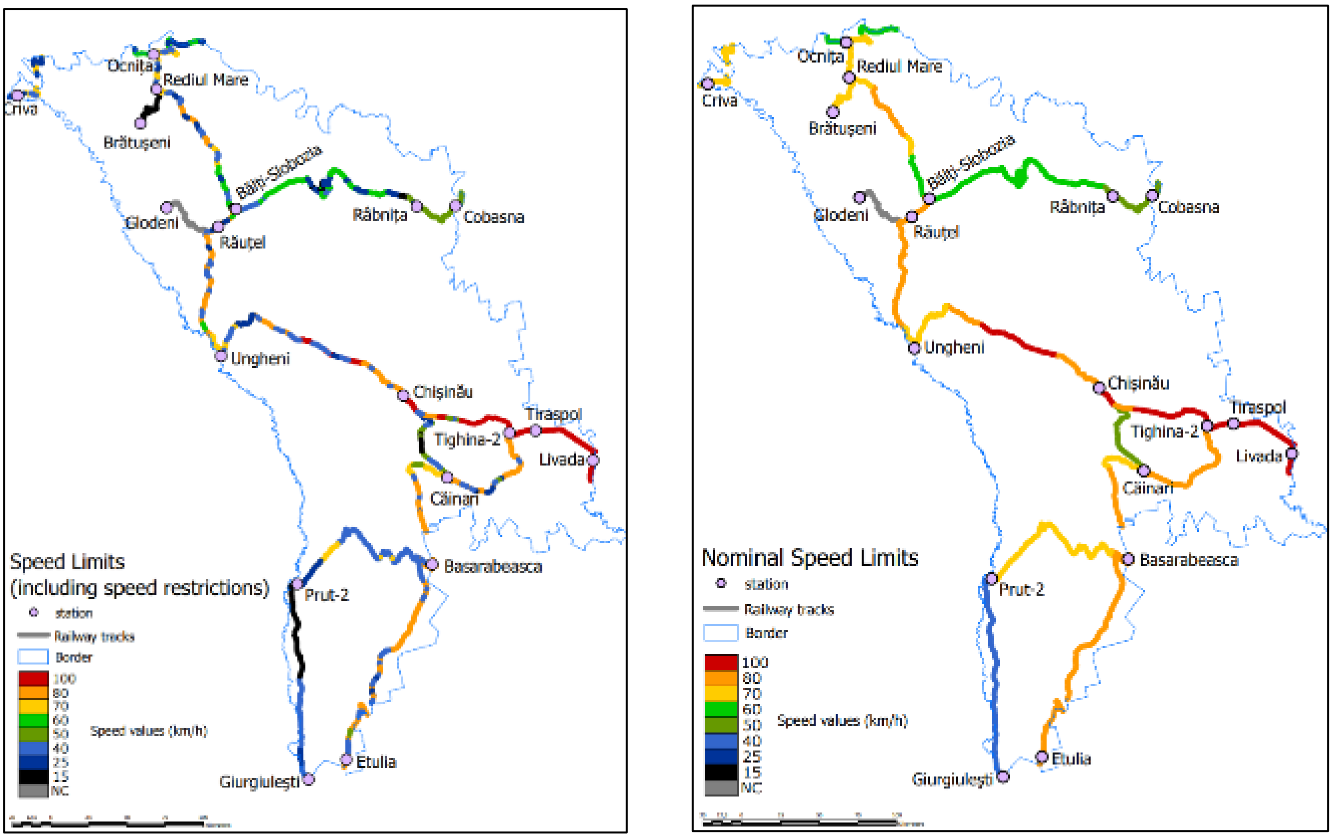


Figure 4.3: Actual and nominal speed limits on the Moldovan network. Source: CFM year 2022

It should be noted that cumulated length of components with defects provided by CFM (about 437 km of main line and 39 km at stations and sidings) may not be fully representative of the cumulative length of track to be refurbished, due to double counting of several line sections.

4.1.2.3 Signalling and Telecommunication systems

The signalling system covers 472.1 km of line with an automated block system, 654.1 km with a semi-automated block system, with some sections also operated manually. Regarding communications, CFM uses train radio communication (SW) and technological operation radio communication (USW).

Generally, the existing rail signalling systems can be considered obsolete, as they were installed between 25 and 70 years ago. In addition, the current technologies are staff intensive with the obligation to keep operating staff along all the lines.

4.1.2.4 Electric power supply

As the network is not yet electrified, this paragraph concerns power supply to systems. Most of the transmission systems of the CFM network are based on analogue multiplexers, which are technologically obsolete, have a very limited capacity, and are impossible to maintain due lack of spare parts. These systems are under replacement by a modern IP-based network on SDH, using optical fibre cables.

Optical fibre cables were installed along most of the rail line, using the CFM10 kV power line as support. To date, only main stations are connected by optical fibres, other stations remain connected through analogue network.

Power supply systems are currently not performing their function to supply electricity to the signalling and telecommunication equipment in a reliable way. It is therefore recommended to replace obsolescent equipment urgently to improve the level of reliability.

There are plans to start electrifying the network, in particular between Chisinau and Ungheni. However, no study has yet started.

4.2 Rolling stock

4.2.1 Ukraine

In the early 2000s, rail rolling stock in Ukraine comprised approximately 3 500 locomotives (diesel and electric), 190 000 wagons (both private and JSC UZ-owned), 4 600 passenger coaches and 1 400 EMU / DMU sections (2-car).

4.2.1.1 Locomotive fleet in Ukraine (2021 / 2022)

JSC UZ electric locomotive fleet is composed of circa 1 200 units including:

- Circa 800 locomotives 3 kV DC
- Circa 400 locomotives 25 kV AC, more than half of them of type Bo'Bo'[7]

Bo'Bo' - 25 kV AC	Co'Co'[8] - 25 kV AC	Bo'Bo' x2 - 25 kV AC	Bo'Bo' x2 - 25 kV AC / 3 kV DC	Bo'Bo' x2 - 3 kV DC	Co'Co' - 3 kV DC
392			**35**	**787**	
206	150	36	35	676	111

Table 4.3: Electric locomotive fleet in Ukraine. Source: prepared for JASPERS by Egis

In addition to this fleet JSC UZ also owns circa 850 diesel main line locomotives and circa 1 250 diesel shunting locomotives. Main line diesel locomotives are mainly old Soviet models with 2 sections. Most recent models are TE33AS diesel locomotives, single section, type ES44ACI from GE (USA) with 70 units. Shunting locomotives are mainly used for operations within marshalling yards and rail stations, as well as movements on tracks belonging to industrial enterprises and towards ports, but due to a lack of diesel locomotives, they can also be used to haul passenger trains composed by few passenger coaches.

The average age of electric locomotives is circa 42 years (normative life span 30 years based on JSC UZ norms), main diesel locomotives circa 32 years (normative life span of 20 years), shunting diesel locomotives circa 38 years (normative life span of 25 years).

Above figures reflect rolling stock in the "inventory book" but the fleet of locomotives in working condition is significantly smaller:

- Main line electric locomotives, circa 775 units (out of 1200 in the inventory book)
- Main line diesel locomotives, circa 205 units (out of 850 in the inventory book)
- Shunting diesel locomotives, circa 810 units (out of 1 250 in the inventory book)

[7] Bo-Bo is the UIC indication of a wheel arrangement for railway vehicles with four axles in two individual bogies, all driven by their own traction motors.

[8] Co-Co is the wheel arrangement for diesel and electric locomotives with two six-wheeled bogies with all axles powered, with a separate traction motor per axle.

More than 600 JSC UZ locomotives are with overdue repairs. In general, it is assessed by JSC UZ that the average wear of locomotives is more than 98%. A plan has been developed by JSC UZ for rolling stock renewal called “locomotive concept 2033”.

It is planned to procure 315 new electric locomotives, including 55 3 kV DC electric locomotives, 180 25 kV AC electric locomotives and 80 25 kV AC / 3 kV DC electric locomotives.

In 2021, Ukraine agreed with France to purchase 130 electric freight locomotives model Alstom Prima T8 - two-section eight-axle electric locomotives for track gauge 1520mm. This contract is currently frozen due to the war situation.

All the existing Ukrainian locomotives are for 1520mm track gauge and therefore incompatible with a future 1435mm network. The existing fleet of locomotives is obsolete and JSC UZ plans to renew the existing fleet progressively up to 2033.

4.2.1.2 Freight wagons in Ukraine (2021)

The total fleet of freight wagons of JSC UZ is circa 82.5 thousand units, about 50% of the total number of wagons, circa 168 thousand units, also considering private wagons. From the existing fleet of JSC UZ freight wagons, the working fleet is circa 62.9 thousand units (76%).

Wagon fleet composition (JSC UZ and privates) is as follows:

Wagon type	Number	%
Gondola	86 500	51%
Tank car	20 200	12%
Grain hopper	15 800	9%
Covered	6 850	4%
Cement	6 560	4%
Platform	5 490	3%
Hot pellet hopper	4 990	3%
Container	4 030	2%
Other wagons	17 700	11%
Total:	**168 120**	**100%**

Table 4.4: Wagon fleet in Ukraine. Source: prepared for JASPERS by Egis

In Ukraine, more than 15 private companies are also providing freight wagons. The share of wagons between JSC UZ and private varies according to each wagon type and goods to be transported. Overall, private companies account for approximately 50% of the total Ukrainian wagon fleet with circa 60% of the tank wagons, circa 50% of the open rail (gondola) wagons and circa 26% of grain hoppers.

“Lemtrans” is the largest private operator of rail rolling stock of Ukraine. The company's primary activities are organisation of transportation by own rolling stock, rendering of transport and forwarding services, information support of the movement of goods, as well as repair of rolling stock. Currently, Lemtrans manages over 20 000 open rail wagons (gondola).

Gondola are “open box” wagons used for the transport of bulk, ore, mineral and very prevalent in former USSR countries.

Figure 4.3: Open box or "gondola" wagons. Source: prepared for JASPERS by Egis

JSC UZ is considering a project to purchase 1435mm track rolling stock including hopper wagons, tank wagons and fitting platforms for container.

The wagon fleet in Ukraine comprises circa 168 thousand units, half of which are owned by JSC UZ and half by private operators. All freight wagons are 1520mm track gauge and incompatible with any planned 1435mm tracks in Ukraine and Moldova.

4.2.1.3 Passenger fleet in Ukraine (2021 / 2023)

The EMU fleet is composed of circa 160 EMU trainsets (circa 50% being 3 kV DC and the other 50% 25 kV AC or dual-voltage).

In general, most of the EMUs are "commuter" units with a speed lower than 140 km/h, except for the most recent "Rotem Hyundai" models (12 units) with a speed of 160 km/h. The number of "in service" rolling stock is not provided but as for locomotives, it could be assessed that it represents about 60% of the inventory fleet.

3 kV DC				25 kV AC and dual voltage 3 kV DC + 25 kV AC			
<140 km/h	140 km/h	160 km/h	> 160 km/h	<140 km/h	140 km/h	160 km/h	> 160 km/h
68	0	0	0	77	0	12	0

Table 4.5: EMU fleet in Ukraine. Source: prepared for JASPERS by Egis

In addition, the fleet of DMUs comprises circa 70 DMUs, composed of several cars (called "sections" by JSC UZ).

On average the EMU fleet is circa 21 years old and circa 18 years for the DMU fleet. Existing 25 kV AC EMUs are all 1520mm track gauge with low speeds, except for a few recent units (12). Most EMUs are dedicated for commuter services (Elektrichka) and would not be interoperable with any new 1435mm network.

Maintenance facilities are generally in poor condition and not suitable for the maintenance of modern rolling stock. A dedicated depot for servicing and repairing Intercity and Intercity high-speed trains was built in 2012.

4.2.2 Moldova

4.2.2.1 Locomotive fleet in Moldova (2023)

All locomotives in Moldova are diesel. The fleet comprises 134 locomotive “sections”, with some locomotives being composed of 2 or 3 sections. In total there are circa 16 to 17 locomotives still in service (one locomotive is “half” in service with one section out of the 2 working). In the next 5 to 6 years, all locomotives Co’Co’x 2 and Co’Co’x 3 will be withdrawn.

Only 12 diesel locomotives Co’Co’ have been recently purchased, TE33AS produced in Kazakhstan, by CFM (2021). Additional locomotive renewal is still needed, however there are no plans or identified projects due to the lack of funds and because CFM priorities are focused on infrastructure rehabilitation projects.

Co'Co'	Co'Co'x2	Co'Co'x3
12	**2**	**3**

Table 4.6: Locomotive fleet in Moldova. Source: prepared for JASPERS by Egis

All locomotives in Moldova are powerful Co’Co’ diesel locomotives for 1520mm gauge. Therefore, not compatible with a future 1435mm network.

4.2.2.2 Freight wagons in Moldova (2023)

The CFM wagon fleet, as per the inventory book, comprises circa 4 500 wagons of various types and purpose. Out of these 4 500 units, circa 53% (2 300 units) are still in service.

- 38% of the in-service fleet comprises classical open-box wagons (gondola)
- 27% of the in-service fleet is composed of cereal wagons, dedicated to the transport of cereal, grains. Loading is achieved by the top and unloading using specific lateral unloading hatches
- 16% of the in-service fleet comprises tank wagons for transport of liquids: petrol, fuel, oil, etc.
- Wagons for intermodal transport represent a low percentage (circa 5%)

Wagon models	Total	In use	% in use
Open-box wagons	1 186	897	37.72%
Cereal hopper wagons	721	633	26.62%
Cement hoppers	195	70	2.94%
Petroleum tank wagons	396	384	16.15%
Bitumen tank wagons	7	0	0.00%
Tank car food products	11	0	0.00%
Universal covered wagons	635	157	6.60%
Box cars for packaged goods	476	4	0.17%
Platforms for containers	292	110	4.63%
Multipurpose flat wagons	257	22	0.93%
Refrigerated wagons	91	0	0.00%
Others	218	101	4.25%
TOTAL	**4 485**	**2 378**	**100.00%**

Table 4.7: Wagon fleet in Moldova. Source: prepared for JASPERS by Egis

The wagon fleet decrease is on average – 2,5% per year. This decrease will also face some "peak" decrease in the next 6 years, with a significant decrease of circa 670 units.

According to CFM, the urgent procurement of wagons is required:

- 1 000 to 1 500 hopper wagons for cereals
- 2 000 to 3 000 gondola wagons for multipurpose use
- 500 platform wagons for the transport of containers

CFM owns a small fleet of old wagons of various types (mainly gondola, cereal wagons, and tanks). The fleet is obsolete and there is an urgent need of fleet renewal. All freight wagons are 1520mm track gauge and incompatible with a new1435mm network in Ukraine and Moldova.

4.2.2.3 Passenger fleet in Moldova (2023)

There are no interoperable EMUs in Moldova, all fleet being 1520mm track gauge and diesel (6 units). Although 5 DMUs have been recently refurbished, all the DMU fleet is 60 years old.

4.3 Operations

4.3.1 Ukraine

The entire rail network is operated by JSC UZ, controlled by the Cabinet of Ministers of Ukraine, with the Ministry of Infrastructure functioning as the main executive body controlling Ukraine's transportation infrastructure (roads, trains, and communications).

JSC UZ operations are split into six territorial rail companies: Donetsk, L'viv, Odesa, Southern Rail, Southwestern Rail and Near-Dnipro Rail. Each region is in charge of managing the operation of regional and commuter passenger transport, freight transport and of the maintenance of infrastructure assets.

Figure 4.4: Regional branches of JSC UZ. Source: prepared for JASPERS by Egis

4.3.2 Moldova

The entire rail network and services are managed and operated by CFM. CFM is controlled by the Moldovan government, with members of various ministries within its Board of Directors. CFM has multiple different sections in charge of different parts of its activity, as well as many regional branches.

Regarding operations, CFM faces several major challenges, which will need to be considered:

- A complex itinerary by the Ukrainian border: several routes in the north and in the south enter and exit Moldova and Ukraine several times. In the North, the Northwest line (to Chernivtsi, in western Ukraine) is crossing the border four times between the countries, before exiting finally a fifth time to its destination. In the South from Cainari to Giurgiulesti the line exits three times before reaching Giurgiulesti facilities.

  The situation has creates additional complexity with respect to controls and train monitoring. Due to the war, joint control is under discussion and shall be implemented shortly. This would affect both passengers and freight, with controls currently done separately on each side generating significant delays. A technical group is in charge of the issue

- Change of gauge at border crossing with Romania: at the Romanian borders (Ungheni and Giurgiulesti) gauge change takes place through changing of bogies (passenger trains) or cargo transhipment. The Romanian network is equipped with 1520mm gauge service tracks that enter the country and transhipment operations are realised in the related Romanian rail stations (Ungheni, Prut and Galati). Giurgiulesti port offers also mixed gauge transhipment lanes.

  This represents one of the major challenges for Moldovan network connectivity. The current system leads to significant delays, limiting capacity to a maximum of 70 coaches/wagons per day

- Rail lines through Transnistria are not in operation: this situation has been recently addressed by the opening of the Basarabeasca – Berezyne line, posing an additional burden to CFM and JSC UZ for the refurbishment of the line. The new section is 23 km, out of which 1.2 km is in the Moldovan territory. Moldova has invested circa 1 Mio EUR to rehabilitate this section.

  A Memorandum of Understanding between Chisinau and Kyiv was signed in June 2023. The Republic of Moldova gained access to Izmail port located on the Danube, as an alternative to the port of Reni. At the same time, Ukraine will be able to export goods to the Republic of Moldova and to EU using the southern route

- The deteriorating condition of the network has resulted in multiple speed restrictions (190), which has negative impacts on the level of service and other multiple consequences, in particular the increase of operational costs and higher tariffs, and the decrease of commercial speeds. In the passenger sector, this translates into less attractive services for the intercity trains compared to road services. CFM announced a very low average commercial speed of less than 30km/h on the network at the beginning of 2023

- Obsolescence with limited and rapidly decreasing availability of rolling stock, combined with financial constraints to invest into new fleet

4.4 Maintenance

4.4.1 Ukraine

4.4.1.1 Infrastructure

Significant deterioration of rail infrastructure affects provision of high-quality and safe freight and passenger transportation services. The situation leads to numerous speed restrictions and lower average speed of transportation of cargo and passengers.

According to JSC UZ, there is a need to repair more than 6 000 km of rails annually, whereas the actual repair indicators do not reach 50%. Due to lack of funds, the policy regarding infrastructure renewal mainly comprises local repairs of main track defects. Overhaul requirement applies to about 27% of the network, with 75% having reached service life. In 2018, overhaul of 555 km of track (6.5% of the need) was completed. It should be noted that there has been a significant decline in overhaul works, with volume in 2007 being 5 times higher than in 2018-2019.

Speed restrictions mainly apply to regional lines; however, it is estimated that about 50% of the network is operated with a limitation in the order of 60 km/h. In 2015, the sections with speed reduction to 40 km/h reached about 300 km in length and, currently (as of early 2022), it is assessed they could reach approximately 4 000 km.

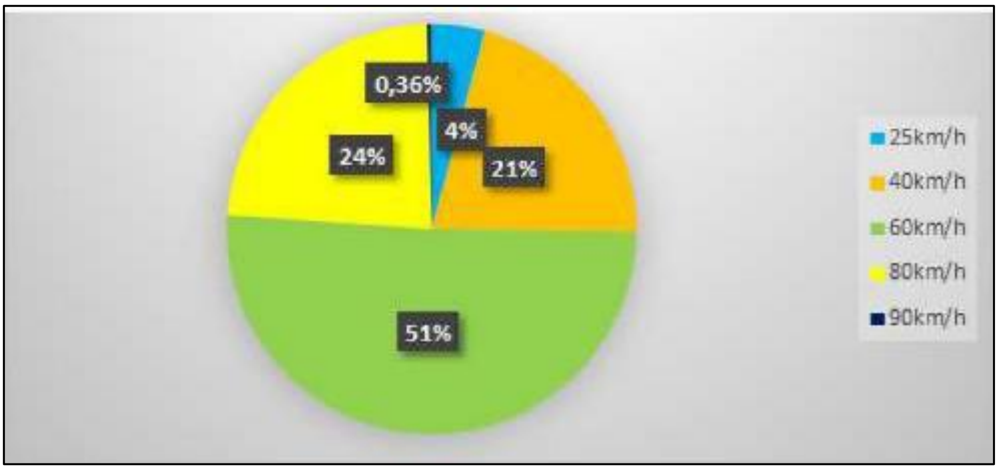


Figure 4.5: Speed restrictions (example of Dnipro region). Source: prepared for JASPERS by Egis

JSC UZ is performing all maintenance works with its own maintenance teams and equipment. Regional branches equipment is outdated and has low performance (tamping, re-laying, welding). No “fast lane” trains for track maintenance work are available.

4.4.1.2 Rolling stock (Ukraine and Moldova)

For existing facilities in Ukraine and Moldova, there is a high level of obsolescence of maintenance facilities with poor working conditions, worn-out maintenance equipment, and staff not trained to perform maintenance on rolling stock with modern technology.

Figure 4.6: Old maintenance locomotive depot in Chisinau. Source: prepared for JASPERS by Egis

Installation of 1435mm gauge in Ukraine and Moldova would pose a significant challenge for existing maintenance facilities. For example:

- Using “dual-gauge” maintenance facilities would involve complex solutions due to the difference of track axis and incompatibility with the use of existing wheel lathe, existing lateral gangways, and automatic washing machine. It would also require complex and costly sets of turnouts (specific for 1435mm / 1520mm), itinerary management inside the depot, etc.

- The maintenance facility itself would need to be divided in 2 separate areas: a 1435mm rolling stock dedicated area and the 1520mm rolling stock part (for the workshop and the stabling yard,)

4.4.2 Moldova

4.4.2.1 Infrastructure

Insufficient investment in capital repair and maintenance budget has led to a highly degraded network: according to a World Bank study dated October 2020, CFM had accumulated a significant backlog in track renewal over the last decades. While the annual amount of capital repairs should be 40 km per year, it reached less than 10km per year in 2013-2014, and between 2015 and 2018 less than 2 km per year. According to an on-going AFD study, more than 38% of the network is facing speed restrictions.

Rehabilitation needs vary significantly across the network with differences in main line condition in each corridor. According to a 2017 EBRD Study, the percentage of urgent rehabilitation on the central corridor is 19.81% (the section Chisinau-Tighina being at that time in a relatively satisfactory condition). The North corridor would require urgent repairs along 36.99% of its length, while for the South corridor along 22.19%.

Moreover, the network has deteriorated further since the study was completed. Comparison with 2021 data indicates a significant increase in defects. If track deterioration is compared to total length of main line sections, more than 38% of the main line network suffers from track defects.

4.5 Border crossing, gauge change and transhipment

4.5.1 Border Crossing Points (BCP)

Proposals for 1435mm track gauge connecting Ukraine with the EU have been conceived previously but have not been further developed.

All neighbouring EU countries (Poland, Hungary, Slovakia, and Romania) have networks based on the 1435mm gauge. For trains crossing EU border points, with some limited exceptions, gauge change is a requirement. At present, there are various solutions to the gauge change necessity, such as dual-gauge, bogie exchanges, other rolling stock related or simply transfer of goods or passenger.

The current EU – Ukraine rail border crossing points, associated infrastructure and operations are described below.

4.5.1.1 Poland – Ukraine

There are currently 7 rail border crossing points with Poland:

1. (Chelm -) Dorohusk PKP - Yahodyn UZ (- Kovel), TEN-T BCP. The cross-border section comprises one 1435mm gauge track and one 1520mm gauge track. The 1435mm gauge track extends eastwards to a shipment yard at Kovel, 59 km east of Yahodyn, while the 1520mm gauge track extends westwards to an oil installation a few km west of Chelm. Both lines are used by freight over their full length. The 1435mm gauge track is electrified as far as Dorohusk. PKP operates a long standing Warszawa - Kyiv overnight service on the 1435mm gauge tracks to/from Yahodyn, where gauge changing takes place by means of bogie exchange. The train thus changes to/from PKP diesel traction for the short cross-border journey. This is the only PKP operated passenger service east of Chelm
2. (Slawków -) Hrubieszów LHS - Izov LHS. This 1520mm gauge line is the "Linia Hutnicza Szerokotorowa (LHS)" between Slawków near Katowice and Vladimir in Ukraine. A limited long-distance international passenger service ended a number of years ago, so current use is limited to freight and "road-train" services. There is currently a project to electrify the section from Kovel in Ukraine to Hrubieszów (the line was formerly part of PKP and called "Steel and Sulphur Rail")
3. Hrebenne PKP - Rava Ruska UZ. PKP-operated 1435mm gauge through service to/from Warszawa, which commenced on 2 June 1996 and was withdrawn in June 2005. No freight traffic can operate, as the tracks to the interchange sidings at Rava Ruska have been dismantled
4. Werchrata PKP - Rava Ruska UZ. A 1520mm gauge freight only crossing, now operated exclusively by UZ and with very limited traffic. The 1520mm gauge lines on the Polish side serving transhipment sidings are all out of use
5. (Przemysl -) Medyka PKP - Mostyska II UZ (L'viv), TEN-T BCP. PKP and UZ operate a daily overnight service between L'viv and both Wroclaw and Warszawa. The 1435mm and 1520mm

gauge lines at this BCP, which take different alignments within Poland, were previously used on alternate days in each direction: in one direction the train changed gauge at Mostyska II by means of an open air SUW 2000-compatible gauge changer, and in the other direction the other train performed a manual bogie change at Przemysl. This arrangement ended, as the SUW 2000 equipment was out of use in 2017. In 2016 JSC UZ introduced a direct Kyiv – L'viv - Przemysl daytime Intercity service, using a modern 1520mm gauge EMU, with on-board customs control. This service was doubled on 24 August 2017, when Ukrainian Citizens no longer needed visas to visit the EU, the additional service running on a different route between L'viv and Kyiv. JSC UZ works 1520mm gauge freight trains to yards within Poland and PKP works standard gauge freight services to Mostyska II. On the Polish side, the 1520mm gauge continues to Zurawica; on the Ukrainian side, the1435mm gauge track ends at a transhipment facility 3 km east of Mostyska II station

6. <u>(Przemysl) Malhowice PKP - Nyzhankovychi UZ (- Dobromyl' - Khyriv)</u>. Closed as a through route, this BCP formerly combined dual gauge 1435/1520mm. Until early 1995, PKP operated a 1435mm gauge Warszawa - Zagorz corridor train through Ukraine via this route and the Kroscienko - Stariava crossing. By July 2004, significant lengths of the 1435mm gauge track within Ukraine were removed north of Dobromyl, with PKP 1435mm gauge carriage sidings and freight remaining on a stub from Przemysl to Przemysl Bakonczyce. Following the lifting of Visa restrictions on Ukrainians there has been a suggestion that this route may reopen to passengers and on the Polish side, all trees were cleared from the track in autumn 2016, triggering some repair work by JSC UZ. By December 2018 there have been ten cross-border trains with politicians, tourists, journalists and volunteers on board. The Polish government now has plans to rebuild this line
7. <u>(Sanok - Ustrzyki Dolne -) Kroscienko PKP - Star'iava UZ (- Khyriv).</u> This line has been closed to all traffic since 9 November 2010, but with Ukrainian visa restrictions lifted reopening may be considered. PKP had operated 1435mm gauge local passenger services between Sanok (Zagórz before 2004/2005) and Khyriv, but recently only freight trains ran between Sanok and Ustrzyki Dolne. A 1520mm gauge track is interlaced with the 1435mm gauge track on the section between Stariava and Khyriv, for the internal UZ passenger service of two trains per day

Regarding cross border traffic between Ukraine and Poland, it is also worth noting that Poland lacks intermodal terminals in its eastern regions (especially those along the Kraków – L'viv corridor) and to provide services that would be related to freight imported/exported from/to Ukraine (location of terminals is based on business considerations and cannot be implemented by administrative means only). In the current situation, Polish developers have concerns about investing in terminals dedicated to the Ukrainian market.

4.5.1.2 Slovakia - Ukraine

Chop is an important rail junction in Ukraine, where the L'viv-Stryi-Chop-Cierna nad Tisou-Kosice-Bratislava rail line meets the L'viv-Uzhgorod-Kosice line. On the Ukrainian side there is the Chop rail station, and on the Slovakian side there is the Cierna nad Tisou rail station. The latter station is on the TEN-T as part of the Rhine-Danube Core Network Corridor. Between the stations Cierna nad Tisou and Chop there are tracks with both gauges 1435mm/1520mm. An important element for cross-border operation is the Cierna nad Tisou transhipment area and an intermodal terminal in Dobra, where the Ukrainian 1520mm gauge line meets the 1435mm gauge infrastructure. In total, there are 160 km of rail lines in a ten square km area of in Cierna nad Tisou.

Another important BCP is Uzhhorod in Ukraine and Mat'ovce on the Slovakian side. A single 1520mm gauge track is heading from the state border of SK//UA to Haniska, near Kosice, in Slovakia. This 88 km rail line is used for freight transport – mainly iron ore for the US Steel factory.

The total rail freight transport between Slovakia and Ukraine is around 16 million tonnes per year, which amounts to about 40% of the entire rail freight transport in Slovakia. The most frequently transported goods are iron ore, coal, and metal. Around 247 000 freight cars are used for transport between Slovakia and Ukraine every year. Slovak national operator ZSSK and UZ agreed to launch a through passenger service in 2017 on the 146 km route between Kosice and Mukachevo, via the Cierna nad Tisou/Chop border crossing.

4.5.1.3 Hungary - Ukraine

Two rail border crossing points are provided:

1. Záhony - Chop dual gauge 1435/1520 mm, TEN-T BCP. An important element for cross-border operation is the Záhony transhipment area, where the Ukrainian 1520mm-gauge line meets standard-gauge infrastructure. A new proposed rail link will use the dual-gauge track (1435mm and 1520mm) and it will not require bogie exchange or new rolling stock with gauge adjustable wheelsets. The dual-gauge rail runs from the border between the two countries to Mukachevo station in Ukraine. Of the two dual-gauge lines across the border, the Záhony link is used only by standard-gauge passenger and freight trains. Generally, two to three pairs of empty (cereal) or loaded (with goods such as bricks, tiles) trains per day (20 to 25 cars long) go from Hungary to Chop and are loaded/unloaded there. At Záhony the 1520mm gauge is currently not used. MÁV manages a 150km 1520mm-gauge network, including a freight wagon bogie-changing facility. Passenger coach bogies are changed at Chop, Ukraine, and since late 2018, a direct standard-gauge inter-city service operates between Budapest and Mukachevo

2. Eperjeske - Solovka (freight only) dual gauge 1435/1520 mm. Freight traffic takes place on 1520mm gauge. There are three to four pairs of freight trains per day (60 to 65 cars long). Generally, bulk goods: grain, ore, carbon black and wood arrive to Hungary from Ukraine, and fuel goes out from Hungary to Ukraine. The 1435mm gauge is currently not used at this BCP

4.5.1.4 Romania – Ukraine

Six rail border crossing points are provided:

1. (Satu Mare -) Halmeu CFR - Diakove UZ (- Koroleve), TEN-T BCP. Freight only and dual-gauge. UZ works to Halmeu on both gauges. The 1520mm gauge traffic runs to and from the gauge-changing and transfer facilities at Halmeu and an oil depot further south near Porumbesti. The 1435mm gauge traffic runs via the Ukrainian corridor line to Chop, with links to and from Cierna nad Tisou in Slovakia and Záhony in Hungary
2. (Sighetu Marmatiei -) Campulung la Tisa CFR - Teresva UZ. Out of use. Teresva to Campulung la Tisa is 1520mm gauge only, with dual-gauge 1435mm/1520mm from there to Valea Viseului. This crossing has been out of use since a new road bridge was opened across the Tisa, between Solotvino and Sighetu Marmatiei. UZ operated a passenger service to Sighetu Marmatiei which was withdrawn during 2007. CFR 1435mm gauge freight traffic to Campulung la Tisa has ceased west of Sighetu Marmatiei
3. (Sighetu Marmatiei -) Valea Viseului CFR - Dilove UZ (- Rakhiv). The route across the border to Valea Viseului is 1520mm gauge only and has been out of use since April 2006 owing to serious flood damage
4. (Dornesti -) Vicsani CFR - Vadul Syret UZ (- Chernivtsi), TEN-T BCP. Carries both freight and passenger traffic. Sofia - Bucuresti - Kyiv / Moscow trains ran via this route but were suspended as of December 2014. However as of July 2017, daily trains ran each way. There are gauge-changing facilities at Vadul Syret

5. <u>(Barbosi -) Galati CFR - Reni UZ.</u> The route across the border is dual-gauge between the transhipment area at Galati and the port of Giurgiulesti (MD). The 1520mm gauge continues to Reni in Ukraine. There are no passenger services
6. <u>Constanta CFR - Illichivs'k UZ {train ferry}</u>. Freight only. 1520mm gauge, with bogie-changing facilities to 1435mm gauge exist at Constanta

4.5.1.5 Moldova – Ukraine

10 rail border crossing points are provided:

1. Giurgiulesti CFM - Reni UZ
2. (Chernivtsi -) Mamalyha UZ - Criva CFM -Lipcani CFM - border - border - Medveja CFM - Larha UZ
3. Ocnita CFM - Sokyriany UZ (- Larha)
4. (Ocnita -) Valcineț CFM - Mohyliv-Podil’s’kyi UZ (- Zhmerynka)
5. (Ribnita -) Cobasna CFM - Tymkove UZ (- Slobidka), TEN-T BCP
6. (Tiraspol -) Novosavitskaia CFM - Kuchurhan UZ (- Rozdil’na), TEN-T BCP
7. (Csinari -) Iserlia CFM - Karabutseny (Ukraine) - 121 km (Ukraine) - Basarabeasca CFM, TEN-T BCP
8. Basarabeasca CFM - Serpneve I UZ (- Berezyne - Artsyz), TEN-T BCP
9. (Basarabeasca - Taraclia -) 208 km CFM - border - Bolhrad (Ukraine) - border - Greceni CFM (- Etulia)
10. (Basarabeasca -) Etulia CFM - Frykatsei UZ (- Reni)

4.6 Organisation, legislative framework, and institutional setup

4.6.1 Ukraine

4.6.1.1 JSC UZ and EU Integration

UZ was turned into Joint Stock Company (JSC UZ) in October 2015, with the Cabinet of Ministers of Ukraine (CMU) as the sole shareholder. The holding has four bodies of management:

1) General meetings of the shareholders- represented by the Cabinet of Ministers

2) Supervisory board

3) The management board

4) The audit committee

The functions of each of the bodies are described in the “Statute of the Stock Company *Ukrainian Rails*”.

The state, as the founder and sole shareholder of the company, represented by the Cabinet of Ministers of Ukraine, establishes that the main goals and priorities of JSC UZ. They were established in a CMU decree in 2019. The priorities are:

1. Satisfaction of the needs of consumers of transport services of passengers and goods by rail transport, taking into account the principles of sustainable development

2. Modernisation and optimisation of the infrastructure of public rail transport and rail rolling stock. To this end, the company must invest in major repairs and modernisation (including a modern system of signalling, centralisation, blocking and communication) of main rail lines and

technological facilities located on them, transmission devices that are directly used to ensure the transportation process

3. To improve the equipment for maintenance and repair of main rail lines and technological facilities located on them, transmission devices that are directly used to ensure the transportation process

4. To optimise the infrastructure of public rail transport

5. To reduce the level of Ukraine's external dependence on the import of rail products and consumables during investment activities

6. Preservation and improvement of the company's financial position

7. Creation of a transparent competitive environment for the introduction of a competitive rail transport market into the unified transport system of Ukraine

8. Increasing the value of assets managed by the company, in particular by increasing investment attractiveness in compliance with the following requirements:

   - ✓ Increasing the company's profitability for the state shareholder

   - ✓ Ensuring effective, rational economic and financial activity of the company in the long term

   - ✓ Ensuring transparency, reporting and disclosure of information of company's activities

9. Ensuring proper corporate governance, compliance with the requirements of legislation in the field of management of state-owned objects and anti-corruption policy

10. Ensuring the development of the company's personnel potential and the implementation of social responsibility functions during the company's activities

11. Ensuring the appropriate level of safety of rail transportation

The corporate structure allows management independence. However, considering that the priorities established by the CMU in 2019 contain several measures intended to harmonise the system with EU and the lack of implementation of them (eliminate the cross-subsidisation of passenger segment by cargo, separation of the infrastructure manager, etc.) it can be concluded that appropriate systems for controlling the management of the company are not in place yet. On 24 March 2023, KPIs for the action of the Supervisory Board were established, with one of them referring to structural reforms according to EU principles.

Despite the independence of the management of JSC UZ as an integrated company, the management of the infrastructure and transport operations has not been enforced. JSC UZ combines the functions of Rail Undertaking and Infrastructure Manager, as was the model in Europe before the separation, and is undergoing a double process of reforms:

- Integration of the work and management of the regional divisions into business verticals responding to operational (and not territorial) criteria: as of the writing of this study, JSC UZ has not yet made the transition. Historically, JSC UZ's regional branches were created based on state-owned enterprises and many management functions are duplicated by branches and headquarters. Important processes were decentralised (i.e., accounting, provision of drivers, maintenance, provision of locomotives). Some interactions with cargo customers and suppliers also occur at the same regional level

- Adoption of the European Model of Rails: Ukraine should have brought into compliance the organisation and legislation of the sector with the directives and regulations contained in the Association Agreement by the end of 2022. Although there has been considerable work in building the capacities of the Ministry and JSC UZ, a clear political will to confront the difficulties of the reforms was missing at the legislative level. In addition, the "Supervisory Board" of JSC UZ was not provided by the shareholders (CMU) with clear KPIs related to the implementation of reforms and key issues, like the separation of infrastructure and services, which are still pending

  The Infrastructure Manager should be independent in its accounts, management, and operation from any Rail Undertaking. In addition, services subject to public service obligations should have also separate accounts. The strategy of reforms of JSC UZ (2019-2023) contained measures leading to solve many of the issues mentioned above. However, the strategy lacked KPIs for the implementation of the reforms (only approved on 24 March 2023) and had the risk of being declarative without any adequate mechanism for enforcement

In early 2023, the Ministry created a Working Group for updating the Action Plan for reforming the rail transport sector. The Working Group is formed by civil servants of the Ministry, deputies of the Parliament and representatives of associations of customers and suppliers.

4.6.1.2 Intervention of the state in pricing

The Law on Rails Transport (Art. 1) defines "rail transport as the production and technological complex of rail transport enterprises, appointed to meet the needs of social production and the population of the country for transportation and to provide other transport services to all consumers without restrictions on the characteristics of ownership and types of activities". The obligation of meeting the needs of the social production is developed on the Art. 2 of the Law on Rails Transport, which states that:

- The activity of rail transport as part of the Single transport system of the country contributes to the normal functioning of all branches of social production, the social and economic development and the defence capability of the state and the international cooperation of Ukraine

- Rail companies, in cooperation with other modes of transport, should carry out the transportation of passengers and cargo in a timely and qualitative manner

Regarding pricing, the tariffs of the rail services (passengers and freight) are, with some exceptions, fixed by the State (at different levels of the administration) and often disconnected from the cost of providing the service.

Ukrainian Law on "Prices and Prices Formation" foresees (Art. 12) the introduction of State regulated prices for goods/services produced/provided by entities that have a monopoly (dominant) position in the market.

According to results of research conducted by the Antimonopoly Commission of Ukraine (AMCU), and the methodology for determining a "monopoly position" (approved in 2002), JSC UZ was determined to have a monopoly (dominant) position with a 100% share in the market of "transport of goods by rail transport". Said methodology recognises a "monopoly (dominant) position of a business entity whose market share exceeds 35% in the considered territory (in this case, Ukraine)".

4.6.1.3 Operations and asset

4.6.1.3.1 Economic efficiency

JSC UZ is a vertically integrated company performing the functions of infrastructure management and the provision of rails transport services, together with other 119 types of economic activities, as for example the production of pharmaceutical products, the provision of touristic services, exploitation of ships, distribution of electricity, provision of centralised water supply and centralised drainage or transportation of thermal energy by distribution heat networks. It combines in its accounts business that sell services as a natural monopoly, business enjoying the facto exclusive rights, and business in competition.

The transport of some categories of goods and the transport of passengers are cross-subsidised:

- At the expense of other types of cargo: the pricing system for the transport of goods is based on the system of the Soviet Union. A basic tariff calculated according to the catalogue of tariffs is approved by the Ministry in an order and multiplied by a coefficient depending on the type of goods. The categories of goods are constructed according to a figurative “market value” of the goods, without an actual link to the cost of providing the service or the point-to-point transport conditions of competitors, including the road (Case No COMP/M.5855 - DB/ ARRIVA). In January 2023, JSC UZ announced that the coefficients of the different categories will be unified.

  In parallel, the tariffs for some services are not regulated. The Law of Ukraine "On Rail Transport" entrusts the CMU the right to determine the procedure for the establishment of tariffs for the transportation of goods. Along with this, it is provided that the calculations of tariffs for works, and services related to the transportation of goods, in respect of which there is no state regulation of tariffs, are carried out according to free tariffs, determined by the agreement of the parties. For example, from 19.02.2018, the wagon component in the tariff was deregulated for the transportation of goods by rail transport within the borders of Ukraine in wagons property of JSC UZ by amending a decree of CMU and an order of the Ministry

- At the expense of a deficient investment in the network and the renewal of the rolling stock. For many years, the renewal of assets has been persistently below the yearly depreciation

As a corollary, the obligation to supply (“meet the needs of social production and the population of the country”), the tariff obligations and the understanding of the rails undertaking as a source of revenue for the state have resulted in different financial burdens borne by JSC UZ which are not properly identified, quantified, and compensated:

- Public passenger transport service obligations (obligation to operate, obligation to carry and tariff obligations) are not properly identified, quantified, and compensated

- Tariff and terms for the core freight transport operations. The Article 15 of the Law on "Prices and prices formation" states that “The Cabinet of Ministers of Ukraine, executive bodies and local self-government bodies that have set state regulated prices for goods in an amount lower than the economically justified amount shall be obliged to reimburse economic entities for the difference between such amounts from the relevant budgets” and “Establishment […of the former…] can be challenged in court”. The amounts have not been neither calculated nor compensated and there have been no challenges in court of the regulated prices by JSC UZ, casting a shadow on the actual independence of the company´s management.

  The obligation to supply implies that many operations are carried as “single wagon” operations, but an appropriate accounting of the cost or benefits of this practice is not carried out. The maximum time of delivery of the goods is fixed by the state depending on the distance between origin and destination

- Taxes paid by JSC UZ that are not paid by its main competitors (road infrastructure does not pay land tax)

4.6.1.3.2 Freight segment

The freight rail system in Ukraine works, to a certain extent, as a packaging delivery or postal company. The functioning of the system is described in the “statute of the rails sector”, in force since 1998. Rail operations focus on grouping and moving the wagons along the nodes of the network with the goal of reaching the destination before the deadline, while optimising the cost of transportation to increase the profits. In this process, six regional “rails companies” cooperate. There are two systems for the allocation of capacity:

1. Localised (as opposed to centralised), which often merges with the operative level of traffic management. This is the system used for single-wagon operations

2. In parallel to this system, there are also “block trains” that work based on a train path between origin and destination. Similarly, train paths are assigned to passenger trains crossing different regional “rails companies”

Therefore, JSC UZ could be in principle capable for the migration of the current system to the European Rail model in what concerns allocation of train paths. However, this would require a previous normalisation of accounts for single wagon operations or the elimination of the legal obligation of this practice. Otherwise, new entrants would skim the market.

The allocation of the train path is however an internal procedure within the rail companies, as only companies within JSC UZ can provide traction services (very few exceptions exist). Therefore, the interfaces for the capacity allocation (network statement defining the catalogue of capacity, the technical description of the infrastructure and the conditions for its access), the allocation procedures and a regulatory body ensuring the non-discriminatory access are missing.

The existing system has proved to have certain advantages in terms of overall operation costs and has maintained a high-market share of the freight and passengers market services. However:

- The system does not create appropriate incentives for improving the quality of the services or the satisfaction of the clients

- The competitive advantage of the rails is based on cost, leading to evident problems of sustainability. According to JSC UZ representatives, the wear and tear of "JSC UZ" assets in 2020 reached almost 100% (locomotives - 96%, freight wagons - 89%, passenger cars - 88%).

Based on the above, a considerable investment in rolling stock will be needed in the near future. The opening of the market of traction services (rails undertakings) would partially relieve the state of the burden of guaranteeing/financing these investments. Furthermore, as a general rule, in the EU the quality of the transport services is encouraged by competition.

The coexistence of different rail undertakings operating on the rail network would also require a new system for the certification of train drivers and the harmonisation of the safety approach to accommodate the regulation and supervision of different rail undertakings.

It can be concluded that JSC UZ faces a conundrum: (a) on one hand, it needs to raise rates to increase revenue and to address future investments in renewal of lines and rolling stock, in the framework of an interventionist state policy that makes it very rigid pricing system and limits the funding, and (b) on the other hand, the customers can abandon rails services to other competitors if the prices are too high (be it future rail undertakings or road transport operators).

It will not be possible to solve the above without policies addressing the “fair competition” between modes. Ukraine has not introduced yet charging schemes for the use of the road infrastructure (tolls).

In addition, the road sector is not subject to the same quantity or scale of “financial burdens” as the rails and the road sector is relatively unregulated. According to state road agency, Ukravtodor, every third truck is in violation of weight norms. In June 2021 a law was passed allowing the government to automatically impose fines via weigh-in-motion systems. As part of the law, intelligent devices with sensors built directly into the asphalt will be able to register and fine overloaded trucks immediately upon hitting the sensor.

Other policy topics like licensing of road operators, roadworthiness of vehicles, skills of drivers and working conditions in the road, use of tachographs, checks for driving times/resting periods, liability of employers for offences of drivers are not yet harmonised.

4.6.1.3.3 Passenger segment

The “Procedure of provision of rails transport services for citizens” (CMU Decree from 19.03.1997 # 252) establishes the framework of passenger operations in Ukraine. According to the procedure, the schedule is determined as follows:

- If within a single region, by the corresponding regional division of JSC UZ
- If within two or more regions, by JSC UZ
- If involving two or more states, by respective international agreements

The rules for determining the number of trains in each direction, the frequency of their running and the minimum number of cars, the volume of passenger turnover to determine the stops of the trains at intermediate stations is established by JSC UZ in agreement with the Ministry of Infrastructure. Additional trains, frequency, stops and creation of stop points can be determined in an agreement between the relevant economic entities and the local authorities.

The performance of the services largely varies on the type of train. Different categories have their corresponding comfort standards (“Rules of passengers, luggage, cargo luggage and mail transportation by rail transport of Ukraine”, Order of MTCU from 27.12.2006 # 1196), as illustrated in the table below.

Train category	***Type of train***	***Speed of movement***		***Category of carriage and seats***
		Route speed	***Maximum speed***	
Intercity + "IC+"	*day time high speed train*	*90 km per hour and more*	*up to 200 km per hour*	*1 class / C*
				2 class / C
Intercity "IC"	*day time high speed train*	*80 km per hour and more*	*up to 160 km per hour*	*1 class / C*
				2 class / C
				3 class / C (P/I)
				K (P/I)

				P (P/I)
Regional Express "RE"	*day time high speed train*	*70 km per hour and more*	*up to 140 km per hour*	*1 class / C*
				2 class / C
				3 class / C (P/I)
				K (P/I)
				P (P/I)
Night Express "NE"	*night time high speed train*	*70 km per hour and more*	*up to 200 km per hour*	*M (VIP) (P/I)*
				L
				K
				1 class / C (P/I)
Night speed "NS"	*night time* *speed train*	*50 km per hour and more*	*up to 140 km per hour*	*M (VIP) (P/I)*
				L
				K
				P
				1 class / C (P/I)
Night passenger "NP"	*night time* *passenger train*	*up to 50 km per hour*	*up to 140 km per hour*	*L (P/I)*
				K
				P
				2 class / C (P/I)
				3 class / C (P/I)
Regional train "R"	*day time speed train*	*50 km per hour and more*	*up to 120 km per hour*	*1 class / C*
				2 class / C
				3 class / C
				K (P/I)
				P (P/I)
Suburban train "S"	*day time*	*-*	*-*	*-*

	suburban train			
City train "C"	*day time* *city train*	-	-	-

Table 4.8: Comfort standards for different passenger train categories. Source: prepared for JASPERS by Egis

Certain additional services are recommended (carpets, hot drinks, etc.), depending on the type of train, in the annex 6 of said rules. The suburban trains (S) have neither operational speed parameters, nor maximum speed of the rolling stock defined.

According to the “methodology for tariff calculation for passenger transportation by rail, except regional, suburban trains and Intercity” (Order of MIU from 19.06.2013 # 412), tariffs are calculated ex-ante in accordance with the plan for the year (based on actual data of the previous period) of:

- Passenger traffic
- Economically justified planned costs, determined based on state and industry standards costs
- Tax rates and fees (mandatory payments) in the planning period

Tariffs are calculated on a nation-wide basis, without considering point-to-point conditions (quality, price, time, etc.) of the interchangeable services (competition of other modes). Therefore, changes in the conditions of interchangeable services (for example, buses or sometimes planes) on a concrete route, will impact the price for the services in all Ukraine and not in the concrete route. For example, an increase of the competitiveness of the road services (market share) in the route Kyiv-Odesa (increase of volume of road passengers and decrease of volume of rail passengers in that route) will force an increase of the tariffs in the route Kyiv-Kharkiv. Therefore, the whole system would become gradually less and less competitive, as it does not allow JSC UZ to react to changes in the market conditions on each individual route.

The tariffs for the intraregional services are agreed between JSC UZ and the local authorities. In theory, the agreement should be formalised in a contract, setting the conditions for compensation. The compensations, although guidelines of the Anti-Monopoly Commission of Ukraine (AMCU) exist, do not comply with the requirements of the Annex of EU Regulation 1370/2007. In practice, the system is cross-subsidised as appointed above.

The suburban trains segment may be characterised by:

- Train occupancy varies from "almost empty" to "over-crowed". JSC UZ's EMUs with 1 000 passenger capacity are not offering any flexibility to accommodate such variation. In the EU, regional rolling stock is offering about 400 places and can be used in multiple units
- Production of Train-km per km of track and passengers per km of track compared to EU countries is at the lowest of the range
- Average commercial speed of regional passenger trains is below 40 km/h, while in the EU the range is 40 to 60 km/h. Low operational speeds are partially caused by the very short distance between successive stops
- A huge proportion of passengers are travelling with free fare and there are no accurate data regarding passenger volumes, origin and destinations
- « Multipurpose » rolling stock used for short distance and long-distance trips. The operation program is more guided by the need to have a robust and simple operation management

process than to provide a customised operation work-shift program dedicated to specific functionality of the passenger services

- Out of date EMU fleet, more than 33 years. Poor technical quality, in large part due to its old age
- Lack of investment in related regional/suburban and city stations
- Timetables are poorly adjusted to the customer and oriented to improve the “operator efficiency”: each individual EMU trainset is facing the same succession of working days with same wear, same operation program and same mileage
- Surveys have shown that the main reason for the passengers to choose the trains is safety. They are dissatisfied by cleanness and comfort. 61% passengers are ready to pay more to reduce travel time and 31% are ready to pay more for more comfortable trains

The monitoring and planning of the public passenger transport, considering an integrated approach that combines the different modes of transport, should be assigned to the competent authorities through relevant provisions in the legal framework. Nowadays, the obligations of the competent authorities (regional administrations) regarding the organisation of rails, electric urban and road transport differ in the competences, functions, and principles.

4.6.1.3.4 State support for investment

The road sector has received considerable support from the state for the modernisation of the infrastructure through an ear-marked road fund. However, the rail sector has not received the same support for the upgrading and maintenance of the infrastructure.

In addition, the integrated management of the company makes that the economic activity of the infrastructure maintenance function is subordinated to the general business requirements dictated by the services and commercial operations. Thus, the infrastructure manager does not make independent decisions from the railway undertaking (traction provider). There are no framework contracts between JSC UZ and the state defining the requirements of performance of the infrastructure and compensating for the cost of the maintenance that the market cannot bear. One of the obligations set by the CMU, as shareholder of JSC UZ, concerns the “investment in major repairs and modernisation (including a modern system of signalling, centralisation, blocking and communication) of main rail lines and technological facilities located on them”. In the absence of an appropriate funding framework, JSC UZ conducts the maintenance considering their own needs and constrained by the availability of funds. Therefore, considerable parts of the network operate below the “operational standards” of design. In fact, less than 20% of the existing network has a significant occupation.

It should be considered that the same network, with not significant changes, used to serve a much bigger business. In 1986 the tonnes shipped by rails accounted to 1 042 Mio tonnes. In 2020, 292 Mio tonnes. That is 28% of the previous figure (-5.1% compounded per year). Therefore, it is likely that just with direct market incomes it would not be enough to bear the cost of maintaining such a network.

The TA funded project AASISTS 2 is to organise several activities for sharing the EU MS experience with Ukrainian counterparts regarding the state funding of rails infrastructure.

Although the Law of Ukraine "On Rail Transport", states that the acquisition of rail rolling stock for passenger transport on long-distance and local trains may be carried out at the expense of the State Budget of Ukraine within the limits of state capital investments, in practice, the state has not provided funds for the renewal of the rolling stock.

In 2021, the Ministry proposed to allocate 0.5% of the “road fund” for the renewal of rolling stock. However, the initiative to use the “road fund” for investing in rails is not institutionalised and an approved methodology for accounting for externalities in transport and conduct cost-benefit analysis for investments is not applied.

4.6.1.4 EU integration and interoperability

Ukraine is increasing its economic ties with the EU. The current land infrastructure connecting Ukraine and the EU has proved insufficient in a situation where the ports were blocked for certain or all goods.

For an efficient development of the rail sector in Ukraine, it will be necessary to develop the TEN-T networks inside Ukraine and seek benefits of network effects.

From an operational perspective, Ukraine is nowadays exempted from the compulsory participation in the international rail corridors for competitive rail freight, as the rail network has a track gauge which is different from that of the main rail network within the Union. The enlargement of the 1435mm network inside Ukraine would change this situation. For each freight corridor, the infrastructure managers concerned and, where relevant, the capacity allocation bodies, shall establish a management board responsible for:

- Implementing the freight corridor plan
- Investment planning
- Coordination of works in the infrastructure
- Establish a one-stop-shop for the capacity allocation
- Coordination of the traffic management

The integration of the Ukrainian rails will also require a technological integration. In this respect, the Art. 56 of the Association Agreement states that “Ukraine shall take the necessary measures in order to gradually achieve conformity with EU technical regulations and EU standardisation, metrology, accreditation, conformity assessment procedures and the market surveillance system, and undertakes to follow the principles and practices laid down in relevant EU Decisions and Regulations. To this end, Ukraine shall, in line with the timetable in Annex III, incorporate the relevant EU acquis into its legislation”. The annex III foresees a period of five years for the implementation of the technical legislation “High-speed rails”.

According to the Railways Law (art 11), “Rolling stock, equipment and other technical means supplied to rail transport must meet the conditions of traffic safety, cargo safety, labour protection, environmental safety and have an appropriate certificate”. Certificates are issued to assess the conformity with a given standard by “conformity assessment bodies”.

The Conformity Assessment bodies work based on national standards, set in technical regulations approved by the Ministry, as well as standards agreed by the (Council of the Community of Independent States). Technical specifications for interoperability have not been transposed and the procurement of certain devices might face limited competition.

In fact, one of the obligations of JSC UZ set in the priorities the CMU relates to “reducing the level of Ukraine's external dependence on the import of rail products and consumables during investment activities”.

Although encouraging the local production is a logical objective, Ukraine passed a Law on Public procurement aiming to ensure an effective and transparent procurement by creating a competitive environment in the field of public procurement. The Law obliges the companies owned by the State (more than 50%) and the companies providing “services for the use of public rail transport infrastructure and operating its facilities for the provision of transport services”.

The Article 23 of said Law specifies that “technical specifications shall not contain references to a specific brand or manufacturer, or to a specific process that characterises a product or service of a particular business entity, or to trademarks, patents, types, or a specific place of origin or method of production. If such a reference is necessary, it must be justified and contain the expression or equivalent”.

4.6.2 Moldova

4.6.2.1 Current CFM status and organisation, financial situation

In 2023, CFM is still a vertically integrated rail company. The CFM State owned Enterprise (SOE) belongs entirely to the State of Moldova.

4.6.2.2 Territorial organisation

CFM is divided in 47 subdivisions: the head office: “Directia Cailor Ferate” (main subdivision) and 46 branches from different districts of the Republic of Moldova. The branches are subordinated to the head office, in fact to the CFM CEO. Currently, the organisation structure is about to be amended, CFM proposed a new organisational chart in 2016. The organisational chart has not yet been implemented, even if it has been approved by the CFM BoD, by the Ministry in charge of transport and by the Ministry of Finance.

The new organisation will comprise the creation of **three new companies**: for rail passenger services, for rail freight services, and for infrastructure management. A fourth company, the existing CFM, will take care of the non-core assets and the additional staff and shall only operate for a transitional period. The new companies shall be fully separated and not controlled by any holding company. A rail regulatory body will be established, and the rail sector will be opened to other operators. Track access charges and PSO will be developed and implemented.

4.6.2.3 Staff

As of September 2022, CFM had 6044 employees, reduced by 19.14% since 2018, mostly by the non-replacement of positions after retirement. In 2018, about 52% of employees were over 52 years old, and only 6.4% were under 30. The shortage of young, qualified people is faced especially due to the old technologies used on the rail sector. There is a shortage of drivers, too.

CFM headcount is allocated to its branches and eight principal locations across the country: Ocnita (7%), Balti (20%), Ungheni (2%), Chisinau (37%), Bender (5%), Rautel (1%), Basarabeasca (22%) and Giurgiulesti (2%), central administration (4%).

4.6.2.4 Current economic results

Turnover in 2021 was 731 Mio LEI (around 36.5 Mio EUR). Business operations are hampered by the weakness of the working capital, with a negative position of -261 Mio LEI in 2021. Therefore, CFM registered an operational deficit of 100 Mio LEI per semester in 2021.

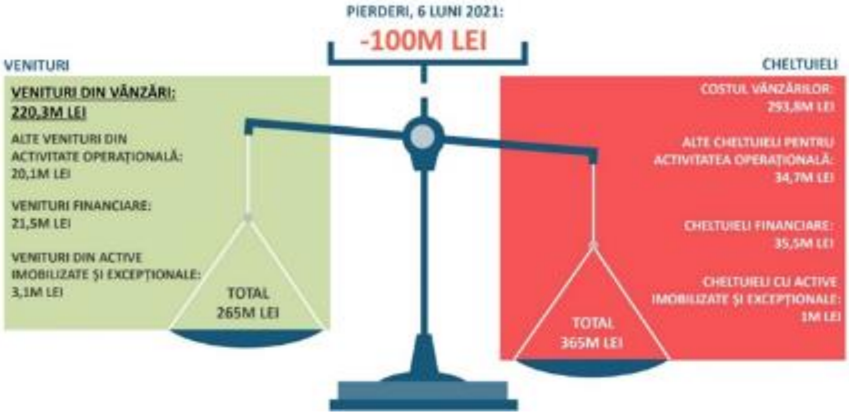


Figure 4.7: CFM semestral operating losses, 2021. Source: CFM, prepared for JASPERS by Egis

In addition, around 800 Mio LEI (around 40 Mio EUR) of pending debts were registered in 2021 (loans 487 Mio, salaries 114 Mio).

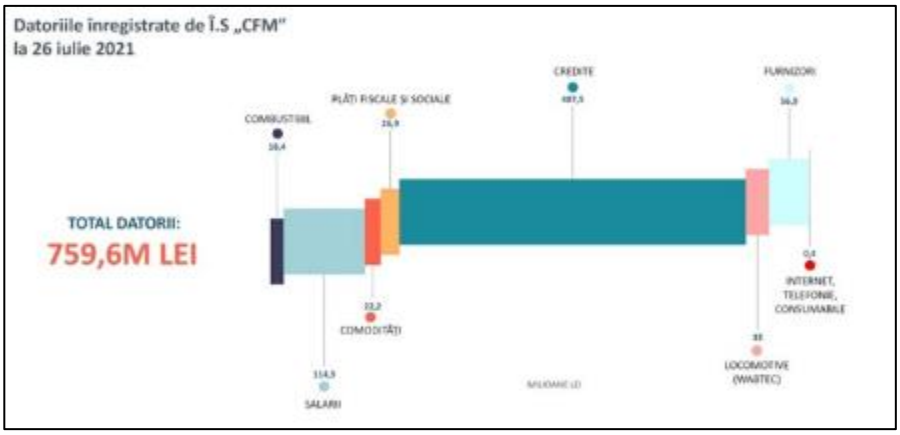


Figure 4.8: CFM debt structure. Source: CFM, prepared for JASPERS by Egis

While revenues tended to reduce over the last years, especially during the COVID-19 pandemic, it is observed that in the first half of 2022 freight revenues, especially transit traffic, have increased significantly compared even to 2019, mainly as a consequence of the war. This is illustrated in the table **below.**

	2019	2020	2021	2022 1st sem
Revenues by type of activity, thousands MDL	1.039.431,20	648.037,20	731.640,90	589.806,00
transport of goods	625.048,20	488.924,60	569.602,70	513.500,30
transport of passengers	157.082,30	24.090,30	10.115,60	6.471,70
auxiliary - secondary activity	185.426,70	86.035,90	44.971,30	31.373,60
other operational activity	26.178,40	11.124,20	27.607,80	7.349,00
from fixed asset operations	14.492,70	2.058,50	5.344,90	1.173,60
financial activity	31.202,90	32.754,50	73.998,60	29.937,80
from exceptional situations	0,00	3.049,20	0,00	0,00
Revenues from goods transport, thousands MDL	625.049,00	488.924,60	569.602,70	513.500,30
local	88.124,00	79.749,50	79.009,60	61.504,40
export	194.083,00	128.612,40	184.519,40	170.944,80
import	193.413,00	223.165,20	224.082,60	68.507,80
transit	149.429,00	57.397,50	81.991,10	212.543,30
Revenue from passenger transport, thousands MDL	157.082,33	24.090,40	10.115,60	6.471,70
suburban	1.532,63	1.317,90	1.437,10	1.114,20
local	2.534,40	1.126,40	923,20	2.687,80
direct, including transit	153.015,30	21.646,10	7.755,30	2.669,70

Table 4.9: Development of revenues 2019 – 2021, including 1st half of 2022. Source: prepared for JASPERS by Egis

4.6.2.5 Harmonisation with EU transport policies and rail reform perspectives

An **Association Agreement** with the European Union entered in force on 1st of July 2016 and Moldova will transpose part of the European Acquis in the transport sector. Harmonisation needs to be implemented within a certain time frame (generally four years).

To implement the EU legislation contained in the Association Agreement, the EU legislation will have to be implemented step by step by creating an independent infrastructure management and separated undertakings for freight and passenger services, as well as the establishment of an independent market regulatory body and rail safety body to ensure transparent, fair, and non-discriminatory treatment for future additional rail undertakings ready to offer services in Moldova.

The decree 1042 of 15 December 2017 approved the 2018-2021 **Rail sector restructuring concept**. The concept, based on the three phases - corporatisation, operationalisation and commercialisation - will help the CFM to implement the new organisational structure, in particular the separation of infrastructure management and operations functions.

The decree 385 of 8 February 2018 approved the action plan for implementing the 2018-2021 Rail sector restructuring concept. The process of rail reform in Moldova is supported since 2022 by the **Rail Code no 19/2022**. It includes the European requirements on a more advanced level, and partially transposes:

- Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European rail area (revision) (Text with EEA relevance), published in the Official Journal of the European Union L 343 of 14 December 2012, as last amended by Commission Delegated Decision (EU) 2017/2075 of 4 September 2017

- Directive 2016/798/EU of the European Parliament and the Council of 11 May 2016 on rail safety (revision) (Text with EEA relevance), published in the Official Journal of the European Union L 138 of 26 May 2016

- Directive 2007/59/EC of the European Parliament and of the Council of 23 October 2007 on the certification of train drivers operating locomotives and trains on the rail system in the

Community, published in the Official Journal of the European Union L 315 of 3 December 2007, as last amended by Commission Directive (EU) 2016/882 of 1 June 2016

In short, the new Rail Code covers the main elements of the market structure (separation of infrastructure management and operation, separation of accounts and market opening (however with the requirement to be nationally registered)) and will enter into force in August 2024. Some Rumanian Private operators may be interested. The preparation of the implementation of its requirements is currently ongoing.

Elements of the Safety Directive as well as for train driver licensing are included in the Rail Code, which will also enter into force August 2024. Major aspects of the new Rail Code are listed below:

- The Code stipulates that three new companies will be established: one for rail passenger services, one rail freight services, and one for infrastructure management. A fourth company, the existing CFM, will take care of the non-core assets and the additional staff. The latter company shall only operate for a transitional period. The companies shall be fully separated and not controlled by any holding company
- Management independence
- Establishment of rail bodies
- Opening up the rail sector
- Financing of the rail: for the financing a Multi Annual Investment Contract (MAIC) as well as PSO will be defined by the competent body – the competent ministry. Furthermore, track access charges will be developed and implemented

After the entry into force and the implementation of the new Rail Code, the overall institutional framework will be aligned to most of the EU requirements.

4.6.2.6 ***Integration with EU rail corridors***

The Moldovan rail network is currently part of the TEN-T “extended” network Rhine Danube corridor. It is connected to the TEN-T network via Romania by two junction points at Lasi and Galati and to Ukraine passing by Transnistria. It is composed by the central main line (TEN-T extended core network Ungheni - Chisinau) and several TEN-T extended comprehensive network branches.

According to the proposal for EU regulation amendment, Moldova will become part of the “extended” TEN-T core network of a new TEN-T corridor “Baltic Black Aegean Sea”.

Further to the East, the connection with Ukraine passing by Transnistria is currently closed. All train traffic from Chisinau/Tiraspol towards Odesa was halted in late February 2022 as a result of the collapsed cross border bridge at Cuciurgan. An existing section between Basarabeasca and Berezyne in Ukraine has been recently re-opened by-passing Transnistrian corridor.

Also, the rehabilitation of the line Chisinau-Ungheni is under discussion with the French Government for a total cost of around 90 Mio EUR.

Due to the restoration of the 22 km section on the territory of Ukraine and 1 km section on the territory of Moldova between the stations Berezyne and Basarabeasca, the rail communication, both through the existing railroad section from Bilgorod-Dnistrovsky to Izmail port and to Reni port can also be launched.

Following discussions between the EU and the Republic of Moldova, the network will be revised according to the situation mentioned above. However, the final version of the map has not been made public yet.

Recently (May 2022) the EU Commission set out an action plan to establish “Solidarity Lanes” to ensure Ukraine can export grain, but also import the goods it needs, from humanitarian aid to animal feed and fertilisers. The Solidarity lanes will use the Moldovan North, Southern and Central corridors.

The importance of the North and Southern corridors in capturing transit traffic is easily understandable as per the rail traffic intensity scheme below (2022). The higher is the traffic, the thicker is the line.

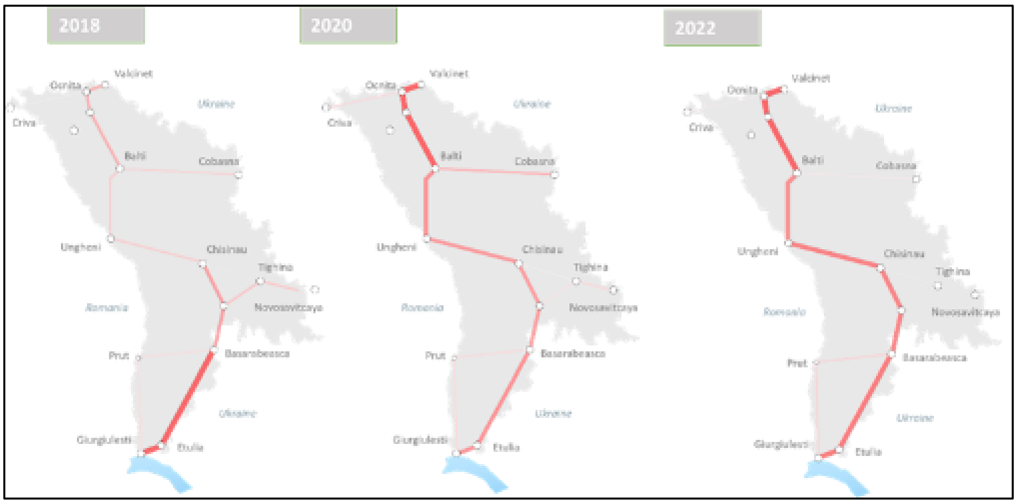


Figure 4.10: Rail intensity on the Moldovan network. Source: AFD

4.7 Demand

4.7.1 Ukraine

4.7.1.1 Passenger demand

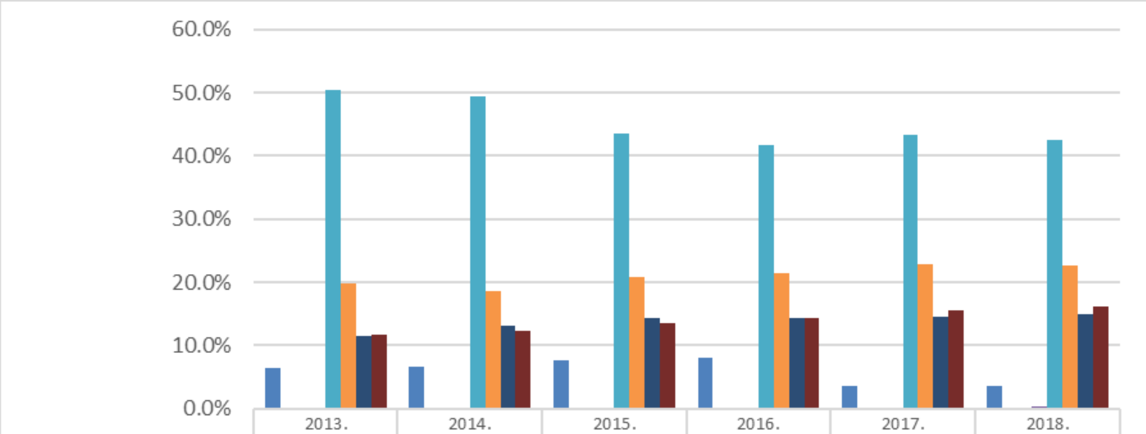
Main passenger demand features for Ukraine are provided below for the latest available representative period.

4.7.1.1.1 Mode split and volumes

According to JSC UZ, about 165 million passengers are transported by Ukrainian rails annually, including suburban travel. Based on JSC UZ ticket statistics, 46 million passengers are carried on intercity lines annually, with more than half using night train services.

Currently, coaches and buses are the predominant mode for passenger travel in the country. The share of rail over the 2013 – 2018 period ranged from 3.5% to 8%, with a clear downward trend and the lowest share recorded in 2017 – 2018[9]. Contrary to the suburban sector, Inter-city rail use underwent a slight increase after 2014. Evolution of passenger mode split for the latest available representative period (prior to the COVID-19 pandemic) is illustrated in the figure below.

[99] It is important to note that the registered decline in 2017 was partly due to a change in the process of recording passenger transport by suburban rail transport.



	2013.	2014.	2015.	2016.	2017.	2018.
Rail	6.4%	6.6%	7.5%	8.0%	3.5%	3.5%
Sea	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
River	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Air	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%
Road (busses)	50.5%	49.4%	43.5%	41.7%	43.4%	42.5%
Trolleybus	19.7%	18.6%	20.9%	21.4%	22.8%	22.6%
Tram	11.4%	13.0%	14.3%	14.3%	14.5%	14.8%
Underground (subway)	11.7%	12.3%	13.5%	14.4%	15.5%	16.2%

Figure 4.11: Passenger departures mode split (%) 2013-2018. Source: prepared for JASPERS by Egis

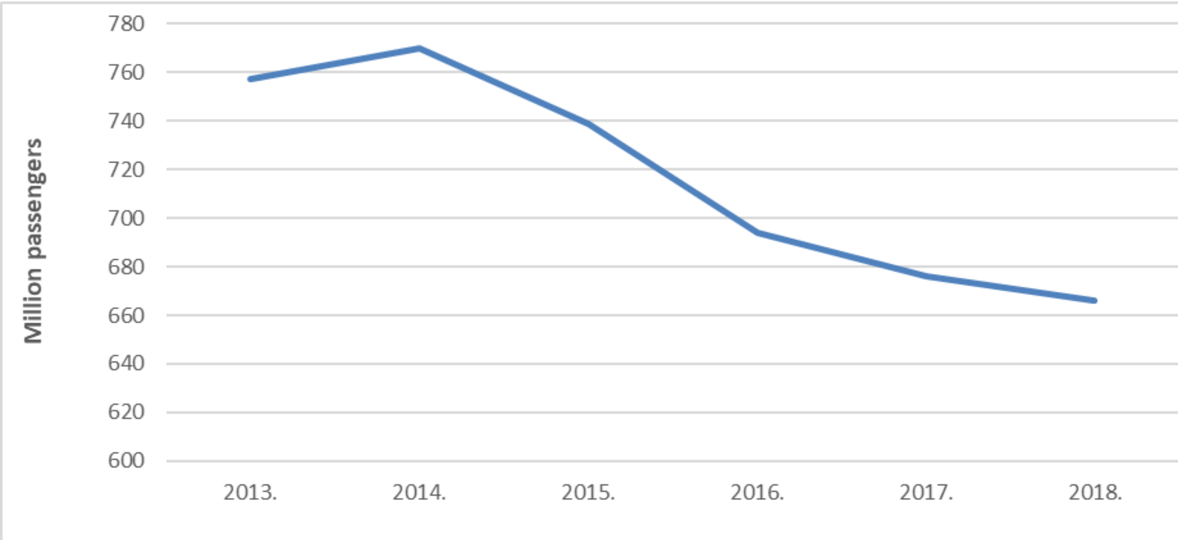


Figure 4.12: Departure of passengers by type of transport (million passengers). Source: prepared for JASPERS by Egis

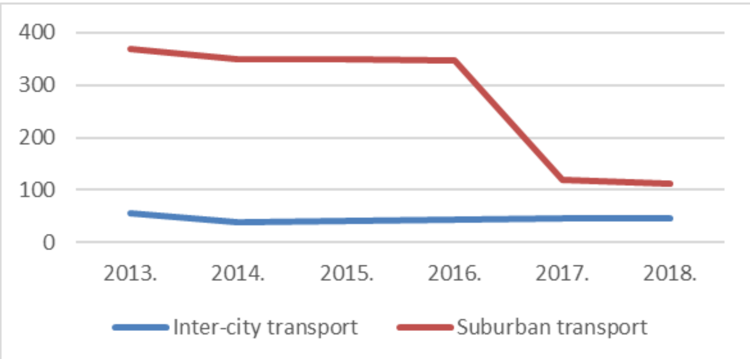


Figure 4.13: Evolution of suburban and long-distance annual rail demand (million passengers). Source: prepared for JASPERS by Egis

Below map shows the level of traffic per rail corridor. This map has been produced for the national transport model in the base year 2019.

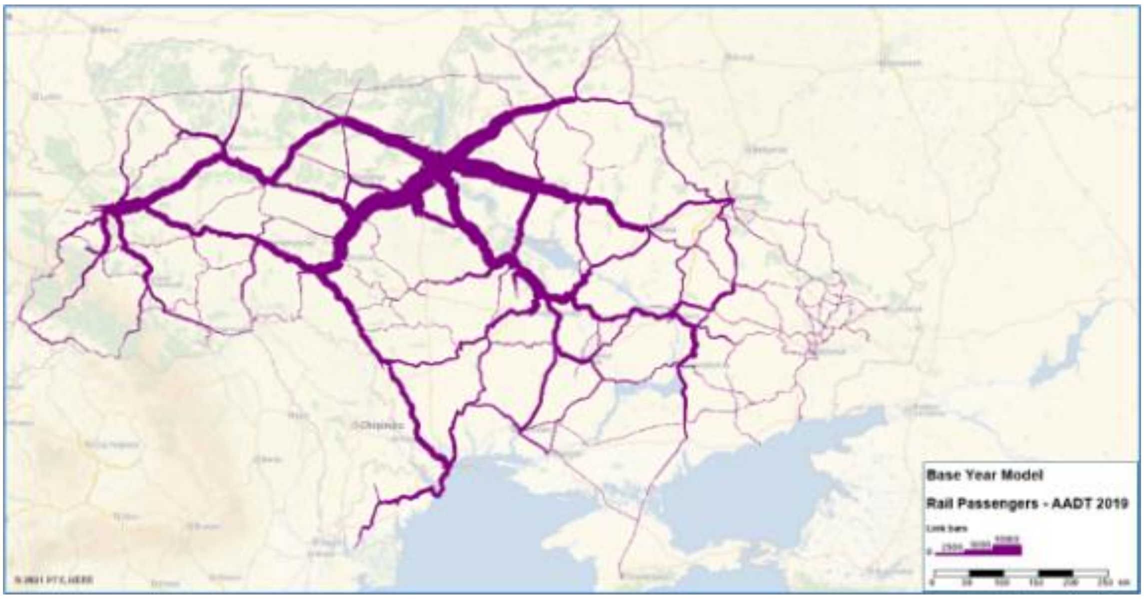


Figure 4.13: Number of daily rail passengers[10]. Source: National Transport Model. Prepared for JASPERS by Egis

To get a broader view of transport flows in Ukraine and potential demand, the map below shows similar information for road traffic (private cars and buses). It includes all types of traffic (including trucks) and is provided in vehicles.

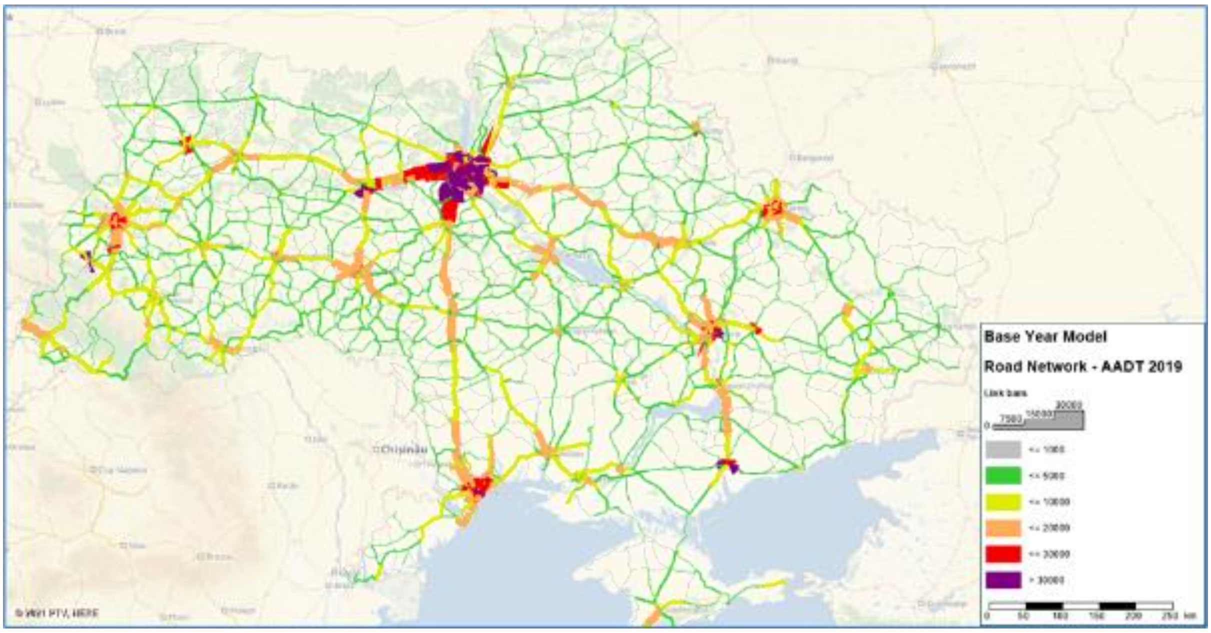


Figure 4.14: AADT (2019, all types of vehicles). Source: National Transport Model. Prepared for JASPERS by Egis

Regarding bus and coach traffic, it can be observed that this mode is highly used for short and medium distances but relatively less for long distance, demonstrating lower competitiveness than could be expected.

[10] Excluding free passengers

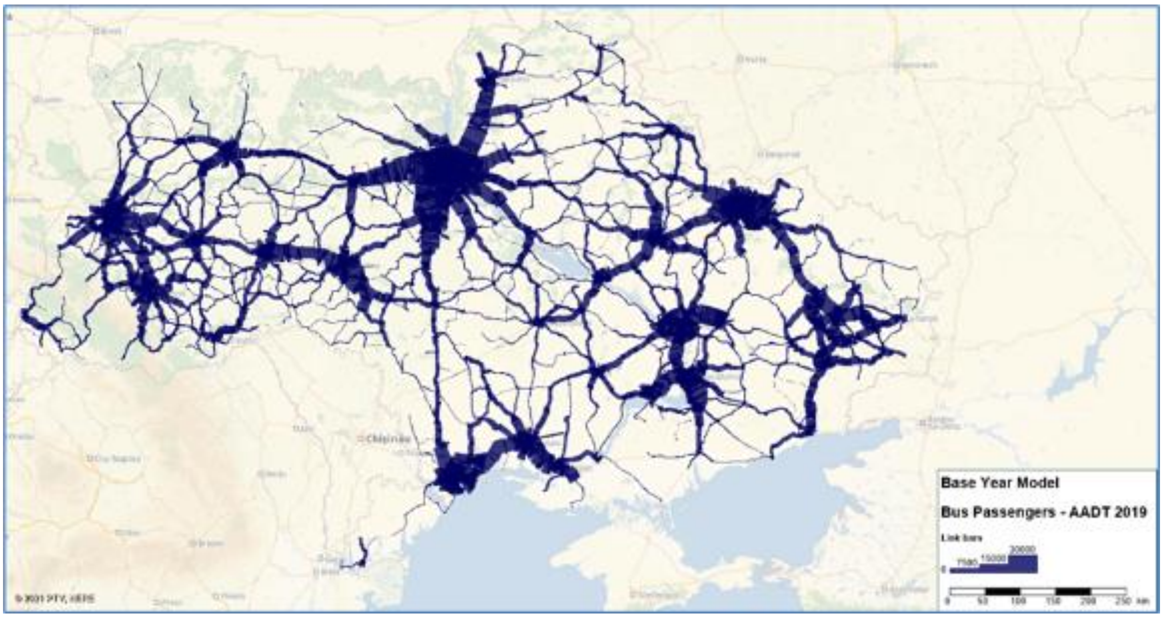


Figure 4.15: Number of daily passengers by bus. Source: National Transport Model. Prepared for JASPERS by Egis

The top five cities generating passenger rail travel in Ukraine are Kyiv, Kharkiv, Dnipropetrovsk, L'viv, and Odesa. Overall, accounting for 57% of the total demand. It should be noted that all these cities have recorded a downward trend of passenger traffic in the last years.

	Number of passengers (in million)	% of overall passenger traffic in Ukraine
Kyiv	41.6	26.3%
Kharkiv	24.2	15.3%
Dnipropetrovsk	13.5	8.5%
L'viv	11.6	7.3%
Odesa	9.5	6.0%

Table 4.10: Evolution of suburban and long-distance annual rail demand (2018, million passengers). Source: prepared for JASPERS by Egis

Total rail passenger kilometres were approximately 25 billion in 2018. Around 91% of passenger kilometres were internal trips (suburban and regional / long distance). Regarding seasonality, it could be seen that the maximum value corresponded with August, when passenger kilometres were 42% higher than in February (minimum recorded value).

4.7.1.1.2 Long distance traffic (national)

Long distance passenger traffic is catered for by different types of services, such as Intercity (IC), Intercity + (IC +), night services (express, passenger or fast), regional express, regional train.

As indicated in the figure below, the highest share of long-distance passenger kilometres by type of service corresponds with the night fast train (69%), followed by Intercity + (11%), night express (7%) and regional (5%). While night services typically cover the longest routes, this nevertheless indicates the attractiveness and convenience of these services within this segment of demand.

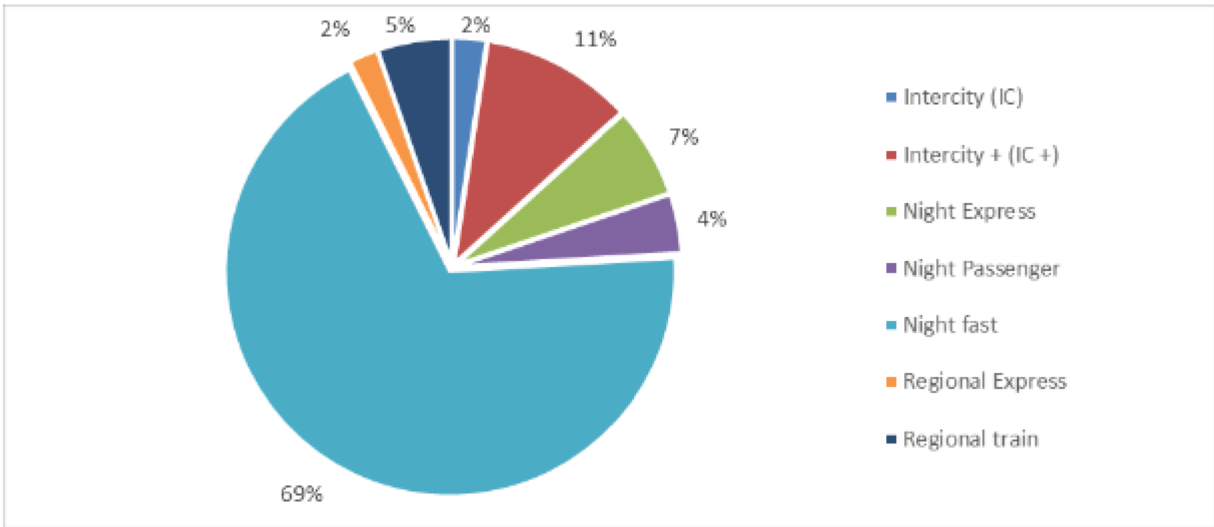


Figure 4.16: Demand breakdown by service type (2018). Prepared for JASPERS by Egis

Passenger traffic also follows a seasonal evolution. July and August are recorded for the maximum value in passenger kilometres, while the minimum value is registered in February. This is illustrated in the figure below.

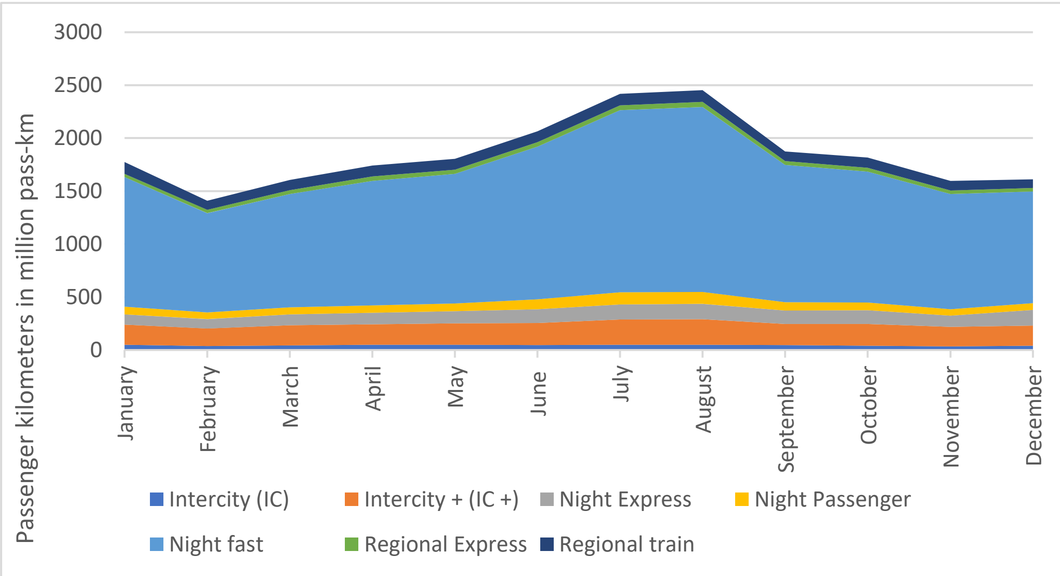


Figure 4.17: Million pass-km by months and by type of train (2018). Source: JSC UZ

It can be seen above that the maximum value corresponded with August, when passenger kilometres were 42% higher than in February.

4.7.1.1.3 International traffic

In 2019, international rail travel reached 2.6 million passengers, according to JSC UZ and 3.9 million passengers according to customs. According to JSC UZ, a very large part of this traffic was short-distance cross-border traffic (78%) mostly to/from Belarus/Russia, the remainder being long-distance international traffic.

Mode split for international travel was as follows, according to 2019 Custom statistics:

Mode	Number of passengers
Rail	3 905 275
Road	78 866 458
Sea	346 415
Air	18 702 615
Pedestrian	262 344
River	8 025
Grand Total	**102 091 132**

Table 4.11: Mode split for international traffic (2019). Source: prepared for JASPERS by Egis

Mode split between rail and road, broken down by neighbouring country, is provided in the table below. It can be observed that of the almost 36 million passengers between Ukraine and the EU, Poland catered for the highest number of passengers (59.3%), followed by Hungary (23.1%), Romania (10.9%) and Slovakia (6.7%). Rail mode split across EU borders ranges is very low, ranging from 1 to 4% depending on the country.

	Total		Rail			Road		
	N° PAX	% share	N° PAX	% share	% total	N° PAX	% share	%
Belarus	7 378 859,00	9%	1 317 072,00	18%	35%	6 061 787,00	82%	8%
Hungary	8 332 460,00	10%	308 606,00	4%	8%	8 023 854,00	96%	10%
Moldova	11 267 416,00	14%	642 741,00	6%	17%	10 624 675,00	94%	13%
Occupied territori	16 417 365,00	20%	-	0%	0%	16 417 365,00	100%	21%
Poland	21 323 437,00	26%	206 406,00	1%	6%	21 117 031,00	99%	27%
Romania	3 920 919,00	5%	20 843,00	1%	1%	3 900 076,00	99%	5%
Russia	11 554 304,00	14%	1 172 181,00	10%	31%	10 382 123,00	90%	13%
Slovakia	2 399 788,00	3%	63 508,00	3%	2%	2 336 280,00	97%	3%
Grand Total	**82 594 548,00**		**3 731 357,00**			**78 863 191,00**		

Table 4.12: Demand breakdown by neighbouring country (2019). Source: prepared for JASPERS by Egis

It can be observed that whilst there was major demand between Ukraine and neighbouring EU countries before the war, rail was transporting only 1% of total passenger traffic, which may be due to the impact from different gauge and a poor service offer. Also, the level of travel to/from Moldova was quite significant.

4.7.1.1.4 Tariff formation (passengers)

The Ministry of Infrastructure of Ukraine prescribes tariffs for the carriage of passengers, luggage, and bulky goods by rail. These are used for the calculation of travel expenses, baggage, and luggage transport by JSC UZ or other business entities engaged in internal traffic. Tariffs are determined based on distance, type of train and coach. There are four main types:

- 3, C → general wagon with seats for sitting
- P → economic-class wagon
- K → compartment wagon
- CB → sleeping (soft) wagon

The price is composed of a fixed part, regardless of the distance and a price per km. Such prices vary depending on the type of train and the type of coach used. The table below shows the rates applying in 2019.

Number tariff zone	Distance, km (from - to)	Passenger train, UAH				Fast train, UAH			
		3, C	P	K	CB	3, C	P	K	CB
1	**1**	9.18	16.28	33.66	83.17	10.00	17.40	35.57	87.74
2	**11**	9.60	17.14	35.48	86.66	10.60	18.23	37.64	91.75
6	**51**	11.55	20.17	41.28	101.00	12.63	21.65	44.09	107.52
11	**101**	13.84	24.15	48.88	119.06	15.21	26.04	52.35	127.13
21	**201**	18.04	31.18	62.06	161.49	19.95	33.88	66.72	173.61
23	**301**	22.45	38.58	76.00	197.33	24.79	41.84	82.24	212.93
25	**401**	26.55	45.81	89.80	232.96	29.38	49.89	97.25	252.00
27	**501**	30.84	53.02	103.62	268.77	34.30	57.81	112.27	290.98
34	**1001**	53.13	91.48	176.43	455.08	59.18	100.07	192.11	495.99
39	**1501**	74.70	127.77	245.49	634.41	83.22	140.02	267.56	691.74
42	**1901**	93.94	160.67	307.80	789.64	104.67	176.21	335.88	862.35
45	**2501**	119.60	204.30	391.08	1008.81	133.27	224.28	427.14	1101.89

Table 4.13: Applied passenger tariff rates (2019). Source: TARIFFS for the transportation of passengers, luggage, and cargo by rail in the domestic traffic, MINISTRY OF INFRASTRUCTURE OF UKRAINE

Prices increased significantly in 2019 and 2020. As an example, the price of a one-way ticket Kyiv-L'viv for 2 adults in a 1st class sleeping compartment was close to 50 EUR.

4.7.1.2 Freight demand

4.7.1.2.1 Total freight

This chapter describes the overall situation of the Ukrainian freight transport market prior to February 2022. The latest available representative period, prior to the COVID-19 pandemic (2014 to 2019), was used. Recent freight data has been used in the chapters below for evaluation of demand impacts from the war.

Between 2014 and 2019, the total volume of freight transportation dropped slowly, from 1.52 billion tonnes to 1.46 billion tonnes. Rail transport declined in that period, from 386 to around 313 million tonnes, while road transport increased from 1.13 billion tonnes to around 1.15 billion tonnes (see Figures below).

Road transport accounts for the largest share of the total freight transport market. In 2019, the share of the road in the total freight transport amounted to 78.24%. The share of rail transport in the modal split declined from around 25% in 2015 to around 21% in 2019 (inland waterway and air freight transport are not presented in the figures below as they are irrelevant to the modal split).

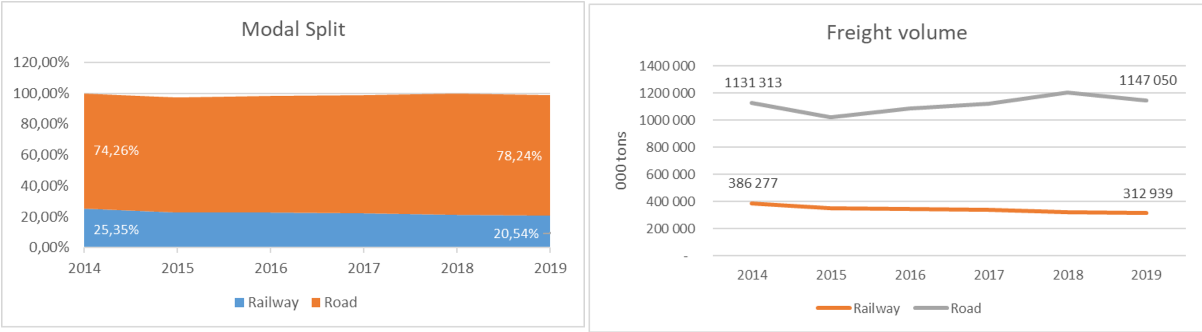


Figure 4.18: Freight mode split and volumes (land modes). Source: Concept Paper on Multimodal Transport, AASIST II Project

The main cause of the above reduction in rail transport was the decline in bulk commodities such as iron ore and coal, where the rail plays a major role. In addition, Ukrainian road transport has become much more competitive over rail in terms of shipping cost over relatively short distances (circa 1000 km) and shipping time.

The top six commodities by weight accounted for around 82% of total rail tonnage in 2019 (see below Figure). Tonnage-wise, a major commodity transported by rail was iron and manganese ore with a total volume of 68.3 million tonnes, followed by coal (40 million tonnes), and wheat (39.8 million tonnes). Between 2014 and 2019 the tonnage of these five commodities dropped slowly, while wheat transportation by rail increased significantly.

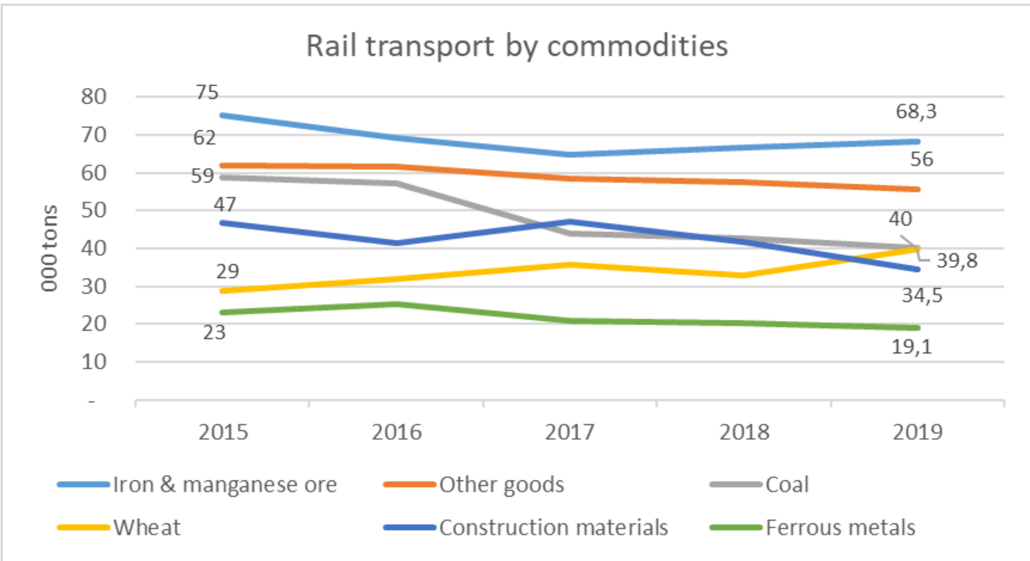


Figure 4.19: Rail transport volumes by main commodities. Source: Concept Paper on Multimodal Transport, AASIST II Project

As seen above, the Ukrainian freight rail transport market is dominated by bulk movements. Despite of advantages of rail to shipping heavy bulk, the road undertakes a significant share in the movement of bulk agriculture commodities in Ukraine, especially in peak seasons, during which the rail is reaching its capacity limits. On relatively short distances, road transport in Ukraine has very often advantages over rail in terms of shipping cost and time. The containerisation rate in Ukraine is below 5%. In 2019, Ukrainian ports handled only 1.07 million TEU (18% more than in 2018). Still, the total weight shipped by containers amounted only to 12.7 million tonnes.

The vast majority of exports are shipped by rail to the Ukrainian ports. Before the war, wheat was one of the major export commodities shipped by rail. The yearly production of wheat amounted to about 100 million tonnes, 60 million of which were exported mainly through ports. Wheat production is concentrated in the Central and South-Eastern parts of the country such as Vinnytsia, Khmelnytskyi, Poltava, Dnipro, Mykolaiv. Therefore, rail connectivity between those areas and the ports is essential for exports.

In 2019, the main export countries of wheat were Egypt, Indonesia, Bangladesh, and Turkey. There were circa 800 wheat elevators in Ukraine, with a total capacity of 90 million tonnes. Wheat is usually stored for two months in the elevator until it is sold to traders. As a result, September-October accrues as the peak season for wheat shipments from the elevators to Ukrainian ports, which creates congestion on the rail network, especially at the port access areas.

Major export ports of wheat are Pivdennyi (formerly, Yuzhny), Chornomorsk, Odesa and Mykolaiv. The total throughput capacity of wheat terminals at the Ukrainian ports used to be 90 million tonnes before the war. Circa 60% of the wheat used to be shipped by rail. The share of road transport in wheat shipments was 35%. Inland water transport amounted to only 5%. The main cause for that high share of the road in the wheat shipments is related to the unreliability of rail transport. As mentioned above, the vast majority of wheat is shipped from elevators to the port in the peak season. Because of the limited capacity of the Ukrainian rail network, especially at ports, pot rail access, Odesa in particular, is often congested. In addition, JSC UZ lacks rolling stock and locomotives during peak season, which results in increased waiting times for shippers at rail consolidation stations and ports. For the shippers, the predictability of supply chains is very important. So, they prefer road transport to rail, which cannot guarantee delivery time.

Another important export commodity in the ports is iron ore, which is produced mainly in the Zaporozhe and Poltava regions from which the vast majority of ores are shipped to ports, transhipped to vessels and shipped to main destinations. The main ports handling the iron ore in Ukraine are Pivdennyi, the river ports Mykolaiv and Izmail, and Chornomorsk. In 2019 main export countries of ores were China, Poland, Austria, and Slovakia.

4.7.1.3 *Overview of the cross-border rail traffic*

Of the 313 million tonnes of annual rail freight in 2019, more than half, 178 million tonnes, was international. 101 million tonnes were transhipped through ports and 77 million tonnes through the land borders of Ukraine. Almost two-thirds of those imports/exports by rail passed through Belarus and Russia.

In 2019, most rail imports (94%) were shipped from Russia and Belarus (see table below). The main commodity imported from Russia was refined oil, coal briquets and iron ore. Almost the same commodities were imported from Belarus. In 2022 these imports have been reduced dramatically.

Border Country	Import	Export	Transit Entry	Transit Exit
Russia	19.0	7.3	6.6	0.2
Belarus	12.1	5.9	0.6	0.2
Poland	0.9	9.6	0.0	2.0
Slovakia	0.6	8.7	0.0	2.3

Hungary	0.02	2.7	0.1	1.4
Romania	0.08	0.6	0.0	0.4
Moldova	0.5	1.3	0.2	1.0
Total	**33.1**	**36.1**	**7.5**	**7.5**

Table 4.14: Rail imports, exports and transit (in million tonnes) by country, 2019. Source: prepared for JASPERS by Egis, data collected from various sources

For exports, traffic in 2019 was much more diversified, with only 36% of it passing through the Belarus and Russian borders and two-thirds of exports shipped through the Western borders to EU countries. The largest traffic was observed with Poland, amounting to 10.4 million tonnes in 2019, followed by Slovakia with 9.2 million tonnes, Hungary with 2.74 million tonnes, Moldova with 1.75 million tonnes and Romania with 607.5 thousand tonnes (see above table).

The main cross-border rail traffic was observed at the Ukrainian – Polish border Volodymyr – Volynsky (8.1 million tonnes) followed by the Ukrainian – Slovak border Chop - Cierna and Tisou (5.9 million tonnes) and Ukrainian – Hungarian border Chop/Batovo – Zahony (2.7 million tonnes). Two of the BCPs mentioned in the table below are connected to a 1520mm gauge rail track on the EU side. The 1520mm rail line extends from Volodymyr – Volynsky BCP to Slawków Poludniowy (near Katowice) in Poland and from Pallo – Mat'ovce BCP to Kosice in Slovakia.

Country/Border	Import	Export	Total
Poland	**863 505**	**9 607 552**	**10 471 057**
Volodymyr - Volynsky - Khrubyshev	606 722	7 503 745	8 110 467
Mostyska II - Przemysl	199 492	1 527 595	1 727 087
Yahodyn - Dorohusk	57 291	576 212	633 503
Slovakia	**586 648**	**8 704 183**	**9 290 832**
Pallo – Mat'ovce	114 463	3 190 472	3 304 935
Chop - Cierna nad Tisou	472 185	5 513 711	5 985 897
Hungary	**24 852**	**2 715 709**	**2 740 560**
Chop/Batovo - Záhony	24 852	2 715 709	2 740 560
Romania	**8 459**	**599 044**	**607 503**
Diakove - Khalmeu	4 806	63 349	68 155
Teresva - Kimpulun la Tisa	3 653	535 695	539 348

Moldova	**495 801**	**1 259 557**	**1 755 358**
Mohyliv – Podilsky - Volchynets	217 871	194 545	412 416
Slobodka - Kolbasna	199 229	127 093	326 322
Mamalyha - Kryva	29 985	11 713	41 698
Karabucena	23 818	-	23 818
Kuchurgan - Novosavitsk	9 535	232 776	242 311
Frykatsei - Etulia	8 787	634 833	643 620
Sokiryany - Oknytsia	6 576	58 597	65 173
Grand Total	**1 979 265**	**22 886 045**	**24 865 310**

Table 4.15: Rail traffic by main BCPs (in tonnes), 2019. Source: prepared for JASPERS by Egis, data collected from various sources

It should be highlighted that import-export traffic was unbalanced, due to the lack of backload from EU countries. For example, exports to Poland amounted to 9.6 million tonnes, while imports comprised only 863 thousand tonnes. With Slovakia, the exports reached 8.7 million tonnes and imports amounted only to 586 thousand tonnes (see table above**Error! Reference source not found.**).

	From West (Import)			Towards West (Export)		
Border country	**Nr. of Wagons**	**Volume (Ton)**	**Avg. tonnes per Wagon**	**Nr. of Wagons**	**Volume (Ton)**	**Avg. tonnes per Wagon**
Poland	151 786	863 505	5.7	143 925	9 607 552	66.8
Slovakia	149 234	586 648	3.9	130 514	8 704 183	66.7
Hungary	47 707	24 852	0.5	41 662	2 715 709	65.2
Romania	12 236	8 459	0.7	11 786	599 044	50.8
Moldova	26 377	495 801	18.8	20 800	1 259 557	60.6
Grand Total	**387 340**	**1 979 265**	5.1	**348 687**	**22 886 045**	**65.6**

Table 4.16: Rail traffic by western neighbouring countries (in tonnes and number of wagons), 2019. Source: prepared for JASPERS by Egis, data collected from various sources

4.7.1.4 *Container supply chains*

Between 2015 and 2020, container transportation in Ukraine increased rapidly. This significant growth resulted from the intensification of feeder services with major trade partners as well as increased containerisation of wheat. In 2019, the total volume of loaded containers in Ukrainian ports reached 1.07 million TEUs. During the COVID-19 pandemic, in 2020, container volume declined slightly, to 1.05 million TEUs.

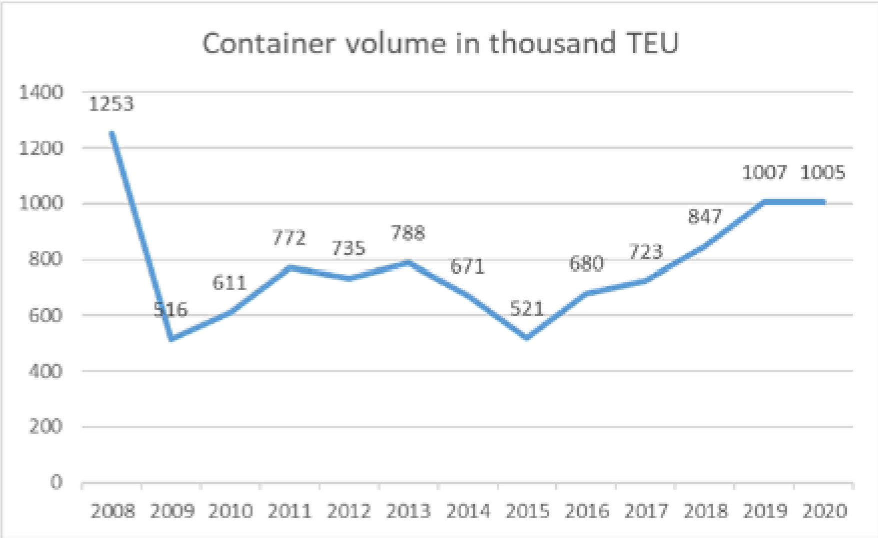


Figure 4.19: Container handling volume in Ukrainian ports. Source: UPSA

In 2020 export container traffic via the Ukrainian sea ports reached around 495 thousand TEUs and import 509 thousand TEUs. Transit container traffic reached only 44 thousand TEUs. Before the war, the majority of container shipping services used to be focused in three main container Ukrainian ports: Odesa, Chornomorsk and Pivdenniy and were mostly based on feeder services from the major shipping lines. These services are largely carried out using 4 000 to 5 000 TEU vessels on the Black Sea route from Malta, Piraeus or one of the Turkish ports in the Sea of Marmara. Odesa is the largest seaport in Ukraine, with around 652 thousand TEUs in 2019. It is followed by Pivdenniy and Port of Chornomorsk, with around 243 and 153 thousand TEUs, respectively.

Since 2017, rail container transportation increased significantly. In 2017, container shipping lines established alliances with port container terminal operators and started regular block container train services from the ports to the main container markets (see Figure **4.20:** Main routes of the domestic block container train services. Source: prepared for JASPERS by Egis

below). This attracted a significant amount of containers from road to rail. So, from 2017 to 2020 rail container transportation in Ukraine increased by around 44% from around 295 thousand TEU to 425 thousand TEU. The main drivers of this rapid growth were (i) the growing demand of international shipping lines (Maersk, MSC) to integrate door-to-door delivery of containers into their service package, (ii) the growing containerisation of bulk export such as wheat, (iii) the introduction of container train services with the adequate speed and schedule by JSC UZ. There is room for the future increase of the rail share in container transportation. However, this will depend on the competitiveness of rail services especially in terms of reliability and shipment time.

Figure 4.20: Main routes of the domestic block container train services. Source: prepared for JASPERS by Egis

Error! Reference source not found.illustrates the dynamics of rail container transportation in Ukraine. Rail container traffic is dominated by import and export, the vast majority of which are the rail container movements between the ports and hinterland. The import has also grown because of the increase of the container trains from China. Domestic rail container transport has also undergone dynamic growth. These services are mainly organised between the main container markets like Kyiv, Dnipro and Kharkiv. Rail container transit was relatively low and included mainly the transit from Belarus and Baltic ports to Turkey.

In terms of connectivity between ports and hinterland Chornomorsk-Kyiv, Odesa-Dnipro and Chornomorsk-Kharkiv were the most intensive domestic routes for rail container transportation. According to JSC UZ, before the war 30% of total rail container volumes were shipped between Chornomorsk and Kyiv. The next most intensive route was Odesa-Dnipro (26%) followed by Chornomorsk-Kharkiv (22%).

Figure 4.21: Rail container transportation volume and main domestic routes. Source: AASIST II

Regarding main container hubs, Kyiv/Zhitomir is a main destination for containers (23%) followed by Dnipro/Zaporizhzhia (16%) and Kharkiv (9%). Almost half of all containers in Ukraine are handled in these three regions. The figure below indicates the main container hubs in Ukraine. The vast majority of containers is transhipped through Ukrainian ports. Container import and exports excluding sea, are relatively irrelevant.

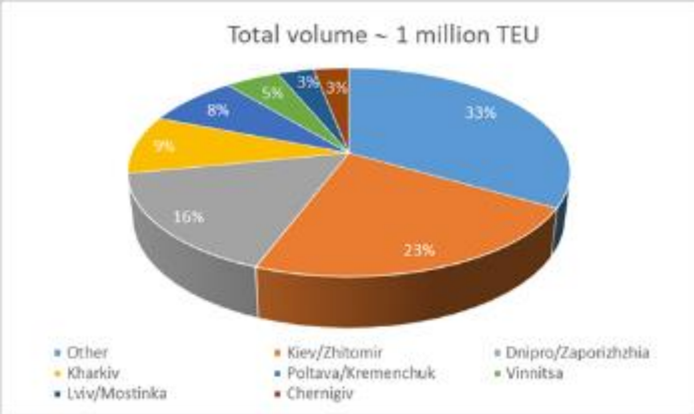


Figure 4.22: Share of regions in the Ukrainian container market. Source: AASIST II

Before the war, there were six inland rail container terminals operated by Liski (subsidiary of JSC UZ responsible for rail container transportation) and nine terminals operated by private entities: TIS, United Global Logistics, Imtrex and Ukrrichport. The following map shows the locations of inland container hubs in Ukraine.

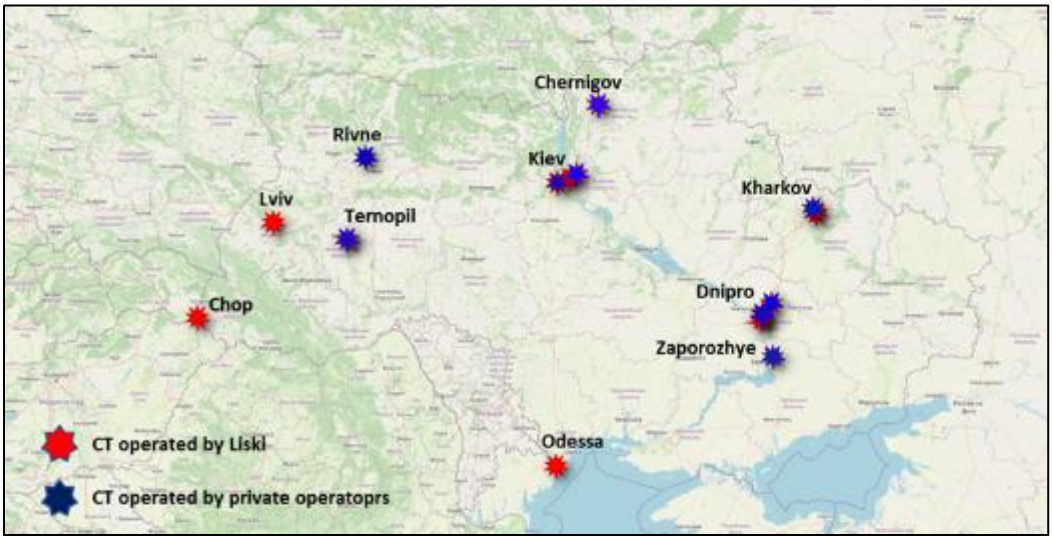


Figure 4.23: Locations of inland container terminals in Ukraine. Source: prepared for JASPERS by Egis

4.7.1.5 *Impact of the war on freight flows*

The Russian-Ukrainian war caused disruption of supply chains and diversion of freight flows from the sea to rail and road transport. The majority of Ukrainian ports have suspended operation for a certain time, which impacted the trade flows and as well as supply chains. In 2022, more than half of the entire freight movement took place domestically. The exports constituted up to 40% of the total freight movements. The share of imported freight decreased to 8% and transit reduced to 2%. Overall, rail tonnage dropped from around 314 million tonnes in 2021 to 150.6 million tonnes in 2022. The most significant decline in freight volumes was observed in the transportation of iron ore, coal, and construction material industries.

This dramatic decline in rail freight volumes resulted from the military aggression, temporary population relocation and economic crisis. This also translated into reduction of the average train speed and train weight limitations on certain rail sections. Overall, in 2022 JSC UZ gave priority to passenger transport (e.g., evacuation and medical trains, etc.), but also delivering humanitarian cargo.

The following tables illustrate the changes in the import and export structure of Ukraine during the war. The war impacted the import-export trade structure, with rail traffic redirected from/to Belarus and

Ukraine to Western Europe. Imports from Russia and Belarus dropped, from 18% in 2019 to 5% in 2022, while those from Europe increased from 45% in 2019 to 54% in 2022. For exports the pattern is similar, with exports to Russia and Belarus decreasing from 10% in 2019 to 2% in 2022 and exports to the EU increasing from 44% in 2019 to 67% in 2022.

Year	RUS,BEL	Europe	Asia	Africa	Amer.
2013	35%	37%	21%	1%	6%
2014	31%	42%	21%	1%	6%
2015	27%	45%	20%	2%	6%
2016	20%	48%	24%	1%	7%
2017	21%	46%	23%	1%	7%
2018	21%	45%	26%	1%	7%
2019	18%	45%	28%	1%	7%
2020	14%	47%	30%	2%	8%
2021	15%	45%	31%	2%	7%
2022	5%	54%	34%	1%	6%

Year	RUS,BEL	Europe	Asia	Africa	Amer.
2013	27%	29%	33%	8%	3%
2014	21%	34%	33%	9%	3%
2015	15%	36%	36%	10%	2%
2016	12%	40%	35%	11%	2%
2017	12%	43%	33%	9%	3%
2018	11%	46%	32%	9%	3%
2019	10%	44%	33%	10%	3%
2020	8%	40%	40%	8%	3%
2021	7%	43%	37%	8%	5%
2022	2%	67%	24%	5%	3%

Table 4.17: Import (left) and export (right) structure (USD). Source: UN Comtrade 2023

In terms of commodities, the most rapid decline was observed in the export of iron and manganese ores, followed by ferrous metals to East Asia and the EU. At the same time, the most significant growth was marked in the import of food and beverages, as well as raw materials from the EU.

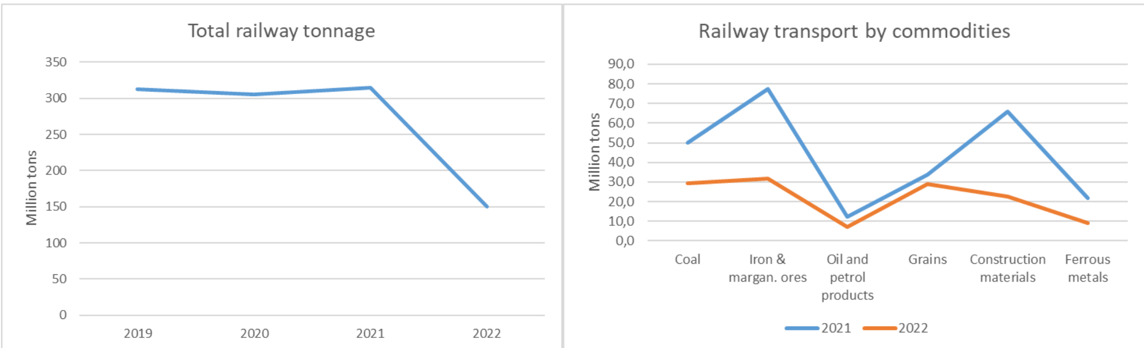


Figure 4.24: Impact of the war on rail tonnage. Source: prepared for JASPERS by Egis

By the beginning of the war, most of Ukrainian ports suspended their operation. Later in 2022, the Grain Deal was signed and grain export through Ukrainian Black Sea ports resumed. However, according to Ukrainian Sea Ports Authority (USPA) the ports are operating at 30-35% of their capacity. The average number of vessels waiting in the queue amounts recently to 90. Despite the operation resumption in the ports, a significant amount of Ukrainian exports has been diverted to the Romanian Black Sea port Constanta. According to the Constanta port administration, in 2022 8.6 million tonnes of Ukrainian grain were shipped through Constanta, by train, truck and barges on the Danube River. In the first quarter of 2023, the grain export through Constanta amounted to 3.3 million tonnes. Accordingly, the freight handling in Constanta has increased from 67.4 million tonnes in 2021 to 75.5 million tonnes in 2022.

In parallel, to support Ukraine in the export of agricultural products on 12 May 2022, EU Member States established the EU-Ukraine Solidarity Lanes, which form the transport corridors for Ukraine's exports and imports. As a part of the Solidarity Lines initiative in July 2022, Romania restored the rail connection of the Galati River port on the Danube to Ukraine, to speed up the export of Ukrainian grain. At the end of August 2022, JSC UZ restored several rail routes to the border with Romania. At the same time, under a pilot project, the rail connection between Ukraine and Moldova was restored between the stations Berezyne and Basarabeasca. These infrastructure projects will increase throughput capacity of the Solidarity Lanes. However, because of the high seasonality of Ukrainian agricultural products as well as the low speed of rail on the Ukrainian territory and limited capacity of border-crossings, they are likely to reach their limits soon.

Following diversion of traffic to the Solidarity Lanes, rail cross-border traffic with the EU grew dramatically. Data on cross-border traffic between Ukraine and Poland shows that the BCPs in L'viv, Volyn and Chernivtsi regions are heavily congested, as the number of wagons running from Ukraine towards Poland and Romania increased dramatically. The greatest increase, of 127%, was observed at the Yagodyn – Dorohusk BCP, followed by Mostyska – Przemysl 97% (see the figure below). Cross-border rail shipments with Poland are concentrated on bulk exports such as iron ores, slag, and ash, while import is focused on general goods which are moved with conventional wagons but can be containerised in the future.

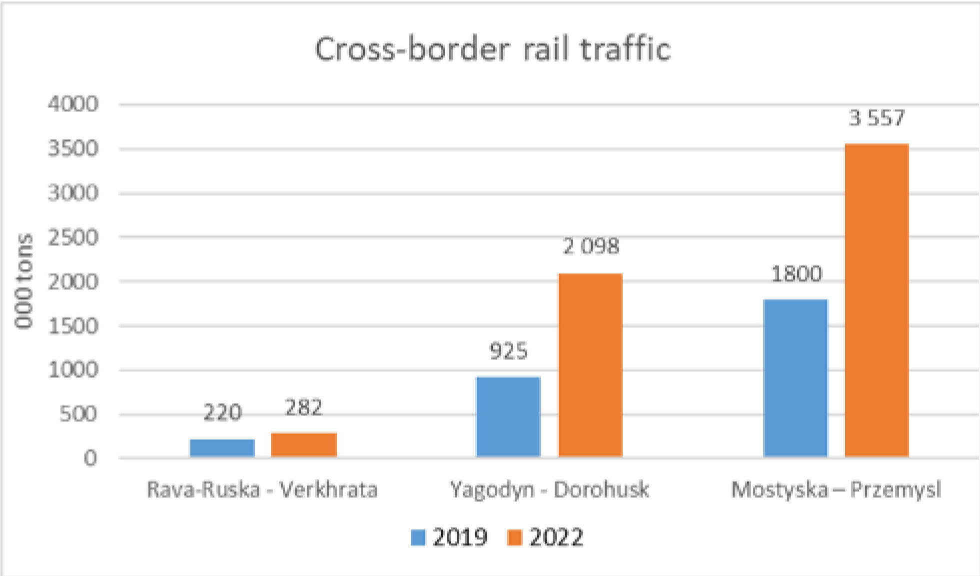


Figure 4.25: Rail traffic through Ukraine-Polish BCPs (in thousand tonnes). Source: JSC UZ

The intensification of cross-border rail traffic caused congestion at the rail border-crossing points. The rail BCPs are reaching their capacity, since the gauge change and border-crossing procedures at the borders take long, resulting in limited throughput capacities and increased border-crossing time of trains. To speed up border-crossing, increase in BCP capacities and streamlining of procedures is needed.

Although it is expected that this situation will change once the war is over and the Ukrainian ports become fully operational, part of this increased traffic with the EU might remain, due to the expected change in the trade relations of Ukraine. At the same time, it can be assumed that EU-Ukrainian freight transport will be affected in short to long-term perspectives due to the changing patterns regarding commodities. For example, bulk shipments from Ukraine towards the EU may reduce, while the transportation of containerised goods may increase. The main factors for anticipated increase in containerised freight between the EU and Ukraine are the following:

i. Ukraine has great potential for increasing containerisation of goods. For example, in 2021 the containerisation rate on rails in the EU was 21%, while Ukraine had around 2% in 2019. A number of commodities shipped by conventional wagons in Ukraine can be shipped by containers. This type of operation will reduce not only the handling cost of freight but will also increase the speed and reliability of the services
ii. In the course of EU integration, Ukraine may possibly turn from a raw materials supplier to a final goods producer. It may be assumed that after the war Ukraine will develop an industry linked to the production of high-value goods and modern technologies (such as renewable energy, battery production, etc.) along the main transport corridors, especially in West Ukraine, which would then require quality logistics services and reliable supply chains. In this regard, container transportation has no alternative, which means that trade in high-value goods would boost containerisation in the country and thus, intermodal connectivity with the EU and other relevant trade partners would be essential

iii. There are many aspects that currently hamper the competitiveness of intermodal transportation in Ukraine. It is envisaged that the planned rail reform and harmonisation of the legal framework in transport to the EU legislation will significantly promote and facilitate intermodal transport in Ukraine and create a solid basis to make it competitive over the road in terms of cost, transportation time and reliability of services

4.7.2 Moldova

Rail transport in Moldova underwent constant decrease in volumes over the last two decades. The rail freight market share decreased to 20.8% in 2018 and the passenger share to 1.59% in 2018.[11] In 2019 – 2021 the decrease continued, also due to the COVID-19 pandemic, to 9% for freight transport. In 2018, CFM carried 4.93 million tonnes of freight, but only 3.31 tonnes in 2021. The major competitor in the freight and passenger sector is road transport.

The domestic passenger transport services were cut by half compared to the pre-pandemic period, mostly due to the end of life of several trainsets. Although international services are operated with modernised coaches, with satisfactory results, the domestic passenger services stopped in the south of the country due to rolling stock decommissioning.

In the first half of 2022, the transport of goods carried amounted to almost 2 million tonnes. The reason for this increase was the blockage of the shipping routes from Odesa due to the Russia – Ukraine war. During the second semester, as the Sea traffic re-started, the performances were roughly aligned with those of 2021.

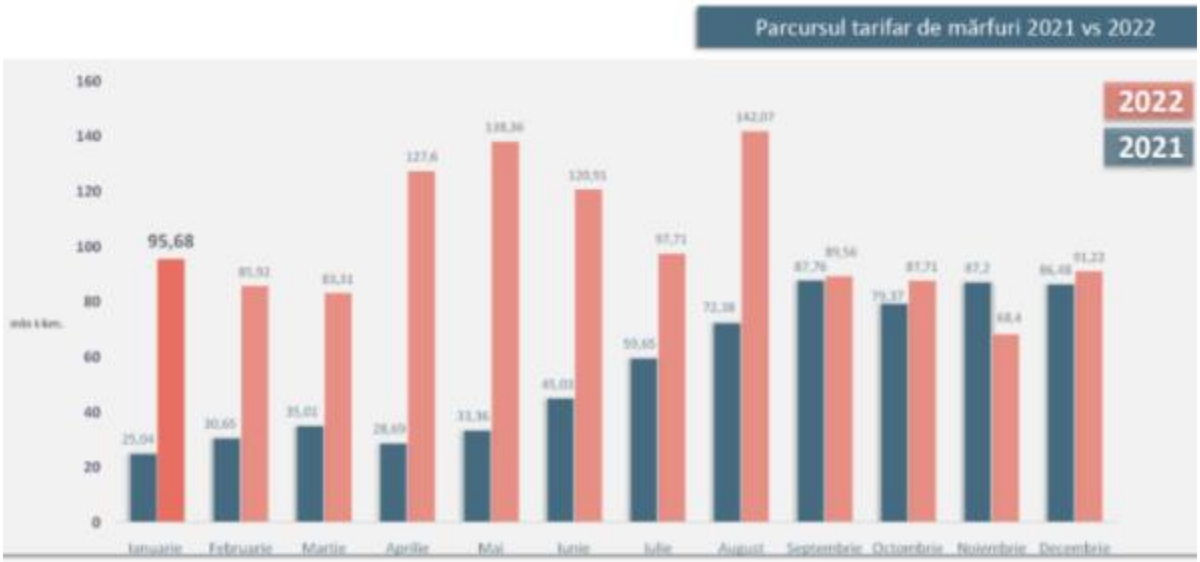


Figure 4.26: Comparison of CFM Rail freight performances 2021/2022. Source: CFM

Transit represents close to 90% of freight traffic within Moldova. The dominant transit flow before the war consisted of iron ore from Ukraine to Romania, with 72% of the total transit tonnage. Exports were dominated by grain (42%), metal products (22%) and other construction materials (19%). Imports are mostly providing scrap iron (23%), fertilisers (18%) and petroleum (16%).

In 2022-2023, transit became by far dominant across the network. Below graphics show the corresponding freight flows.

[11] World Bank, „Tracks from the Past, Connectivity for the Future: Revitalising Moldova's Rail Sector", 2020

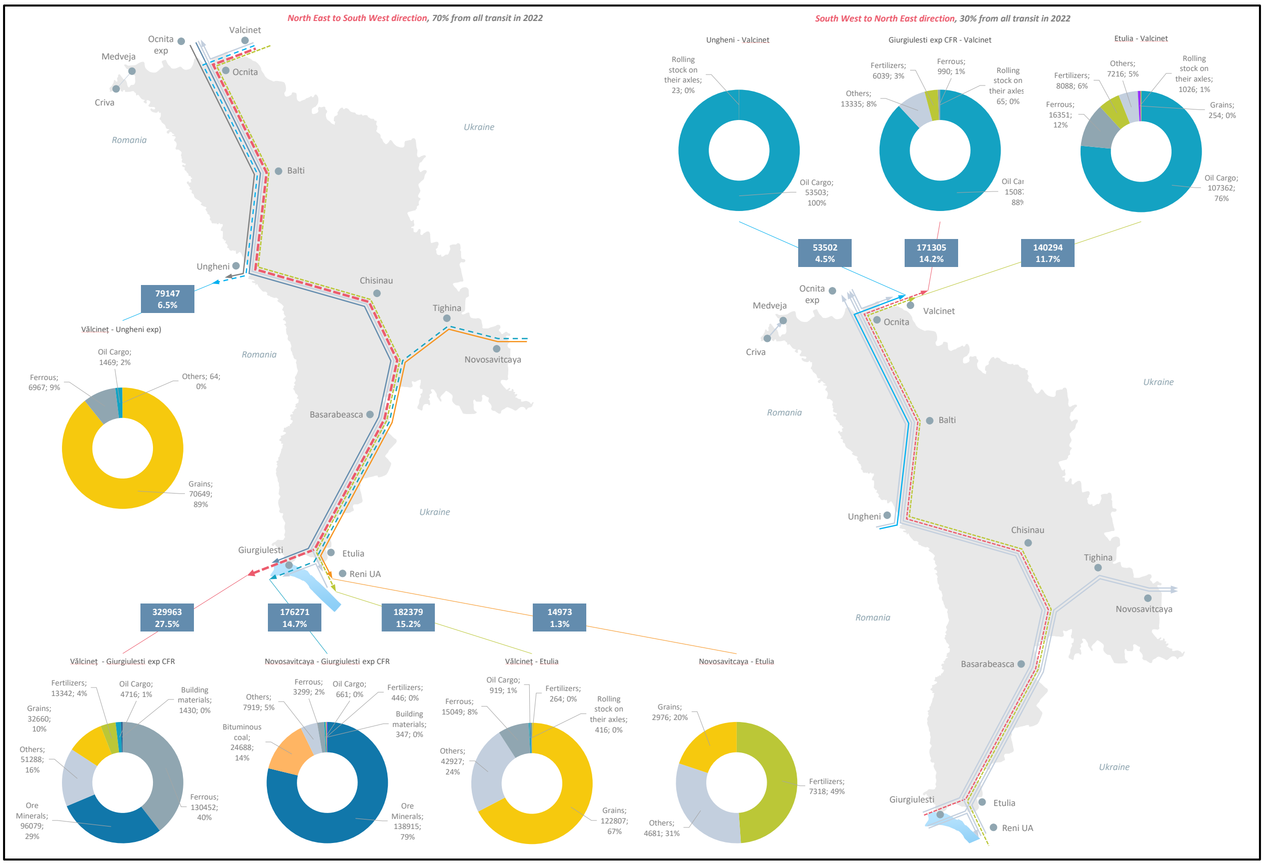


Figure 4.27: Comparison of CFM Rail freight performances 2021/2022. Source: CFM

The importance of the North-South corridor is remarkable, with mainly cereals from Ukraine transported from North to South, and petroleum products from South to North heading to Ukraine.

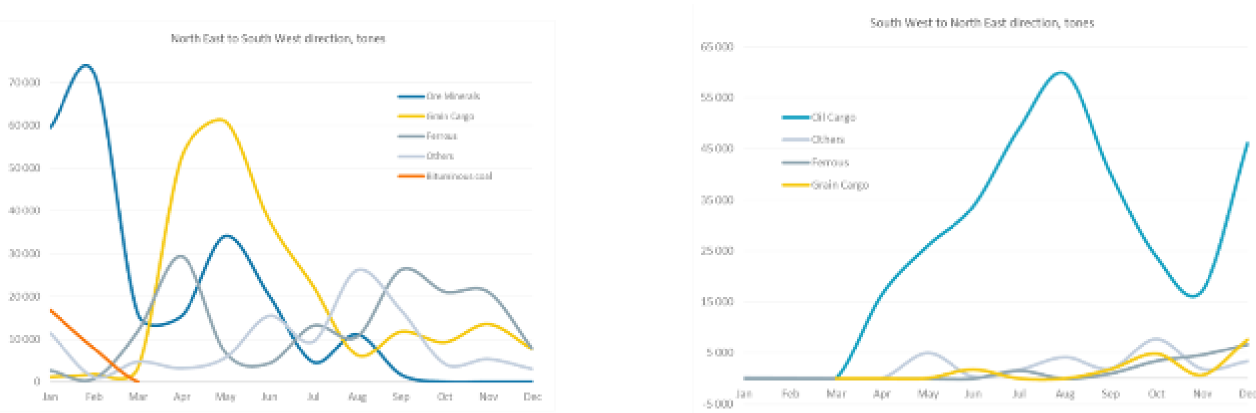


Figure 4.28: Rail transit analysis. Source: AFD

4.8 Environment

4.8.1 Legislative overview

This section deals with the overview of legislation in terms of environment which is relevant for transport projects preparation and their assessment and subsequent approval. It gives the latest information on the approximation of the Ukrainian and Moldovan law with the *acquis Communautaire* which is covered in the European Commission's annual Association Implementation Reports for each country.

Some sources suggest that in the process of approximation, the issue of taking into account the rulings of the European Court of Justice when implementing the *acquis Communautaire* has so far not been considered[12]. Nevertheless, the candidate countries could greatly benefit from the significant practical experience of the EU member states in the implementation of EU legislation and the interpretation of the provisions of directives and regulations by the ECJ.

<u>Ukraine</u>

Since gaining independence in 1991, Ukraine has made significant progress in its environmental management. The country developed a wide regulatory and legal base for environmental legislation; became signatory to major international and regional environmental agreements; established the Ministry of Ecology and Natural Resources tasked with setting the country's environment policy; and established the Environment Protection Fund and the Nature Protection Fund, among others. In addition, over the years of independence, a vibrant civil society and active non-governmental organisations working on 2 environmental issues have emerged.[13]

Since 2016, Ukraine's implementation of the EU acquis has been presented in the EU's annual Association Implementation Reports. In February 2023 the European Commission issued the latest analytical report on Ukraine's application for membership of the European Union. Cluster 4 covers topics relevant for this study: transport, energy, trans-European networks, environment, and climate change.

According to the report, Ukraine has taken notable steps to align with the EU cross-cutting rules on the environment acquis. Ukraine is a party to the Aarhus Convention and has already taken positive steps to implement Aarhus rights (access to environmental information, public participation in decision-making and access to justice) into national law. Ukraine is also party to the Espoo Convention, albeit having received a caution for non-compliance. Ukraine has enacted framework legislation on environmental impact assessments and on strategic environmental assessment. However, according to the report, its implementation needs addressing as procedural irregularities and uneven enforcement have been reported in the national and transboundary contexts.

On air quality, Ukraine is partially aligned with the EU, in particular with the national emission reduction commitments directive, Ukraine has set air quality standards in line with those of the EU, except for fine particulate matter.

Ukraine updated its Water Code and river basin districts have been established. Ukraine joined the Water Convention and ratified the Water Protocol. General principles of marine water protection are reflected in the legislation. Monitoring is planned for marine waters, including for protected areas. The marine environmental strategy was approved in 2021, aiming to achieve and maintain a good environmental status pursuant to the Marine Strategy Framework Directive.

There is partial alignment in the area of nature protection, in particular with the EU nature directives. Ukraine invested efforts to identify and designate its Emerald Network. The country is encouraged to continue with designation once circumstances allow in order to meet the objectives of the Natura 2000 network, given that the national Emerald Network reaches only 40% sufficiency rate to achieve the Network objectives and requires significant expansion. Capacities for the setting-up and running of a good management system for Natura 2000 sites need to be set up. Important gaps in the alignment with the Habitats Directive need to be addressed and work to address invasive alien species should start as circumstances allow.

[12] elni_2022_Andrusevych
[13] World Bank Document

In the field of industrial pollution and risk management Ukraine adopted concepts and action plans aimed at aligning with the EU acquis in this area. Standards have been established for arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons content in the ambient air to improve air quality. Yet, significant legislative work and investments are needed for industrial and livestock rearing activities that fall under the EU's industrial emissions legislation. The existing national limits for the emission of pollutants and discharge do not meet the Industrial Emissions Directive's best available technique associated emission levels, including for the approximately 220 large combustion plants.

Regarding industrial accidents, Ukraine acceded to the UNECE Convention on the Transboundary Effects of Industrial Accidents (TEIA) in 2022. Ukraine's legislation needs to be updated to meet the TEIA requirements, as well as additional EU requirements.

In the area of noise, further alignment of legislation with the EU acquis is needed.

In relation to the EU's waste management legislation, the Government has adopted a national waste management strategy to 2030. Also, framework legislation on waste management that approximated certain provisions of the Waste Framework Directive came into force in July 2022. Further real efforts are needed to shift to waste prevention, waste recovery and recycling systems and to establish a functional waste hierarchy and manage specific waste streams, including hazardous waste. The issue of illegal landfills needs to be tackled systemically.[14]

Moldova

Moldova applied for the EU on 17 June 2022. Since 2016, Moldova's implementation of the EU acquis has been presented in the EU's annual 'Association Implementation Reports'. The analytical report on Moldova's application for membership of the European Union issued by the European Commission in February 2023 states that the country is at an early stage of preparation on the area of environment and climate change. Gaps in the level of legislative alignment have grown with the expansion and deepening of EU acquis following the European Green Deal. In general, challenges remain concerning capacities for mainstreaming the environmental and climate acquis and the European Green Deal in all policy areas, as well as for effective implementation and enforcement of legislation. Environmental protection and green transition would benefit from increased political attention and a whole-of-government and whole-of-the-economy approach.

The main elements of the EU acquis are enshrined in law, although Moldova needs to achieve further alignment with EU horizontal legislation and implement the rules. Laws on environmental impact assessment and strategic environmental assessment exist but further alignment is needed. Moldova is a party to the Aarhus and Espoo conventions. Implementation of its current environmental strategy is challenged by the lack of funding, low administrative capacity, especially for implementation and enforcement of environmental legislation, and heavy reliance on international donors.

On waste management, Moldova has achieved a certain level of alignment. Its legal framework approximates the EU Waste Framework Directive. However, law enforcement and the level of investments for efficient implementation are insufficient, and the vast majority of waste is unrecycled and disposed at landfills.

On air quality, Moldova needs to develop legislation and take further action on implementation.

[14] Analytical Report following the Communication from the Commission to the European Parliament, the European Council and the Council Commission Opinion on Ukraine's application for membership of the European Union; February 2023

On water management there is limited alignment with EU law. Water resources are subject to general protection and the legal framework on water contains provisions on preventing pollution.

Moldova is drawing up water management and flood risk management plans for each river basin district.

On nature protection, Moldova is partially aligned with the EU acquis. Moldova needs to pursue its work to identify and designate its Emerald Network to meet the objectives of the Natura 2000 network. The Moldovan Emerald Network only covers 8.1% of territory and its sufficiency rate to achieve the network objectives is only 24%. It needs to revise the national biodiversity strategy and action plan and introduce legislation to transpose appropriate assessment, monitoring and reporting requirements. It needs to remedy enforcement issues related to the protection of species and sustainable use of resources and management of protected areas and both update and enforce forest policy. Moldova intends to raise the percentage of territory covered by forests by 25%.

Moldova has started to align with EU provisions on industrial pollution and risk management, by adopting a Law on Industrial Emissions. Significant investments are needed for industrial and livestock rearing activities falling under the EU's industrial emissions legislation. Moldova has put in place a pollutant release and transfer register system and is a party to the UNECE Convention on Transboundary Effects of Industrial Accidents.

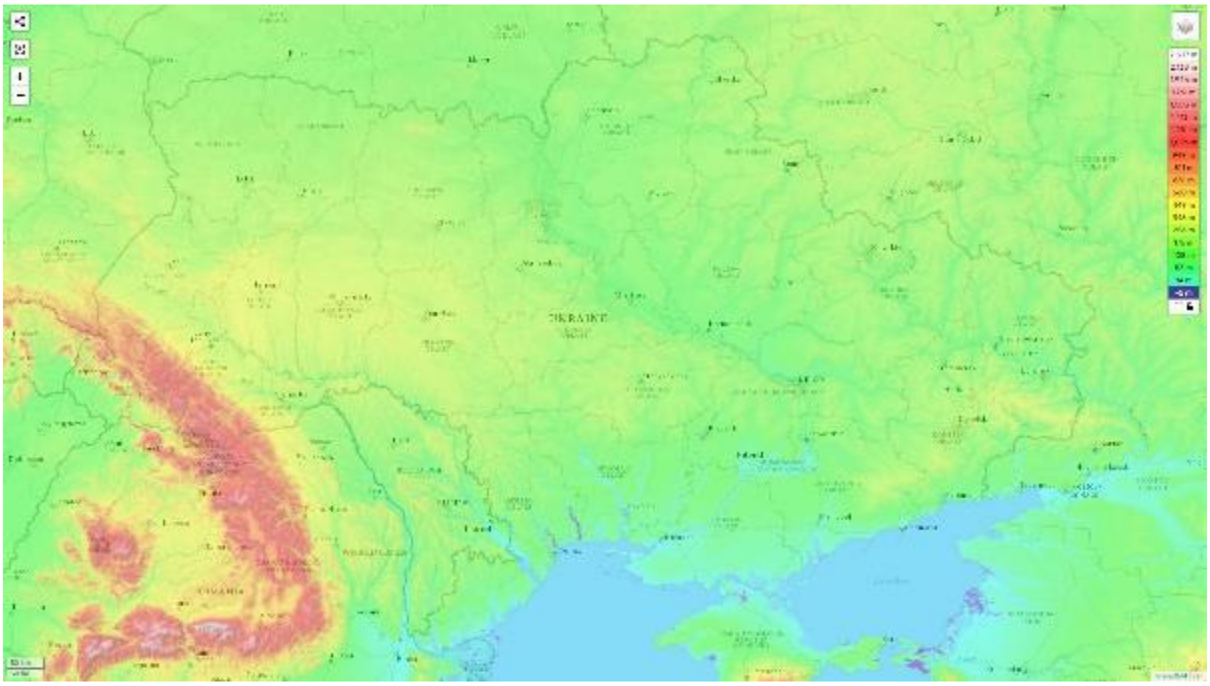
Moldova is at an early stage of alignment with EU noise legislation.

4.8.2 Environmental baseline

This chapter provides basic information about existing environmental baseline to be taken into account when planning and developing transport corridors. In the next stages of the study preparation, other elements might be identified as important input factors for further decision making.

<u>Topography</u>

In terms of topography, both countries Ukraine and Moldova are fairly similar.



Ukraine consists almost entirely of level plains at an average elevation 175 m above sea level. There are mountainous areas, such as the Ukrainian Carpathians in the west and Crimean Mountains in the south, on the country's borders and they account for some 5% of the country's area. The general relief features of Ukraine are determined by geo-structural features. Most orographic formations (Volyn, Podil, Dnipro, and Donetsk highlands, the Dnipro lowlands, and the Ukrainian Carpathians) are oriented from northwest to southeast in accordance with the direction of the main geo-structural elements that also determine the location of the largest rivers[15].

Moldova is a landlocked country, although it is close to the Black Sea; at its closest point it is separated from the Dniester Liman, an estuary of the Black Sea, by only 3 km of Ukrainian territory which directly affects the development and logistics potential of the country's route corridors. Most of the country is moderate hilly plateau, elevations never exceed 430 m. Moldova's hills geologically originate from the Carpathian Mountains. In the south of the country there is a small flatland, the Bugeac Plain.

<u>Soil</u>

Ukraine's fertile plains, called steppes, are ideal for growing crops, which is why Ukraine is referred to as the "breadbasket of Europe." Approximate 58% of the country's territory is considered arable land. Almost 2/3 of the Ukrainian territory consists of chernozem, which is very fertile type of soil and can produce high agricultural yields with its high moisture storage capacity. Soils become increasingly salinized to the south as they approach the Black Sea.

Moldova has about 75% of its soil type chernozem. The soil becomes less fertile towards the south but can still support grape and sunflower production. The hills have woodland soils, while a small portion in southern Moldova is in the steppe zone, although most steppe areas today are cultivated. The lower reaches of the Prut and Dniester rivers and the southern river valleys are saline marshes.

<u>Natural resources</u>

In terms of natural resources Ukraine is very rich and mineral resources occur in high concentrations and close proximity to each other. The country has abundant reserves of coal, iron ore, natural gas, manganese, salt, oil, graphite, sulphur, kaolin, titanium, nickel, magnesium, timber, and mercury. Ukraine is also heavily industrialised country, with many mines, chemical processing plants and metallurgical works. Many of Ukraine's major cities contain potentially hazardous industries, including Kyiv, Kharkiv, Kryvyi Rih, Mariupol and Odesa. As regards Moldova, the natural resources are quite limited. The greatest resources are soil and climate.

<u>Waters</u>

Most of the rivers of Ukraine drain into the Black Sea and Azov Sea and belong to the bigger Mediterranean basin. Major rivers include the Dnieper, which is the longest, Dniester, Southern Buh, and Siversky Donets. Ukraine has thousands rather small lakes, located in the floodplains of major rivers. The largest lakes of Ukraine are located along the coasts of the Black Sea and the Sea of Azov.

Surface freshwater bodies of Ukraine cover more than 24 000 km^2, or 4% of the total territory of the country. These include rivers, lakes, reservoirs, ponds, channels, etc. The hydrographic unit is the river basin area. There are 9 river basin areas in Ukraine.

Almost 70% of the drinking water supply relies on surface water sources, which increases the importance of reducing their pollution, including through adequate treatment of wastewater and limiting the discharge of polluted water into surface and ground water bodies.[16]

The main causes of surface water pollution are the discharge of polluted municipal and industrial wastewater directly into water bodies and through the city sewage system, as well as the entry of

[15] https://mepr.gov.ua/wp-content/uploads/2023/01/Natsdopovid-2021-n.pdf
[16] World Bank Document

pollutants into water bodies in the process of surface runoff from developed areas and agricultural land[17].

The two largest rivers in Moldova are the Dniester (Nistru in Moldova) and the Prut, which both originate in the Carpathian Mountains. The forms a short section of the Moldova/Ukraine border in the northeast and empties into the Black Sea. The second-longest river is the Prut, a major tributary of the Danube River. The Prut River forms Moldova's entire border with Romania before flowing south into the Danube. Like the Nistru, the Prut originates in the Carpathian Mountains in southwestern Ukraine. On the Moldovan-Romanian border in northwest Moldova lies Lake Stanca-Costesti, through which the Prut River flows. Two other lakes fed by the Prut are the Manta and the Beleu, which are protected wetlands.

<u>Internationally protected areas</u>

Ukraine is home to over 70 thousand of flora and fauna species and is also on crossroads for over 100 species of migratory birds. Almost 5.4% of the country's area (approximately 3 million hectares) is protected. The National Environmental Strategy 2020 for Ukraine mentions as main threats to the country's biodiversity loss of habitat due to agricultural activity, deforestation, urban expansion, and industrial activity, as well as the introduction of invasive species. For the purposes of this study only Emerald Network and Ramsar wetlands categories from internationally protected sites were used – see map nr. 1. These, however, are often overlapping with other categories, such as Key Biodiversity Areas, UNESCO Man and Biosphere, etc.

Ukraine's 5th National Report to the Convention on Biological Diversity (MENR 2015c) identifies the key threats to biodiversity. These are the uncontrolled use of forest resources, land degradation, and over-exploitation of the steppes, recreational activities, and wastewater pollution of the aquatic and coastal ecosystems, regulation of the Dnipro River and its tributaries changing the natural mode of floods, organic pollution, and destruction of natural habitats. Additional key threats are natural factors such as excessive overgrowing of small rivers by air-water vegetation that reduces the biodiversity of aquatic organisms (plants and animals), invasive species, and climate change in forest areas.

Ukraine signed the Bern Convention on 17 August 1998, which entered into force in 1999. As part of its commitment to preserving the country's biological diversity, Ukraine works on the setting-up of the Emerald Network since 2008. Ukraine has listed dunes, pine forests and cypress, juniperus and yew forests among threatened habitats for protection. Examples of Ukraine's precious biodiversity include the wolf, *Canis lupus*, the great bustard, *Otis tarda*, the largest game bird in Europe and the Crimean orchid, *Steveniella satyrioides*. 194 sites have been identified as suitable to join the Emerald Network in the country (by February 2016), 159 of which have already been officially nominated as candidate Emerald sites by the Standing Committee to the Bern Convention in December 2015.

Regarding the Ramsar Convention, the convention entered into force in Ukraine on 1 December 1991.Ukraine currently has 50 sites designated as Wetlands of International Importance.

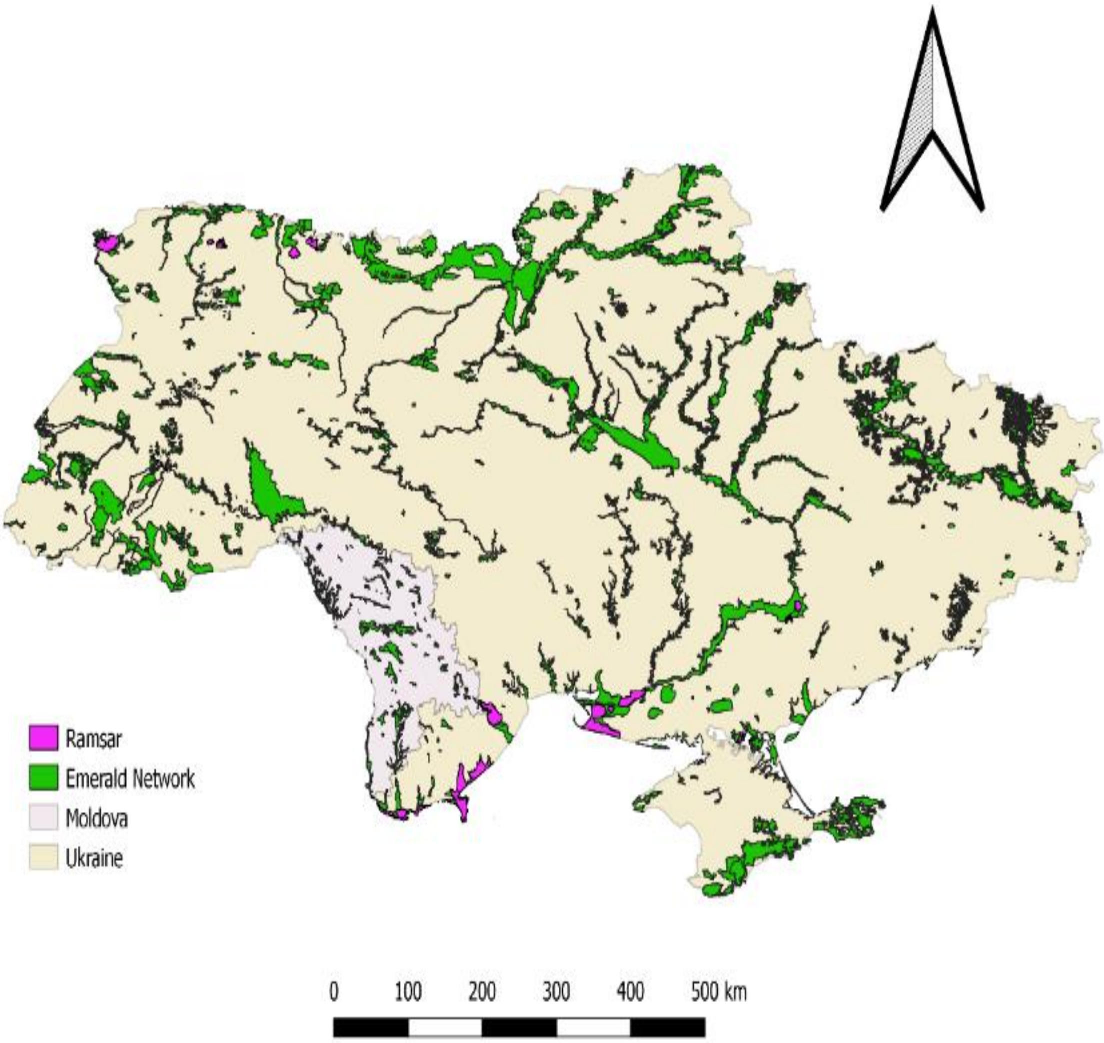
The Republic of Moldova acceded to the Bern Convention on 24 May 1994, which entered into force the same year. Since the country started working on the setting-up of the Emerald Network, it has listed more than 20 different habitats of European importance which need a specific site preservation, such as the *Thermophilous* and Supra-Mediterranean oak woods and the Continental Steppe. 36 sites have been identified as suitable to join the Emerald Network in the country (by February 2016), 18 of which have already been officially nominated as candidate Emerald sites by the Standing Committee to the Bern Convention in December 2015. These sites would help preserve habitats for the lady's-slipper orchid, *Cypripedium calceolus*, the great crested newt, *Triturus cristatus*, and the Danube salmon, *Hucho hucho*. The largest permanent freshwater salmon and more than 85 other species of

[17] National report on the natural environment state in Ukraine in 2021: https://mepr.gov.ua/wp-content/uploads/2023/01/Natsdopovid-2021-n.pdf

plants and animals of European are identified as present in the country and should be protected by the country through the Emerald Network.

As regards the Ramsar Convention, in Moldova the convention entered into force on 20 October 2000. Moldova currently has 3 sites designated as Wetlands of International Importance.

Map. nr. 1 – Internationally protected (terrestrial) sites



Vulnerability to Climate change

In general, Ukraine is characterised by a favourable climate for human activity. The continentality of the climate increases from west to east and is demonstrated through regional circulation in the atmosphere. The diversity of the climate is also related to the types of subsoil, which varies from flat to mountainous (Ukrainian Carpathians, Crimean Mountains). The latitudinal course of meteorological values is influenced by the highlands. The considerable length of the sea coastline affects the climate of coastal areas. The climate of Ukraine generally consists of microclimates, which is manifested in the heterogeneity of horizontal and vertical gradients of climatological indicators due to the complex interaction of the active surface in the system of natural and transformed landscapes[18].

Ukraine's 6th National Communication Report to the UNFCCC (MOE 2014) summarises the following key sectors of vulnerability to climate change impacts:

- Agricultural sector – Grain yield may decrease by 10–16% due to increase in the frequency and severity of drought during the growing season, decrease in the frequency of precipitation and an increase in the intensity of rainfall, and lack of sustainable snow depth needed for crops to weather sub-freezing temperatures
- Forests – Long-term climate change is very likely to show generally negative impact on forests, the impact of increasing climate variability on terrestrial ecosystems are expected to be negative and significant. Increasing the fire danger is very likely in the various regions of the country
- Human health – The report expects that human health will be affected through changes in vector ecology, as well as impacts of extremes of temperature (cold season and heat waves)
- Energy –the national energy strategy until 2030 has as one of its objectives the elimination of natural gas import dependency through substantial increase in domestic gas production (shale gas, coalbed CH_4 and coal gasification). Given the high energy intensity of coal and shale gas production, this policy might increase the GHG emissions

The drivers underlying the projected increase of emissions are mostly the projected long-term development trends of the national economy, including an increase in production in the energy intensive industry sectors; improvement of population life standards; development of the agricultural sector; and an increase of domestic coal and natural gas mining[19].

4.8.3 Natural and war related hazards – potential red flags

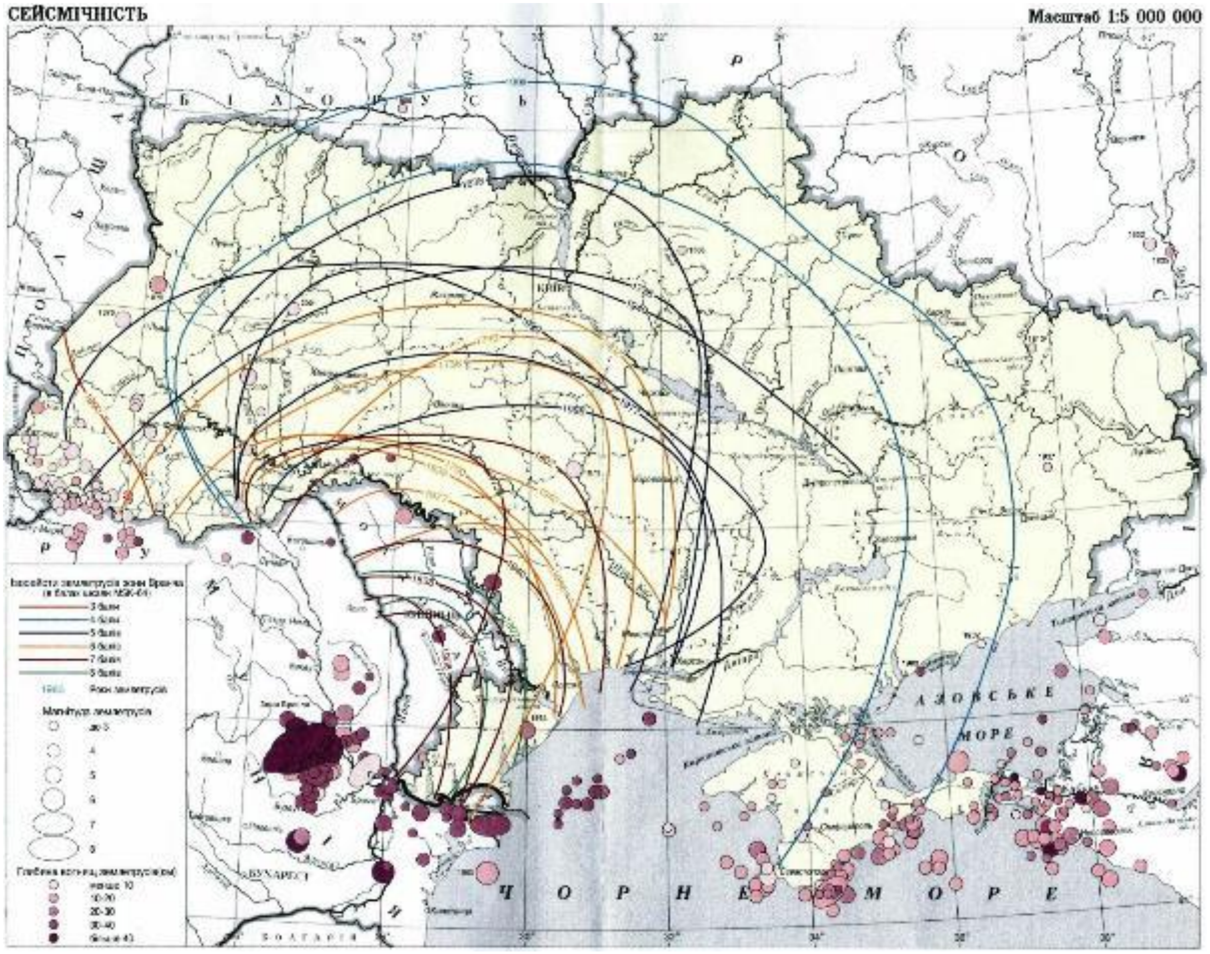
This chapter presents the existing hazards in the environment, be it natural or manmade, which should be taken into account in further planning of the transport network. Naturally, more details will be needed in the next stages of the study preparation.

Seismology

There are two basic seismic regions in Ukraine - Carpathian and Crimean-Black Sea. These are also relevant for Moldova. Seismicity of the Carpathian region is defined by earthquakes with epicentres in Zakarpattya, Carpathians, Prykarpattya and also in the nearby territories of neighbouring countries: Poland, Slovakia, Hungary and Romania. The most seismically active is Zakarpattya. Seismicity of the Crimean-Black Sea region is defined by the epicentres of the earthquakes located in the Black Sea,

[18] National report on the natural environment state in Ukraine in 2021: https://mepr.gov.ua/wp-content/uploads/2023/01/Natsdopovid-2021-n.pdf
[19] https://unfccc.int/documents/8642

near the Southern coast of Crimea which are characterised by the highest indicators throughout the Ukrainian territory: magnitudes up to 6.8 [20].



Industrial pollution and old environmental burdens

Under the Soviet system, the economy of Ukraine used 1.3-1.5 billion tonnes of raw materials every year, most of which returned into the environment as waste[21]. Consequently, there are several localities in Ukraine which – if possible – should be avoided when designing transport corridors due to radiation or industrial pollution, mainly if the future freight would transport dangerous goods.

The main burden on the environment in the industrial sector is caused by enterprises of the chemical, metallurgical, mining, and electric power industries. The list of activities and facilities that pose a high environmental hazard includes facilities the construction and operation of which can negatively affect the natural environment state. Among these objects, the most dangerous are the objects for the production of explosive substances and disposal of unusable ammunition; enterprises of the chemical and oil refining industry; facilities using chlorine and ammonia (refrigeration plants, water treatment plants, etc.), pesticide and agrochemical warehouses, ammonia pipelines. The largest number of chemically hazardous objects is concentrated in the Donetsk, Dnipropetrovsk, Luhansk and Kharkiv regions, which should be considered when planning route corridors[22].

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20 Seismicity of Ukraine | WORLD DATA CENTER (wdc.org.ua)

21 Disasters Waiting To Happen - Oct. 22, 2010 | KyivPost

22 National report on the natural environment state in Ukraine in 2021: https://mepr.gov.ua/wp-content/uploads/2023/01/Natsdopovid-2021-n.pdf

The majority of hazardous waste is located in three regions: Donetsk, Dnipropetrovsk and Zaporizhzhia all of which have giant, Soviet-era heavy industrial plants and factories. There are at least two plants whose industrial waste ponds, if breached, could cause a disaster and these localities should be avoided when considering transport corridors: Mykolaiv Alumina Plant and Zaporizhzhia Aluminium Plant.

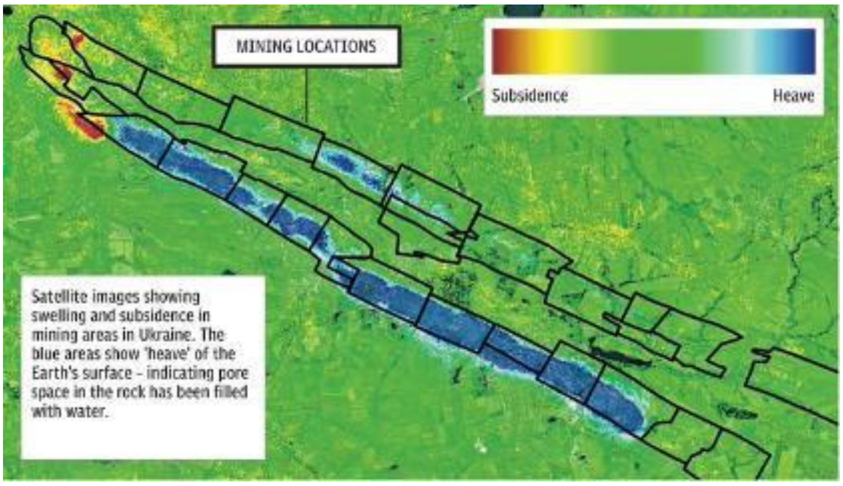
The area around a giant potassium salt mine in Kalush, Ivano-Frankivsk Oblast, is also a locality to avoid when planning transport corridors. Some 55 years ago a factory was built there to mine the deposits of potassium salt and produce fertilisers. It was shut down in 2001 and designated as an environmental disaster zone. Dombrovska pit lake formed in the abandoned opencast mine and it is one of the most saline inland water bodies in the world[23]. In 2010 the Ukrainian government started removing toxic waste from the dump, which is Europe's largest site of hexachlorobenzene.

Within the Dniester River Basin, there are enterprises of the oil-and-gas, chemical, and energy industries, whose operations result in accumulation of large-tonnage industrial waste. Tailings storage facilities (TSFs) are potentially hazardous facilities for water resources. They are earthen reservoirs, natural or artificially made in the natural environment, for industrial waste disposal which is transported from its production sites mainly by hydraulic means through pipelines and stored in a liquid, sludge- and paste-like state. When any TSF system fails, the liquid component of the waste penetrates the protective functions of the enclosing structures, comes out and causes destruction. These types of hazards can cause accidents that will lead to escape of pollutants into surface and groundwater (including to the transboundary UA - MD Dniester River[24]) given the hydrographic network of the facilities' location. This can result in poisoning of the natural environment components, flooding, destruction of residential and industrial buildings and transport infrastructure elements.

As a part of a UN project "Enabling Transboundary Cooperation and Integrated Water Resources Management in the Dniester River Basin", a large-scale inventory of 31 TSFs containing over 160 million tonnes of hazardous waste was completed. As of 2019, there are 465 TSFs storing over 6 bln tonnes of waste from various industries, including metallurgical, chemical, oil refining, extractive, energy, etc. Drawing on the results of the study, a summary of the inventory was prepared[25] and the documents were forwarded to the competent authorities of the Republic of Moldova and Ukraine. The major ones investigated in the study were located in the Ivano-Frankivsk Region, Lviv Region and Odesa Region (Moldovan Thermal Power Plant).

Another slow environmental disaster may be happening in Donbas due to the abandonment of groundwater pumping from the region's coal mines. Research published in February 2022 showed the extent to which the ground has been deforming due to rising groundwater. Mine drainage is typically polluted with high levels of salts and metals and is already contaminating wells and drinking water sources, while subsidence can damage buildings and infrastructure. There are particular concerns over the discharge from the Yunkom mine, site of a nuclear test in the 1970s.[26]

[23] Unique Pit Lake Created in an Opencast Potassium Salt Mine (Dombrovska Pit Lake in Kalush, Ukraine) | SpringerLink
[24] Save the Dniester river together (dniester-commission.com)
[25] GEF Project - Dniester (dniester-commission.com)
[26] Second Chernobyl: Eastern Ukraine threatened with radioactive disaster (telegraph.co.uk)



Similar to Ukraine, also Moldova carries its environmental damage legacy from the Soviet era. Moldova's soil and groundwater were contaminated by lingering chemicals, some of which (including DDT) have been banned in the West[27]. Similarly, certain farming practices, like destroying forests to plant vineyards, have contributed to the extensive soil erosion to which the country's topography is already prone.

4.8.4 Environmental impacts

This chapter summarises general impacts identification stemming from planning of rail infrastructure and it also tries to address further work needed to be done under current circumstances, when data needs to be gathered from a country at war. Also, it provides some estimates as to what other impacts/aspects – apart from those usually taken into account in standard environmental procedures – will have to be considered in the next steps.

Rail transport is widely recognised as the most energy-efficient and least polluting mode of motorized transport. Especially in Europe, the development of the trans-European transport networks and the increase in interoperability between adjacent countries has led to a growth in the modal attraction of the rail for both passengers and freight compared to other modes of transport.

Analysing environmental impacts of rail infrastructure

Environmental impacts of transport infrastructure, negative as well as some positive, are well documented. Starting from the most obvious, transport infrastructure causes nearly permanent modifications to hydro-geological patterns in the landscape, with consequential changes in run-off, sedimentation, and water quality. Moreover, transport infrastructure causes loss, fragmentation and degradation of natural habitats, adds new habitat, introduces barriers to movements, and increases wildlife mortality; all of which affects ecological processes related to population dynamics, e.g., colonisation, extinction and genetic exchange.

In the present study, however, the corridors are existing, and the measures aim at modernising them with a possibility in some cases to altering them.

When it comes to corridor planning and biodiversity, the impacts are to a great extent determined by the spatial alignment of the corridor in the landscape. In certain landscapes, some areas would be more suitable for construction while others would be less, according to the spatial distribution of biodiversity components, such as habitats and populations that could be more or less significant from a biodiversity

[27] NATO - News: Destroying dangerous pesticides in Moldova, 28-Feb.-2013

point of view. In addition, the effects of a poorly located road/rail with very low permeability for wildlife movements would also be difficult to mitigate, at least with reasonable costs.

Likewise, from a resource-efficiency point of view, each landscape has a particular distribution of resources that could potentially be used for transport infrastructure construction, and a given topology which delineates suitable and less suitable corridor locations from a constructional point of view. Adequate consideration of the geological conditions before construction could positively influence – not only - cost in a considerable manner. The subsurface characteristics, such as soil type and soil depth, could have an adverse effect on the infrastructural project through the costs coupled with ground stabilisation measures, as well as material transport. Soils differ in their capability of frost action, swelling and shrinkage which, if not anticipated, could increase the maintenance frequency due to failures. The soil characteristics could also increase the total cost of the construction project or result in an increased need to excavate or fill different sections along a route. Excavations increase the amount of material generated from a construction site which could, if the material cannot be used within the project, require further material transport.

In situation such as this where site visits are not possible, the use of GIS tools like spatial ecological models and geological models, could provide more explicit input into otherwise necessary procedures, like SEAs and EIAs. The outputs of these models could influence the design of the rail corridors in the landscape.[28] Naturally, once the situation allows, on-site investigations could follow.

The impacts of measures subsumed by this study aiming at modernisation and development of the rail corridors include the following:

- Impacts on water bodies: need to rebuild and redesign bridges
- Impacts on (nationally and internationally) protected areas
- Impacts on soil/geology/groundwater – with consideration of local hazards/risk of natural and manmade disasters (seismology, floods including coastal, landslides, fires, industrial pollution, etc.)
- Impacts resulting from (re)designing of transport nodes mainly in urban areas
- Impacts on air quality and human health (noise and vibration)
- Impacts on cultural heritage
- Impacts resulting from necessary demolition works
- Impacts resulting from the operational phase and maintenance
- Impacts resulting from material transportation, etc.

Armed conflict related environmental consequences

While environmental damage of war is generally evident in the environment, its extent is difficult to measure. Pollution caused by military activities often goes unreported, as monitoring systems have been disrupted or destroyed, and such damages continue to accumulate. From the first days of the war, the Ukrainian government launched several tools to document the environmental damage. This includes a dashboard with data on the impact of the war on the environment, “EcoZagroza” ЕкоЗагроза (ecozagroza.gov.ua), and the work of the State Environmental Inspection, which recorded over 250

[28] Design and evaluation of rail corridors based on spatial ecological and geological criteria - ScienceDirect

cases of crimes against the environment and over 1200 cases of damage to the environment from the aggression[29]. Special units have been collecting evidence, including photos, video, and satellite images and, where possible, air and soil samples for laboratory tests. The information from the EcoZagroza webpage, including its map version ЕкоЗагроза (ecozagroza.gov.ua), could be another source of information for the purposes of this study and pre-assessment of the impacts of measures.

Recent research has shown that there are mainly physical, mechanical, and chemical impacts on soil - the movement of heavy military equipment compacts the soil, impairs the ability of water to penetrate it and makes it more vulnerable to erosion. The construction of fortifications causes landslides, waterlogging, soil subsidence, etc. The formation of craters after explosions disrupts the air-water regime in the soil. Regarding the chemical pollution of active hostilities locations, the results of the analysis of the samples showed a high level of pollution by heavy metals, in particular, the level of cadmium was exceeded by 5 times, zinc by 3.5 times, and molybdenum by 2 times. These pollutants pose little threat to groundwater but may pose a risk to plants. And if food crops grow on such lands in the future, heavy metals can eventually enter people's bodies through food and harm human health[30].

The use of explosive weapons in populated areas generates pollution from pulverised building materials – which may include asbestos, metals and combustion products, large volumes of debris and can lead to soil and groundwater pollution by damaging waste water pipes. Pollution threats can be increased where light industry or facilities such as petrol stations are in close proximity to residential areas. Other contaminants include weapons residues, such as metals and explosives. In addition to rockets and artillery, there has been evidence that Russia has also used banned cluster munitions in urban areas.[31]

Along at least one beach near Odesa the Ukrainian military have laid landmines in an effort to prevent an amphibious landing. The intense shelling of sites like the notorious Snake Island may have left permanent scars on bio and geodiversity. The fighting close to Kherson, to take the bridge over the Dnieper, resulted in fires in the Black Sea Biosphere Reserve. These fires were detectable from space and may have destroyed trees and unique habitats for birds in the largest nature reserve in Ukraine.

Additional factors for consideration should be the location of old environmental hazards resulting from industrial pollution and the necessary clearing of the country from explosives and military material. This is particularly important for Ukrainian military infrastructure and naval facilities, including that in close proximity to civilian areas. Military attacks have resulted in fires releasing harmful air pollution where large smoke plumes spread over civilian areas. These are composed of toxic gases and particulate matter and, where conventional weapons have been stored, heavy metals and energetic materials. At these sites, there will also be substantial soil and water contamination, the extent to which these pollutants can migrate from military facilities will vary depending on the site. Where efforts were made to extinguish fires, the pollution may include residues from firefighting foams. Damaged naval sites have the potential to generate coastal pollution. Where facilities have been in operation for many years, this new pollution may build on existing military contamination.

[29] According to the Criminal Code of Ukraine, "the mass destruction of flora and fauna, poisoning of the atmosphere or water resources, as well as other actions that could cause an environmental catastrophe" are a criminal offense.

[30] Research 'Impact of Russia's war against Ukraine on Ukrainian soil' conducted by the NGO "Ekodiya".

[31] Ukraine invasion: rapid overview of environmental issues - CEOBS

4.9 SWOT analysis

SWOT analysis is a valuable planning tool for the rail network because it helps identify and evaluate the internal strengths and weaknesses of the network, as well as the external opportunities and threats it faces. This covers many aspects including existing infrastructure and rolling stock, technological capabilities, operational efficiency, workforce, and geographical location.

The analysis conducted and summarised above has led to the following conclusions, which confirm to a significant extent initial hypothesis of the study as presented in former reports. These are as follows:

4.9.1 Ukraine

4.9.1.1 Strengths

Extended existing rail infrastructure. The existing rail infrastructure provides sufficient capacity and coverage. All important origin and destinations in UA are accessible via the rail network. This generates a high level of resilience to operational disturbances.

The **Modal Split** in relation to passenger and heavy bulk traffic is dominated by the rail/public transport sector.

Property ownership related to the rail system. The rail system owns large areas along the existing railway lines, which can be used for further development of the network.

Generous alignment. Some lines in the Ukrainian network are characterised by a generous alignment, which allows to reach even higher operational speeds than currently allowed. With investments into modern interlocking systems, track protection, traffic management and communication, level crossings and limited alignment corrections, operational speed of 200km/h on certain parts of the network are possible.

High axle loads and train development length. With the high axle loads of 25t and longer train development length of approximately 1000m, the capacities for heavy bulk transport are comparatively high.

High level of resilience against war acts of terrorism. The configuration and decentralised management of the Ukraine rail network enables it to adapt to operational disturbances on certain lines.

4.9.1.2 Weaknesses

Low technological level of the rail system. The Ukrainian rail system has significant performance issues due to the relatively low level of traffic organisation and traffic management. With the introduction of modern interlocking and traffic management systems (ERTMS), the performance and therefore the competitiveness of the UA rail system can be significantly improved.

Budgetary constraints leading to lack of investments and maintenance. Due to the general budgetary situation in the country the financial resources for development and maintenance of the UA rail system are limited. Many rail lines are suffering from operational speed restrictions due to lack of maintenance. Engineering structures (large bridges, tunnels) may already have reached the end of their economic life or have experienced war damage and require significant investment.

Outdated rolling stock. Rolling stock for passenger transport and freight transport is obsolete. Apart from some recent purchases of passenger rolling stock, the existing fleet is not competitive with other modes of transport.

Lack of siding. Some lines are missing siding capacities, which reduces capacities of certain lines. With the introduction of additional sidings and a related reorganisation of the block system, higher capacities can be reached.

Different power supply systems. For historical reasons, the Ukraine rail system has two different power supply systems (AC and DC). The two systems are also in use in neighbouring countries (RO, MD, HU – AC), PL (DC), SK (both systems). A consolidation of the power supply system can generate operational gains.

Different track gauge than in the neighbouring EU countries. The Ukraine rail system is currently not compatible with the EU rail system. Integration of the rail gauge system is essential for future economic development of Ukraine.

4.9.1.3 Opportunities

Availability of EU funds. With the increasing availability of EU funds and loans of International Financial Institutions (IFIs), the performance of the rail sector can be secured in the future.

Operational integration into the EU rail system. With an integration of the UA rail system into the EU rail system in terms of operational procedures, time schedules, capacity allocation etc. the UA rail system can benefit from the recent years of technological and operational development of the EU rail system.

Integration of the UA economy into the EU economy. Economic activity can be enhanced through the improvement of the border crossing procedures with the EU.

Integration into European Transport Corridor. As part of the future revised TEN-T regulation there will be opportunities for enhanced coordination in the medium and long-term development of the lines.

4.9.1.4 Threats

War or similar hostilities continue. This impacts on the rehabilitation and further development of the Ukraine economy in general and the transport/rail system in specific. Apart from delaying the implementation of the strategy, the overall social and economic damage would increase and limit the development perspectives.

Availability of private cars. With the further economic development, the availability of private cars will increase, which provides a threat to the rail sector.

Development of road infrastructure. With increasing investments into the road sector, the rail sector will face strong competition in passenger and freight transport. As the liberalised road sector will also benefit from private investments, the rail sector will lose traffic share.

Rail system cannot be modernised and therefore will not be competitive. Other transport modes would overtake the demand and the Modal Split would develop against the strategic objective of environmental and climate protection.

Delays in the accession of Ukraine into the EU. With delayed the political integration of Ukraine into the EU, the exchange of passengers and freight between Ukraine and the EU will be difficult. This negatively impacts not only the border crossing traffic, but also the economic interaction between the two economies.

4.9.2 Moldova

4.9.2.1 Strengths

Significant properties related to the rail system. The rail system owns large areas along the lines, which can be used for the further development of the network.

High axle loads and train development length. With the high axle loads of 25t and the longer train development length of approximately 1000m, the capacities for heavy bulk transports are comparatively high.

4.9.2.2 Weaknesses

Low technological level of the rail system. The Moldovan rail system has significant performance limitations due to the relatively low level of traffic organisation and traffic management. With the introduction of modern interlocking and traffic management systems (ERTMS), the performance and competitiveness of the MD rail system can be significantly improved.

Budgetary constraints leading to lack of investments and maintenance. Due to the general budgetary situation of MD, the financial resources for development and maintenance of the MD rail system are limited. Many rail lines are suffering from operational speed restrictions due to lack of maintenance. Engineering structures (large bridges, tunnels) might have reached the end of the economic lifecycle or have been impacted by the war and require significant investments.

Outdated rolling stock. The rolling stock for passenger transport and freight transport is obsolete and is not competitive when compared with other modes of transport.

Lack of siding. Some lines are missing siding capacities, which reduces capacities of certain lines. With the introduction of additional sidings and a related reorganisation of the block system, higher capacities can be reached.

Very low modal split for passengers and freight. The MD rail system plays only a secondary role in the national transport system. Measures to increase the competitiveness of the rail system are essential.

Rail lines through Transnistria are not in operation. This situation has been recently addressed by the opening of the Basarabeasca – Berezyne line, posing an additional burden to the CFM and JSC UZ for the refurbishment of the line.

Several routes in the north south enter and exit Moldova and Ukraine several times. This situation creates additional complexity with respect to controls and train monitoring. Due to the war, joint control is under discussion and shall be implemented shortly. This would affect both passengers and freight, with controls currently done separately on each side generating significant delays. A technical group is in charge of the issue

4.9.2.3 Opportunities

Availability of EU funds. With the increasing availability of EU funds and loans of IFIs, the performance of the rail sector can be also secured in the future.

Operational integration into the EU rail system in general and into the RO rail system in particular. With an integration of the MD rail system into the EU rail system in terms of operational procedures, time schedules, capacity allocation etc. the MD rail system can benefit from the recent years of technological and operational development of the EU rail system. This integration will provide better access to Danube ports and the port of Constanta, as well as to the EU Adriatic and East Sea ports.

Shortest connection from Odesa port towards the EU. The line from Odesa via Chisinau (in two alternatives) is the fastest way to connect the Odesa region and port with the EU economy. However, the best option is dependent on the geopolitical developments.

Integration of the MD economy into the EU economy. This is including the improvement of the border crossing procedures with the EU.

Integration into European Transport Corridor. As part of the future revised TEN-T regulation there will be opportunities for enhanced coordination in the medium and long-term development of the lines.

4.9.2.4 Threats

Transnistria situation continues. This impacts the rehabilitation and further development of the Moldovan economy in general and the transport/rail system in specific. Apart from delaying the implementation of the strategy, the economic cooperation with Ukraine would be impacted.

Rail system cannot be modernised and therefore will not be competitive. Other transport modes would overtake the demand and the Modal Split would develop against the strategic objective of environmental and climate protection.

Availability of private cars. With further economic development, the availability of private cars will increase, which provides a threat to the rail sector.

Development of road infrastructure. With increasing investments into the road sector, the rail sector will face strong competition in passenger and freight transport. As the liberalised road sector will also benefit from private investments, the rail sector will lose traffic.

5. Study objectives and criteria for the option analysis

Study objectives are divided into **general objectives**, resulting from the relevant EU and national policies and **specific objectives**, based on the outcome of the analysis conducted.

These objectives will form the basis for the selection of the preferred options for key parts of the Ukrainian and Moldovan rail systems. Selection criteria for the options analysis are defined in section 5.3.

5.1 General objectives

General study objectives are based on relevant EU and national policies and in line with the proposed integration of the Ukrainian and Moldovan rail systems. These are presented below.

5.1.1 Technical and operational integration of the Ukrainian and Moldovan rail systems into the EU, including ERTMS

A main study objective is to ensure the progressive integration of the Ukrainian and Moldovan rail systems into the EU. While the transition needs to be implemented as soon as possible, it should be effected in a staged manner, while considering the following aspects:

- Available resources. This includes both financial resources as well as other aspects such as the technical and administrative capacity of the stakeholders
- Ensuring the necessary capacity for current and anticipated demand and related rail traffic. At all the stages of integration, sufficient capacity should be provided to cover relevant passenger and freight functionalities
- Infrastructure investments should be accompanied by necessary operational and organisational measures. If the Ukrainian and Moldovan legal and organisational set-up is not adapted to EU requirements and the operations adjusted to foreseeable changes, the investments in infrastructure alone will not lead to effective integration

One of the key elements to achieve integration is ensuring rail interoperability. In that regard, compliance with the technical specification for interoperability (TSI) is essential.

Although a smooth transition ensuring proper functioning of the entire rail network in the two countries is required, including local and regional lines, the ultimate goal for operational integration should be a centralised traffic management system, based on ERTMS on the main corridors. For certain aspects, e.g., international freight logistics, centralised traffic management system should ideally involve all relevant countries sharing a specific corridor.

5.1.2 TEN-T network development

The European Commission has proposed to extend four TEN-T corridors into Ukraine and Moldova: North Sea – Baltic, Baltic Sea – Adriatic Sea, Rhine – Danube and Baltic Sea – Black Sea – Aegean Sea. In addition, a revision of the extension of the TEN-T rail core, extended core, and comprehensive network to Ukraine and Moldova is ongoing, to ensure that the relevant connections for both passengers and freight are properly addressed.

A principal objective of this study is to identify and suggest possible prioritisation of investments for the development of the rail TEN-T network, with a special focus on TEN-T corridors in both countries.

5.1.3 Increased competitiveness of the rail system

Rail plays a crucial role in the Ukrainian transport system and in support of economic and social needs. A competitive and efficient rail system will be key to maintaining and enhancing this role, thus, ensuring its sustainability. This is a key step to achieving further shift of demand from other modes, in particular for freight.

5.1.4 Provide a high level of operational safety

Ensuring high safety of passengers and freight is a must, both for those transported by rail and third parties involved, such as, pedestrians or cars crossing the rail lines. This should be a non-negotiable condition the highest priority for the foreseeable investments.

Rail is generally considered to be a relatively safe mode of transport. However, the recent accident in Greece and similar accidents that have occurred previously in other EU countries, prove that it is not enough to install modern signalling systems. For example, sufficient attention needs to be taken to ensure that those systems are properly utilised during the operational stage by adequately trained and sufficient personnel. Suitable maintenance should also be ensured.

5.1.5 Provide a high level of system security

Security is an essential aspect for the success of the rail system. On the one hand, this means the security of the passengers and freight transported and at stations, stops and their vicinity.

On the other hand, it also means security of the system as a whole, including IT, data subsystems and technology employed. The latter is especially relevant in the current situation, with an increased risk of cyberattacks, particularly in Ukraine.

5.1.6 Technical sustainability

Technical sustainability implies avoiding over-dimensioning of the rail system, to ensure that limited resources are rationally utilised, considering the expected demand and functionality of a certain line and/or station. It implies developing robust technical solutions, appropriate to actual needs.

5.1.7 Liberalisation of rail operations

Liberalisation of rail operations is an important tool to stimulate and optimise the use of the rail network, while enhancing the quality, punctuality, cost, and diversity of services. By liberalising operations, competition between operators is possible, allowing users to choose between different operators and prices for a range of services offered.

In the EU, liberalisation of the rail freight market is already a reality and in many EU countries the passenger services, especially for long-distance, have also been successfully open to competition.

To achieve liberalisation, a complete separation between the rail infrastructure manager and the passenger and freight operators is needed, as a minimum. In Ukraine and Moldova, this process is under way, but has not taken place yet.

5.1.8 Financial sustainability (CAPEX and OPEX)

Ensuring and improving the financial sustainability of the rail systems in Ukraine and Moldova is crucial to ensure its performance in the long-term.

Considering that the foreseen integration of both countries into the EU is likely to trigger a significant injection of funds for capital investments, it is essential that measures to improve financial sustainability at the operational stage are identified and put in place, since operations and maintenance are likely to be funded, to a significant extent, at the national level.

The aim should be to simultaneously reduce costs (mostly O&M) and increase revenues, ensuring a functioning network that enables efficient operation and competitive services.

5.1.9 Environmental and social sustainability

Rail and related intermodal transport are considered environmentally friendly modes of transport and thus their promotion is generally in line with the objective of achieving sustainability.

It is nonetheless necessary to ensure that the relevant environmental and social aspects are adequately considered at all stages of infrastructure development as well as at subsequent operational and maintenance stages.

In addition to usual environmental aspects to be considered (flora, fauna, emissions, water framework directive, protected areas, cultural heritage, etc.), it will be important that social aspects and potential impacts are adequately assessed, given in particular the impact of the ongoing war.

5.1.10 Climate proofing

Climate proofing for investments is a requirement to be considered in all stages of the project cycle. This is to ensure consistency with the Paris Agreement and EU climate objectives, i.e., consistency with a credible greenhouse gas (GHG) emission reduction pathway in line with the EU's new climate targets for 2030 and climate neutrality by 2050, as well as with climate-resilient development.

Climate proofing is a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects. The following figure summarises the climate proofing process on investments.

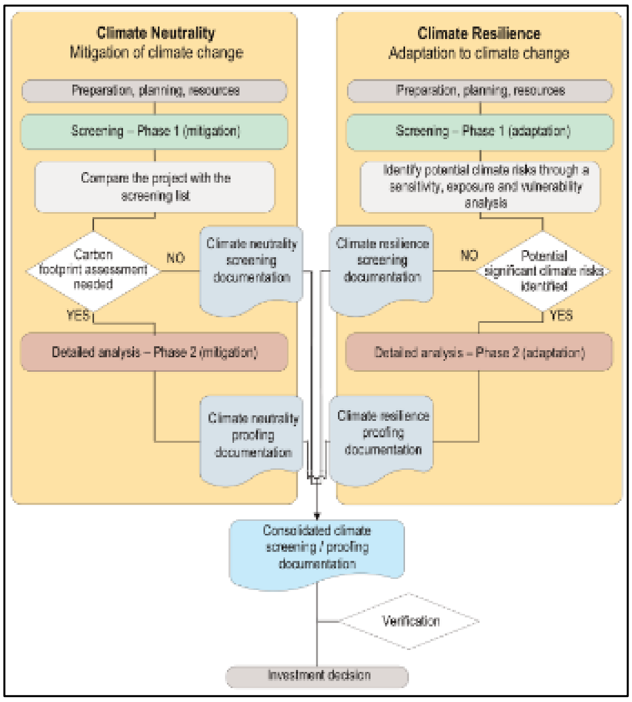


Figure 5.1: Climate proofing and the pillars on 'climate neutrality' and 'climate resilience'. Source: European Commission technical guidance on the climate proofing of infrastructure in the period 2021-2027, September 2021

5.1.11 Economic sustainability and circular economy

Transport is a demand derived from socio-economic behavioural mobility needs. Rail transport plays an essential role in satisfying economic needs in Ukraine, with a lesser, yet significant role and potential in Moldova.

Options and measures arising from this study should be focused on meeting current and anticipated needs of the countries concerned, helping also to tackle wider or local economic and social issues. It must also be ensured that any potential negative impacts from study measures can be identified and mitigated to the extent reasonable.

In line with EU policies and objectives, the future development of the rail system in Ukraine and Moldova should consider the circular economy principles in its design and procurement, construction, operation, and maintenance. This will be aimed at minimising waste and negative environmental impacts, whilst maximising use of secondary raw materials.

5.1.12 Supporting the recovery and the development of the Ukrainian and Moldovan economy

In Ukraine, recovery and further development of the economy once the war is over is crucial. The rail system has played an important role in the Ukrainian economy, in particular for freight connections between the industrial and agricultural production areas and the Black Sea Ports.

In order to continue playing a relevant role in the economic recovery and development, the rail system will need to adapt to the foreseeable changes in the economic and industrial landscape. The integration of the country in the EU and the expected impact on trade after the war will change economic flows and patterns in Ukraine, likely progressing closer to the west and further from the east.

In Moldova, the current role of the rail network in the economic development of the country is limited. However, EU integration jointly with modernisation of the rail system will improve accessibility to relevant markets and facilitate industrial development in the country.

5.2 Specific objectives

The specific study objectives, while in some cases linked to some of the strategic objectives above, are formulated based on the outcomes of the analysis conducted. Given the nature of the study, they are generally focused on issues related to the rail system.

5.2.1 Providing a suitable institutional and organisational basis for integration including the project delivery system

Organisational aspects can be a major constraint to effective integration at the operational and infrastructure level. Whilst a frequent issue for international traffic, constraints at the organisational level can also hinder operation and development of the rail system at the national level. In the framework of eventual transition to the 1435mm gauge and overall TSI compliance, it is highly desirable that opportunities to avoid these issues are identified and assessed properly.

5.2.2 Safeguarding operations

The analysis has proven that rail modal split for certain commodities in Ukraine is well above the EU average. This is due to different reasons, notably including the high density of the rail network, fairly attractive and affordable rail services, low income and car availability per head, bad condition of the road network and suitability of rail for the majority of transported freight.

The situation is completely different in Moldova where the modal split of rail is low. A similar situation applies to border crossing traffic in both countries.

The key to support the rails and avoid mode shift onto the road and other modes will be to safeguard the operational reliability of the system, for both passengers and freight. Among others, this implies that current capacities on the different rail sections should not be reduced when aiming at track gauge change.

In Ukraine, this aspect will also be linked to damages caused to the rail network by the ongoing war. Therefore, the priority should be to repair the damages and safeguard the operations for passengers and freight.

For example, if the capacity of an existing double track section with 1520mm gauge is reduced when developing new capacities for 1435mm gauge, part of the traffic may need to be diverted to other routes or modes, at least until a network of 1435mm gauge track is developed.

5.2.3 Limit operational disturbance during implementation

Ensuring the operational reliability of the rail system is key to retaining high rail mode split and demand.

Operational disturbances during implementation should therefore be limited to the extent possible, to prevent existing traffic shifting to other modes. If this is not adequately planned, it can be difficult to recover lost rail traffic, as evidenced in EU countries.

5.2.4 Increase operational resilience and efficiency

One of the problems faced by rail transport is its inherent lack of flexibility. In a situation where transition to a different track gauge is foreseen, if not carefully planned, this might be exacerbated.

In Ukraine, as shown in the conclusions of the analysis, the fact that the rail company is rigidly divided in six regional branches makes the operations even less efficient and resilient than usual. This may also create some issues in Moldova, where different regional branches also exist, but with a lower number of responsibilities and competences than in Ukraine.

Thus, to ensure the future sustainability and integration within the EU, the Ukrainian and Moldovan rail systems should maximise operational resilience and efficiency. This should be achieved whilst avoiding over-dimensioning, since this would jeopardise financial sustainability.

5.2.5 Support rail mode split

As indicated by the analysis, rail mode split in Ukraine is very high for passengers and certain freight commodities, when compared to most of EU countries. Safeguarding and increasing, where possible, the current rail mode share is a key objective that should be considered when planning the future integration of Ukrainian rails with the EU.

The situation is different in Moldova and regarding cross-border traffic in both countries, where rail mode share is low. In both countries, further integration with the EU is likely to increase rail modal split.

5.2.6 Increase of the rail BCP freight and passenger throughput capacity

The current throughput capacity of rail BCPs between Ukraine, Moldova and the EU is very low, limiting considerably the possibility to use rail for international traffic, particularly for freight. The throughput capacity at the main BCPs (Medyka/Mostyska, Dorohusk, Chop, etc.) is limited to six freight trains per day, as there are several limiting factors, including transhipment capacities, administrative procedures (border police, tax and customs, phytosanitary checks, etc.) traffic and information management, outdated equipment, or lack thereof, lack of staff, available infrastructure, and constraints, etc.

Based on the above and in order to facilitate achieving of many of the study objectives, increasing throughput and transhipment capacities at BCPs is a key short-term objective.

5.2.7 Ensure capacity, interoperability, reliability, and transmissibility[32] of major rail nodes

Analysis conducted indicated that the most relevant rail nodes for the transition to 1435mm in Ukraine and Moldova are L'viv, Kyiv, Odesa, and Chisinau. Ensuring their capacity, interoperability, and transmissibility (maintaining their strategic role post-transition), for both passengers and freight, is essential for a successful integration with the EU rail system.

The development of the rail nodes should be planned considering all the relevant functionalities. It should also be ensured that the transition to 1435mm gauge is implemented avoiding disturbance of the operations and ensuring enough capacity for each gauge at all stages of the transition.

Although all functionalities should be considered, main node functionalities should be identified for each of the nodes. Priority should be given to those functionalities when planning the future node development and when distributing available capacities.

Since the aim is to also increase the use of rail for international traffic, the situation at major nodes in the neighbouring countries is also a relevant aspect to be considered. While assessing nodes in the EU countries in detail is not part of the scope of this study, the main nodes in this respect have been identified and their transmissibility and available capacities are key aspects for the identification of suitable international routes, in particular for freight.

5.2.8 Improve accessibility to and from the main production and distribution facilities

Rail accessibility to and from the main production areas in Ukraine and Moldova, as well as important distribution facilities (such as maritime and inland waterway ports and large logistic areas) is not satisfactory in many cases.

In Moldova, the current condition of the rail network implies significant speed and operational restrictions. In Ukraine, the situation was better, but is has significantly worsened due to the impacts of the war.

Freight is a very important functionality for the railways also generating significant income for the rail infrastructure managers, hence supporting the future financial sustainability of the rail system. One of the first aspects to be considered to attract freight to the rails is to ensure good and reliable accessibility to the production and distributions areas.

[32] In this case, transmissibility of a node refers to the efficiency of circulation of through traffic, i.e., traffic transiting the node, via the node.

5.2.9 Improve accessibility to and from main distribution areas within the EU

Due to reduced accessibility to Black Sea ports, Ukraine has had to identify alternative routes for freight exports, agricultural products in particular. Several weaknesses have been identified in this regard, as highlighted in the analytical part of this study.

A key weakness is linked to the difficulty in accessing the main distribution areas in the EU by rail, such as the Baltic, Black and Adriatic Seas and the Danube ports.

Once the war is over and operations at Black Sea ports are resumed to their full extent by Ukraine, dependence on such connections will be lower. However, with an improved rail network integrated with the EU, for certain O/D pairs and specific freight commodities, the use of ports or land distribution centres in EU countries might continue.

Although this goes a bit beyond the scope of this study and no specific measures are proposed in this regard, this objective is included to ensure that measures proposed take this aspect into consideration.

5.2.10 Opening up the Ukrainian and Moldovan rail markets to up-to-date technologies

The analysis informing the study indicated that the rail systems in Ukraine and Moldova make extensive use of obsolete technologies, which renders them very inefficient and may jeopardise safety and security. Importantly also, existing organisational setups are very rigid and regionalised, which hinders implementation of new technologies requiring homologation and certification.

Therefore, opening up the rail markets to up-to-date technologies is essential for future development and EU integration of both systems. In addition to safety and security improvements, the use of new technologies will increase the capacity of the system and its operational flexibility.

5.2.11 Maximise interoperability of the two rail electrification systems

As shown in the analysis, in Ukraine two rail electrification systems (3kV DC and 25kV 50Hz AC) are currently in use. The neighbouring countries also have different electrification systems: Hungarian and Romanian lines are electrified with a 25 kV 50 Hz AC system, while in Poland 3kV DC is currently in use (rail Baltica is planned to be electrified with a 25 kV 50 Hz AC system). In Slovakia, like in Ukraine, parts of the network are electrified with a 25kV 50 Hz AC system and other parts with a 3kV DC system.

In the short term, maximising interoperability across the two electrification systems is necessary. In the mid to long-term, a decision on the preferred system should be adopted by Ukraine for the electrification of new rail lines (e.g., future 1435mm gauge lines).

In Moldova, the rail network is currently non-electrified in its entirety. However, should electrification of certain corridors be foreseen, all the above should also be considered.

5.2.12 Increase locomotive availability

The analysis conducted indicated a locomotive shortage (3kV DC, 25kV 50Hz AC, diesel for shunting operations) and confirmed the fact that the ones currently operating are old and outdated in both countries. In addition, the situation in Ukraine has worsened due to the war.

Increasing availability of locomotives is very relevant to improving the current rail systems. This should be strategically planned, considering the different situations regarding electrification, the different track gauges in Ukraine and Moldova compared to the EU and the current development of locomotives with alternative propulsion technologies, such as hydrogen, battery electric, etc. Locomotives for shunting operations and for maintenance are also essential and should be properly considered.

Due to the expected liberalisation of the rail sector in both countries, coordination with interested foreign and private passenger and freight operators will be necessary.

5.2.13 Increase gauge-specific wagon availability (passenger and freight)

As is the case for locomotives, availability of passenger and freight wagons is limited. This also applies to certain types of specialised wagons, such as hopper or tank wagons, on the EU side.

Increased availability of gauge-specific wagons should be provided considering the relevant O/D patterns and type of traffic (i.e., type of commodity for freight and speed profile for passengers). This will be very relevant in the future, if Ukraine and Moldova have a rail system with two track gauges, as it might define the preferable gauge on which they will run. The possibility to use wagons with variable gauge systems (such as SUW2000, TALGO, etc.) should also be considered.

Due to the expected liberalisation of the rail sector in both countries, it is necessary to coordinate the increase availability of gauge specific wagons with interested foreign and other private passenger and freight operators.

5.2.14 Increase driver availability and familiarisation with use of modern technologies

Availability of drivers has been also identified as an issue for both Moldova and Ukraine. In addition to addressing the current shortage, both existing and future drivers should be properly trained for the use of modern technologies, especially for signalling and communications, and the use of alternative fuel rolling stock.

5.2.15 Reduce journey time and increase level of service (LOS) for international rail passengers

International passenger traffic from and towards the EU in Moldova and Ukraine is mostly road-based. There are several factors influencing this, the low level of service and long journey travel time being two of the most relevant reasons.

Reducing the travel time and increasing LOS will be critical to increase the use of rails for international travel. In relation to journey time, delays at border crossings will have to be tackled to achieve this objective.

5.2.16 Increase reliability and reduce OPEX for international rail freight

The most relevant criteria for freight operators and logistic companies to select their preferred mode of transport are reliability and cost. Therefore, in order to render rail transport between the EU, Ukraine and Moldova competitive for freight, operational reliability and cost should be maximised and reduced, respectively.

5.2.17 Support intermodal transport

For certain freight commodities and small production areas, the use of rails on their own might not be a realistic solution. However, if a proper logistic chain that takes advantage of intermodality and combined transport is developed, the rails can also be considered as an alternative for part of the journey for certain categories of traffic that are not considered, in principle, best suited for rail on the entire trip.

One of the objectives of the integration of the Moldovan and Ukrainian rail systems in the EU should be to increase the use of the rails as part of intermodal and combined transport. For this, identification and improvement of the logistic chains with significant potential, especially in relation to the EU, is essential.

5.3 Selection criteria for the implementation of 1435mm corridors in Ukraine and Moldova

The selection criteria for the implementation of 1435mm corridors in Ukraine and Moldova have been defined based on the above extensive list of study objectives.

5.3.1 Operational capacity of the 1520mm network

Given the importance of the Ukrainian rail system for the national economy, impacts on the capacity of the rail system are crucial. This will be especially important for heavily utilised lines, where capacity should be maintained.

5.3.2 Operational capacity of the 1435mm network

The 1435mm network will be gradually developed, from West to East, connecting to / from main EU corridors and across existing nodes within Ukraine and Moldova. It will be essential that sufficient capacity is provided throughout the different phases of its development to accommodate the demand potential of the targeted functionalities, both on the different new sections and at the node level.

5.3.3 Operational speed of the 1435mm network

The Ukrainian rail system is operated at relatively low average operational speeds (30km/h for freight trains and 90km/h for passenger trains). Given the long distances involved, an increase in operational speed will be crucial for a successful trail system. This can be reached by a combination of measures, such as improved traffic management, rail sub- and super-structure, construction of new rail infrastructure, improved transhipment, and logistics management, etc. A unique opportunity in this regard will arise from the development of new 1435mm network and associated corridors.

5.3.4 Operational reliability, efficiency, and safety

Due to the low technological level of traffic management (interlocking system), the operational speed cannot be significantly increased. The improvement of the Ukrainian interlocking system to EU standards would have a significant impact on the operational reliability and efficiency and allows operation with higher speeds. Other elements having an impact on this criterion are crossing train paths, complexity of technical solutions, maintenance requirements, etc.

5.3.5 Project development time

Land purchase, extended environmental and administrative procedures, licensing, and permitting of new technical equipment, complex engineering design and weaknesses in the consultancy and construction sector, etc., may have a negative impact on the time necessary for project development and should be considered when adopting specific decisions on the development of the 1435mm network.

5.3.6 Project implementation time

Construction of complex engineering structures (tunnels, large bridges, etc.) or under difficult soil conditions, works within urban areas and rail nodes, implementation under operational conditions may all have significant negative impact on timescales and should meaningfully inform the development strategy for the new network.

5.3.7 Interruption of operations of the 1520mm system during implementation

In the event that current traffic cannot be maintained or redirected onto alternative routes during construction works, major disruption is likely to occur, leading to operational and wider impacts. Since the Ukraine economy is highly dependent on the rail system, this can hinder social and economic development, as well as severely limit network resilience. Double track lines are naturally less vulnerable to upgrading or transformation, however in case operation reaches the capacity limitations, the impact can still be significant.

5.3.8 Implementation cost – CAPEX

A high-level cost estimate has been carried out for the different options considered regarding he development of the new 1435mm network in Ukraine and Moldova. This has been based on generalised cost for substructure, superstructure, power supply, catenary, signalling, level crossings, etc. There may be major differences in overall investment cost depending on the routes and corridors developed and therefore the estimated CAPEX will be an important criterion in the option analysis.

6. Options analysis

6.1 Track gauge development

The rail system in Moldova and Ukraine comprises almost exclusively, except very short sections in the vicinity of some border crossing points, 1520mm track gauge. When aiming at the integration of both national systems within the EU, development of 1435mm gauge track(s) on defined corridors is to be envisaged.

The analysis conducted indicates that Ukraine has a relatively high rail mode share, concerning passengers and certain commodities in freight. It is therefore imperative that throughout the planned transition to 1435mm gauge, the system retains its ability to efficiently accommodate current levels of demand and operations, which has been reflected as a key study objective. On this basis, a rapid transition with a complete and seamless switch to 1435mm gauge is neither a desirable nor realistic option, also given Ukraine’s extensive and dense rail network. Hence, the option analysis presented below assumes that the rail system in Ukraine, will most probably combine 1520mm and 1435mm gauge tracks into the foreseeable future.

In Moldova, the situation is significantly different, with very low traffic on the rail for both passengers and freight. Moreover, the existing rail infrastructure is in bad condition and the rolling stock is outdated, leading to low speeds and a very unreliable system. Considering also that Moldovan traffic is more oriented towards Romania, the possibility of considering a full transition to a 1435mm track gauge system in the long-term should not be ruled out.

6.1.1 1520mm track gauge network

Prior to a 1435mm rail network being available, most of rail traffic in Ukraine and Moldova, especially freight, will have to rely on the existing 1520mm network. Therefore, the study has a key objective to safeguard operation for passengers and freight, including during the implementation of the measures. Importantly also, damage to the current rail network in Ukraine is constantly increasing due to the war, despite the efforts to repair them as soon as possible. Therefore, it is likely and a study assumption that significant further works on the current 1520mm network will be necessary after the war is over.

Thus, investments that allow for the continuous and effective operation of the 1520mm system will be crucial. This could include, for example, modernisation of damaged and outdated infrastructure, but also investments at border-crossing areas to improve their effective throughput capacity.

Nevertheless, bearing in mind the expected integration with the EU and the planned transition to 1435mm track gauge, it is recommended that when investing in the 1520mm network, such investments already consider a future potential transformation into the 1435mm gauge system by, for example, using polyvalent sleepers able to accommodate both gauges. This approach has been applied successfully in similar situations (e.g., Spain), with the difference in cost of such sleepers being insignificant.

The possibility to develop polyvalent sleepers for Ukraine and Moldova needs to be assessed in a specific study, and in coordination with the relevant manufacturers. In section 6.6, an example of polyvalent sleepers using baseplate-based rail fastening system is shown. Its adequacy to the Ukrainian and Moldovan cases needs to be further assessed.

6.1.2 1435mm track gauge network

A gradual transition to a 1435mm rail network in Ukraine and Moldova is envisaged as the core measure in the integration with the EU rail system. Sustained use and ultimate success of 1435mm rail infrastructure for freight in Ukraine and Moldova is likely to be triggered by the existence of several corridors that accommodate important desire lines, creating a network effect.

Until this network effect is achieved, ensuring the capacity of the 1520mm rail network and the transhipment facilities are key to safeguard operations. Thus, the aim should be the introduction of 1435mm tracks with a minimal reduction of the existing 1520mm operational capacity in relevant corridors.

Further development of the 1435mm line infrastructure in Ukraine and Moldova would also require major reorganisation at the existing rail nodes. Therefore, a concept or a feasibility study, etc., for 1435mm line development should also consider the reorganisation of adjacent rail nodes (e.g., L'viv, Kyiv, Chisinau, Kharkiv, Dnipro, etc.), ensuring efficient operation of both systems (1520mm and 1435mm), as well as further seamless transformation of the Ukrainian and Moldovan rail systems.

The development of transhipment facilities (intermodal and inter-gauge) will be essential to accommodate this transition and therefore should be strategically planned (the development of node studies and a logistic concept for Ukraine and Moldova is recommended in this regard).

Ensuring the integration and maximising the interoperability between the 1520mm and 1435mm systems will be key for the success of the latter. This was pointed out by the Ukrainian authorities in their comments to the interim reports:

"An equally important part of the analysis should be the question of integration (rail connectivity) of the corridor to the existing rail freight and passenger network of 1520 mm on the territory of Ukraine".

(Comments from Secretariat of the Cabinet of Ministers of Ukraine and Ministry of Infrastructure of Ukraine 21.11.2022)

6.1.3 Strategic options for future gauge development in Ukraine and Moldova

Three strategic options for the future rail gauge development in Ukraine and Moldova have been assessed.

6.1.3.1 Rehabilitation and further development of a single 1520mm network in Ukraine and Moldova

As the further integration of the Ukrainian and Moldovan economies into the EU economy is crucial for the integrity and economic development of both countries, it is expected that the traffic between the countries and the EU will increase considerably. To retain and develop a 1520mm network only would require significant investment in transhipment facilities and/or rolling stock-based solutions, bridging the gauge difference between the 1520mm and 1435mm systems.

Moreover, the technological gap is rapidly widening between the EU rail system and the Ukrainian and Moldovan systems due to the disparity in investment levels (interlocking systems, traffic management, etc.) and the impact of the war. Lower levels of service and outdated technology associated with 1520mm has resulted in an uncompetitive transport mode when compared with increasing private car ownership.

This strategic option was not further pursued.

<u>Pros:</u>

- Existing infrastructure system
- Existing but outdated rolling stock

<u>Cons:</u>

- Transhipment losses at the border between EU and Ukraine/Moldova
- Requires large investment into transhipment facilities and/or rolling stock-based solutions
- Lower technological level compared to the 1435mm system
- Lower Level of Service compared to the 1435mm system
- Lack of competitiveness with other transport modes (road, air, inland, etc.)
- Low level of operational integration into the EU rail system
- Reduced system performance during rehabilitation

6.1.3.2 Full transformation of the existing 1520mm network into a 1435mm network

Given the size of the Ukrainian rail system, the full transformation would require enormous financial resources and very long delivery timeline. During the gradual implementation of this transformation, rail operations would be significantly impacted, as the two systems are not compatible.

The 1520mm system, with its larger train development length (1000 m) and higher axle load (25 t), is more suitable for the transport of large quantities of heavy bulk traffic (ore, coal, gravel, etc.). Hence, the transformation would lead to a reduction in system capacity. Moreover, existing rolling stock would have to be adequately replaced.

This strategic option was not further pursued. However, in Moldova, depending on the future evolution of the rail traffic, a complete long-term transformation to 1435mm could be an option.

<u>Pros:</u>

- No transhipment losses
- High Level of Service
- High technological level
- High level of competitiveness with other transport modes (road, air, inland, etc.)
- Operationally fully integrated into the EU rail system

<u>Cons:</u>

- Extremely high implementation cost
- Reduced capacities for heavy bulk freight
- Full replacement of rolling stock necessary

6.1.3.3 Development of a backbone 1435mm network, while maintaining the existing 1520mm network largely operational

The development of a separated 1435mm network focussing on the functionality of fast passenger (international and national IC trains) and fast freight (container, etc.) services. This allows to use the strength of the 1520mm system in relation to its capacities for heavy bulk freight and coverage for local and regional trains. The 1435mm system would, therefore, focus on the areas with the highest populations and potential for development of new industries, which interact with the EU economy, while the 1520mm system would focus on areas where bulk freight is dominating.

<u>Pros:</u>

- Reduced transhipment losses
- High Level of Service for fast traffic
- High technological level for the 1435mm system
- Increased competitiveness with other transport modes (road, air, inland, etc.)
- High level of operational integration into the EU rail system
- Disruption of system performance during rehabilitation of the 1520mm system is minimised
- Rolling stock can be gradually replaced

<u>Cons:</u>

- Operation of two separate systems, implying higher operational and maintenance cost
- Operational interface issues for common lines/alignments of both systems

Running two networks in parallel has several risks, mainly linked to the interaction of both networks in sidings, at the stations and marshalling yards and in crossings. It also implies additional operation and maintenance cost as specific rolling stock (including rolling stock for maintenance and marshalling activities), and maintenance facilities would be needed for each network. Those issues need to be adequately addressed and a detailed financial analysis is necessary to ensure the sustainability of this solution.

However, the pros of this strategy outweigh the cons. Therefore, this is considered the preferred strategy for the EU integration of the Ukrainian and Moldovan rail systems.

6.1.4 Options for the modernisation of the Moldovan and Ukrainian rail networks aiming at their integration within the EU rail system

With all those considerations, several options for the development of the rail network aiming at its integration within the EU rail system were developed. The assessed options include nine infrastructure development options and one operational option (use of variable gauge rolling stock). The options considered are described below.

Due to the significant investments needed to develop the backbone 1435mm network in Ukraine and Moldova, none of the nine infrastructure options considered includes the development of a new double-track 1435mm line in a separate alignment. In the Feasibility Studies for the different corridors, this option could be considered if a significant 1435mm demand potential is identified. However, it is recommended to focus first on developing a 1435mm backbone network in both countries.

Similarly, the study options do not include the development of high-speed rail lines in Ukraine and Moldova. Option 8 envisages developing a new 1435mm track in a separate alignment to increase speed. However, it is foreseen as a conventional line, not a high-speed line. Developing high-speed rail lines requires detailed studies, including a robust demand forecast, that go beyond the scope of this study.

Option 0: Use of variable gauge rolling stock

Variable gauge rolling stock is available in the market and widely used for passenger services, with various available technologies (TALGO, SUW2000, DB AG/Rafi, etc.), but not all of them being compatible with the others. this rolling stock is equipped with specific and complex axles, allowing to change the distance between wheels.

The gauge-changing facilities consist of a device that “forces” the gauge adjustment of the wheels. It consists of a pair of “running” rails that gradually vary in width between the two gauges, combined with other rails and levers to perform the wheel gauge change.

Figure 6.1: Gauge-changing facility. Source: prepared by Egis for JASPERS

For freight trains these technologies are mostly under development, most of them still at prototype or testing level. Moreover, a specific fleet of wagons with expensive bogies would need to be available, as well as specific gauge-changing facilities.

Based on the above, variable gauge rolling stock could, in principle, be a suitable solution for passengers, particularly in the short-term, until a 1435mm network is developed. Its implementation for some services and along some corridors could significantly shorten trip length for international passenger traffic.

However, variable gauge technologies require significant investments from rail operators. Currently, only a few passenger vehicles in Ukraine are equipped with SUW2000 (circa eight units – no information was available of whether they are still in operation). If the rail market is liberalised in Ukraine and Moldova, foreign rail operators with already available variable gauge vehicles could also be interested in providing such services.

Nevertheless, it should be considered that it will also be necessary to have the equipment for the change of the gauge installed within the relevant border crossing areas (there is an existing one for the Polish SUW2000 system installed in the Mostyska BCP). Therefore, further investment in gauge-changing facilities would be needed in both countries.

Option 1: "Status quo" 1520mm double-track rehabilitation

Option 1 considers limited rehabilitation works on existing 1520mm tracks, to resolve existing speed restrictions, poor rail infrastructure condition, war damages, etc. Thus, it does not imply a comprehensive rehabilitation of the entire line/section, as works would be limited to the specific parts in which those problems have been identified. Performances (speed, capacity) would be restored to the original design parameters without any improvement.

Use of polyvalent sleepers for a potential future transformation to 1435mm could be considered when implementing this option, depending on the scope and location of the rehabilitation. It should be assessed on a case-by-case basis.

Although it is not considered as an independent option, this option also applies to existing single-track 1520mm sections. The implementation cost of a single-track section would be proportionally lower.

Option 2: 1520mm double-track upgrading

This option considers a full refurbishment of one of the existing 1520mm tracks, including an improvement of the signalling system with shorter signalling blocks (1 km instead of 2.5 km[33]) and implementation of new level crossings with barriers. Original design and layout would be kept without any specific work for track realignment.

Use of polyvalent sleepers for a potential future transformation of this track to 1435mm could be considered when implementing this option.

Although it is not considered as an independent option, this option also applies to existing single-track 1520mm sections. The implementation cost of a single-track section would be proportionally lower.

Option 3: 1520mm single-track upgrading; 1520mm to 1435mm single-track transformation

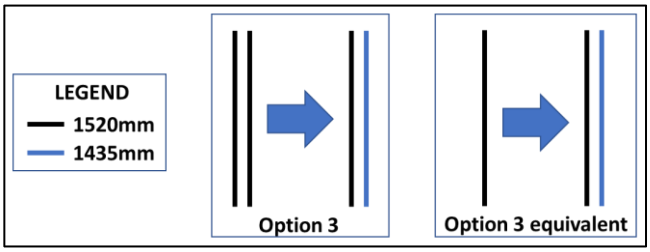
This option considers a full refurbishment of one of the existing 1520mm tracks, including an improvement of the signalling system with shorter signalling blocks (1 km instead of 2.5 km) and implementation of new level crossings with barriers. Original design and layout would be kept without any specific work for track realignment.

Use of polyvalent sleepers for a potential future transformation of this track to 1435mm could be considered when implementing this option.

The second track would be transformed from 1520mm to 1435mm track gauge while maintaining the existing right of way. A modern signalling system with ECTS level 2 or 3 would be foreseen for this track (the options analysis regarding the preferred signalling system for the 1435mm network is developed in section 6.4).

Although it is not considered as an independent option, modernisation of an existing single 1520mm (or dual-gauge) track and development of a parallel 1435mm track has been considered equivalent to this option.

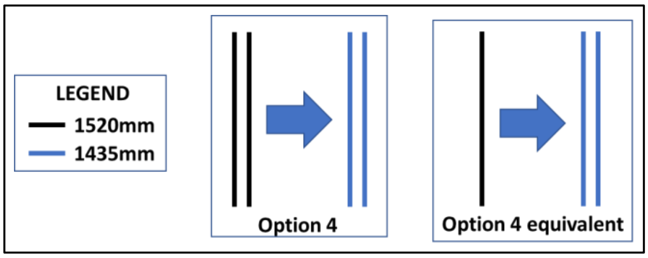
[33] This is an assumption used in this study for the cost estimate, which has been considered for the modernisation of the 1520mm tracks in all options, except Option 1. The feasibility of reducing the block distance in the existing 1520mm network would have to be assessed on a case-by-case basis in the specific Feasibility Studies for the modernisation of each corridor.



Option 4: 1520mm to 1435mm double-track transformation

Option 4 considers the transformation of both existing 1520mm tracks to 1435mm gauge. The existing right of way, land and structures would be re-used for the implementation of the new 1435mm tracks replacing the existing 1520mm tracks. A modern signalling system with ECTS level 2 or 3 would be foreseen for both tracks.

Although it is not considered as an independent option, transformation of an existing single 1520mm (or dual-gauge) track to 1435mm and development of a parallel 1435mm track has been considered equivalent to this option.

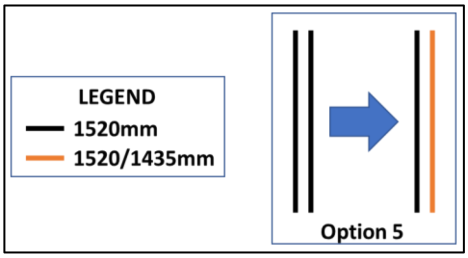


Option 5: 1520 single-track upgrading; 1520mm to 1520/1435mm single-track/dual-gauge transformation

This option considers a full refurbishment of one of the existing 1520mm tracks, including an improvement of the signalling system with shorter signalling blocks (1 km instead of 2.5 km) and implementation of new level crossings with barriers. Original design and layout would be kept without any specific work for track realignment.

Use of polyvalent sleepers for a potential future transformation of this track to 1435mm could be considered when implementing this option.

The second track would be converted to dual 1520/1435mm gauge. This track would have to be implemented with a signalling system compatible with the other track (for 1520mm trains) and with ECTS level 2 or 3, as the suggested signalling system for the 1435mm network.



A dual-gauge track is composed of specific sleepers able to accommodate two tracks on the same way, one being 1520mm and the second being 1435mm. Generally, it can consist of three rails, with both gauges sharing a common rail or of four rails, with each gauge having two independent rails.

Three-rail dual-gauge

This solution is widely applied in several countries like Spain. However, the difference between the Ukrainian/Moldovan gauge and the standard-gauge is too small to allow for this solution.

Figure 6.2: Three-rail dual-gauge track. Source: Spanish Ministry of Transport and Adif

Four-rail dual-gauge

Four rail solutions for 1520mm and 1435mm dual-gauge tracks are configured with different centreline for the tracks in each gauge, e.g., rail 1 and 3 would be used by 1520mm vehicles, whereas rails 2 and 4 would be used by the 1435mm ones - "interlaced tracks" as shown in the figure below. Developing four-rail dual-gauge tracks creates complex constraints to be solved due to this asymmetry, combined with the width difference of the rolling stock, as for example, catenary axis and position, signalling equipment, free structural profile of structures, and stations (particularly regarding platforms). It can also have an impact on the rolling stock itself, requiring specific solutions regarding pantograph width.

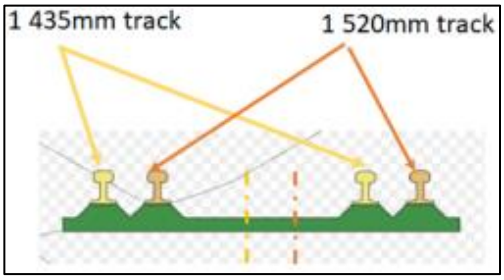
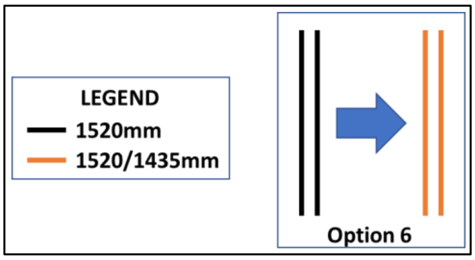


Figure 6.3: Four-rail dual-gauge track scheme. Source: prepared by Egis for JASPERS

This solution is currently used in Moldova and Ukraine in the vicinity of the border crossing areas and is the only feasible one for these countries.

Option 6: 1520mm double-track to 1520/1435mm double-track/dual-gauge transformation

Option 6 considers full transformation of the existing 2 tracks 1520mm to dual 1520/1435 mm gauge tracks. Both tracks would have to be implemented with the signalling system compatible with the existing one (for 1520mm trains) and with ECTS level 2 or 3, as the suggested signalling system for the 1435mm network.



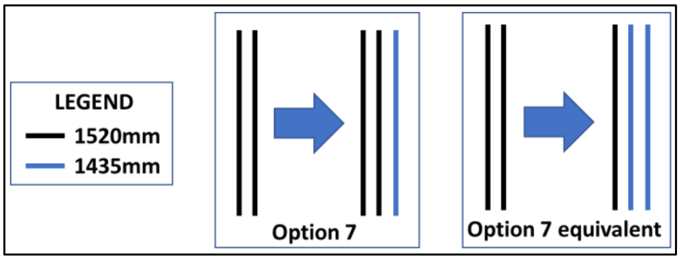
Option 7: 1520mm double-track upgrading; 1435mm single-track parallel new construction

This option considers a full refurbishment of existing 1520mm tracks, including an improvement of the signalling system with shorter signalling blocks (1 km instead of 2.5 km) and implementation of new level crossings with barriers. Original design and layout would be kept without any specific work for track realignment.

Use of polyvalent sleepers for a potential future transformation of these tracks to 1435mm could be considered when implementing this option.

In addition, running in parallel to these two existing 1520mm tracks, a new 1435mm track would be added. A modern signalling system with ECTS level 2 or 3 would be foreseen for this track.

Although it is not considered as an independent option, a double-track section for which it is foreseen the modernisation of one of the existing 1520mm (or dual-gauge) tracks, transformation of the other one to 1435mm and development of a parallel 1435mm track has been considered equivalent to this option.

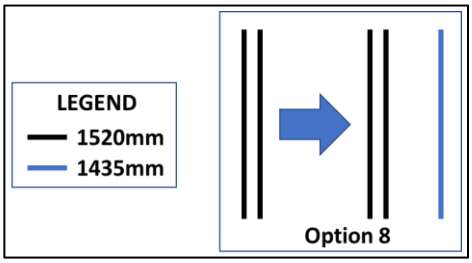


Option 8: 1520mm double-track upgrading; 1435mm single-track independent new construction

Implementation of a full refurbishment of existing 1520mm tracks, including an improvement of the signalling system with shorter signalling blocks (1 km instead of 2.5 km) and implementation of new level crossings with barriers. Original design and layout would be kept without any specific work on track realignment.

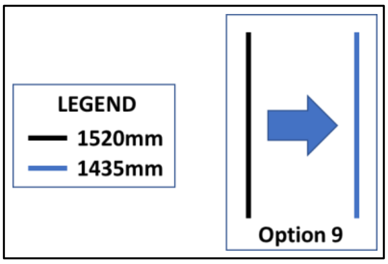
Use of polyvalent sleepers for a potential future transformation of these tracks to 1435mm could be considered when implementing this option.

In addition, running independently to these two existing 1520mm tracks, a new 1435mm track would be added. The new track would run independently from the existing right of way, if needed, to allow for a higher design speed. A modern signalling system with ECTS level 2 or 3 would be foreseen for this track.



Option 9: 1520mm single-track to 1435mm transformation

Implementation of a full transformation of an existing single-track 1520mm to 1435mm gauge. The existing right of way, rail land and structures would be re-used for the implementation of the new track. A modern signalling system with ECTS level 2 or 3 would be foreseen for this track.



6.1.5 Cost estimate for infrastructure options

6.1.5.1 Implementation cost

To assess the suitability of each of the proposed options cost estimates were prepared of a typical linear km of single-track of main line.

The following components have been considered:

- Track substructure
- Drainage - main line
- Track superstructure
- Turnouts
- Level crossings
- Sidings
- Supply and installation of fencing (for high speed only)
- Small bridges
- Signalling - ETCS - interlocking - telecommunications
- Overhead Catenary System (OCS)
- Power supply

For the majority of these components, unit prices are considered for “1 linear-km of single-track”. However, for a few, such as turnouts, level crossings and bridges, unit of prices are expressed for a component unit in the format of “number for 1 km”. For example, “0.1” for level crossings means that, on average, it is considered that there is 1 level crossing every 10 km (so 0.1 for 1 km).

For construction / installation / transport, either a usual rate of 35% has been applied or specific costs have been calculated (e.g., for track substructure and superstructure). An additional overhead cost for project management and design of 5% and 15% contingencies have been considered for each option.

Two different types of terrain have been considered for the estimate:

- Flat terrain: Standard situation with low gradients
- Heavy terrain (e.g., area of Carpathian Mountains): Heavy gradient, lot of curves, some of them narrow with speed restrictions, large and heavy volume of embankments, lots of structures, retaining walls, etc.

For the "heavy terrain", a sensitivity impact has been applied to the unit price of each component compared to the "flat terrain". For example, for track substructure, it has been considered that the unit price is 1.5 times the one calculated for the "flat terrain", due to more difficult track alignment with more quantities / volumes of sub-layers, etc.

Additionally, the following considerations are important regarding the estimate for each option:

- Except for option 9, the cost calculation for all other options considers that the current situation is an existing 1520mm double-track section. Thus, the cost of options 1 and 2 for existing single-track sections would be proportionally lower
- Similarly, the following simplifying assumptions are made regarding the estimate for the following combinations, not covered by any of the nine options:
  - If the proposal for an existing single-track section is to modernise the existing 1520mm (or dual-gauge) track and develop a parallel 1435mm track, the cost of option 3 has been considered
  - If the proposal for an existing single-track section is to transform the existing 1520mm (or dual-gauge) track to 1435mm and develop a parallel 1435mm track, the cost of option 4 has been considered
  - If the proposal for an existing double-track section is to modernise one of the existing 1520mm tracks, transform the other one to 1435mm and develop a parallel 1435mm track, the cost of option 7 has been considered
- For this typical cost estimate per linear km of single-track, no larger structures (long bridges, tunnels, viaducts, marshalling yards, large stations) or grade separated road crossings with over/underpasses have been considered. This would significantly increase the cost in the sections requiring those components and should be considered in detail at design stage. However, in section 7 of this study, for the calculation of the total estimated cost per alternative, a generalised cost for long tunnels and bridges has been considered
- GSM-R / FRMCS has not been considered in this cost estimate because it is assumed that it will be installed at network level and not individually for each section
- It has been considered that the new 1435mm network will be developed with ETCS level 3. However, it should be noted that the cost assumed for ETCS level 3 is a rough estimation, since this solution is currently being implemented only at prototype level and thus there are no robust cost references available
- The estimate for all the options includes electrification with a 25kV 50Hz AC system. This means that the cost for the modernisation of non-electrified sections or their transformation to 1435mm envisages electrification
- For simplification, land acquisition costs have not been considered. Land acquisition would represent an extra cost (especially for option 8), plus be a possible cause of significant delays

- In the options that include modernisation of existing 1520mm tracks, the use of polyvalent sleepers could already be considered, allowing for a future 1435mm conversion. This additional cost has not been included and would have to be considered at design stage according to more accurate studies from sleeper providers

The following table shows the resulting cost estimate for each option.

Option	Cost per kilometre flat terrain (Mio EUR)	Cost per kilometre heavy terrain (Mio EUR)
Option 1	0.998	1.137
Option 2	3.632	4.159
Option 3	4.153	4.854
Option 4	4.314	5.051
Option 5	5.600	6.326
Option 6	7.357	8.219
Option 7	5.592	6.797
Option 8	6.158	7.184
Option 9	2.330	2.736

Table 6.1: Implementation cost estimate per kilometre for each option. Source: prepared by Egis for JASPERS

In conclusion when comparing the cost of options 2 to 9, the most expensive is Option 6, confirming that dual-gauge solutions are much more expensive to implement (although the cost of Option 8 could go above it on certain lines, if the land acquisition cost is considered). The cheapest one is Option 9 as it implies only a single-track modernisation. Options 7 and 8 with three tracks are, logically, more expensive to implement (especially Option 8 as one track is in a separate alignment) than options 2, 3 and 4. The cost difference between options 2, 3 and 4 is mostly related to the proposed signalling system for each of them.

Due to the high level of uncertainty at this stage and the generalised approach to the cost estimate, it is reasonable to consider a ±15% variance to the values shown in table 6.1.

As shown in the table below, the cost components that have the highest impact on the estimate are track superstructure, signalling, power supply and OCS (considering that these estimates do not include the land purchase cost nor the cost for large structures). Although the table shows the results for the flat terrain only, the cost components with the highest impact are the same for heavy terrain.

Easy profile cost distribution per component	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
TRACK SUBSTRUCTURE	2%	5%	4%	4%	3%	2%	5%	5%	4%
DRAINAGE- MAIN LINE	1%	1%	1%	1%	1%	1%	1%	1%	1%
TRACK SUPERSTRUCTURE	34%	31%	26%	24%	33%	35%	29%	26%	22%
TURNOUTS	1%	1%	1%	1%	1%	2%	1%	1%	1%
LEVEL CROSSINGS	0%	0%	1%	1%	1%	0%	1%	1%	2%
SIDINGS	2%	1%	4%	1%	2%	1%	2%	2%	4%
SUPPLY AND INSTALLATION of FENCING (for high speed only)	0%	0%	0%	0%	0%	0%	0%	0%	0%
SMALL BRIDGES	3%	1%	1%	1%	1%	1%	2%	2%	1%
SIGNALLING - ETCS - INTERLOCKING - TELECOMMUNICATIONS	16%	21%	26%	32%	25%	28%	25%	25%	33%
OCS	10%	11%	9%	9%	9%	8%	10%	9%	8%
POWER SUPPLY	16%	12%	10%	10%	8%	6%	8%	11%	9%
OVERHEAD COSTS	17%	17%	17%	17%	17%	17%	17%	17%	17%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6.2: Flat terrain cost distribution per component. Source: prepared by Egis for JASPERS

6.1.5.2 *Operation and maintenance cost (O&M)*

Unlike for the implementation cost, no detailed calculation of the O&M cost has been performed. In this case, only general qualitative considerations have been used to estimate the O&M cost for each option, leading to their categorisation in four groups[34] (low, medium, high, and very high). To distribute the options in these four categories, the following aspects have been considered:

<u>Number of tracks</u>

It is, of course, more expensive to operate and maintain a rail line that has a higher number of tracks. However, some of the components are independent of the number of tracks and there are some synergies once you have more than one track. Thus, for example, the O&M cost for a double-track section is not double the cost of a single-track section.

<u>New/modernised or not modernised</u>

A new line or a fully modernised line is cheaper to maintain than an old or just partially refurbished line (assuming that the modernisation keeps the same parameters as before). This is because major refurbishment works, or new components, need reduced average maintenance cost for a longer period. Thus, especially in the years following the construction/modernisation, O&M costs would be significantly lower.

<u>Speed</u>

The faster a rail line is, the more expensive it is to operate and maintain, mostly because of the track superstructure (need to maintain the proper geometry) and the Overhead Catenary System (OCS). Moreover, both components have a significant impact on the total O&M cost.

It is estimated that the maintenance work periodicity to ensure the required geometric quality of the track is about 4.5 years for a speed of 120 km/h. For higher speed, it is therefore possible to estimate, based on experience in Europe, that this frequency would be increased as follows:

- For a speed of 160 km/h, track geometric quality maintenance works every 2.5 years
- For a speed of 200 km/h, track geometric quality maintenance works yearly

<u>Dual-gauge</u>

Dual-gauge solutions require more intensive maintenance of the track superstructure, switches and turnouts, and the OCS, especially in the four-rail configuration, which is the only one feasible for these countries. This means that dual-gauge solutions have a much higher O&M cost due to:

- Track superstructure elements need more frequent track geometric quality maintenance, specially switches and turnouts
- Only universal tamping machines can be used, creating a limitation in performance
- Welds are more complex to execute
- Specific care regarding the maintenance of the OCS is needed due to the need to accommodate rolling stock of both gauges which, will have a different contact point, as the line-centre is not the same for both gauges

[34] This categorisation is not based on a specific cost threshold. It is qualitative and its purpose is to provide a rough idea of the O&M cost implications of each option. This categorisation has not been used to select options.

Signalling

The cost of operating and maintaining the signalling system is linked, to a high-extent, to the amount of on-ground equipment necessary. Thus, the shorter the block distance is, the more expensive it is.

If ETCS L3 is implemented (with virtual blocks), a significant O&M cost reduction is expected due to a much lower need to install on-ground equipment.

Structures

Larger structures and stations require a significant O&M cost. However, as those elements are not considered in the investment cost estimate for a typical linear km developed for the nine infrastructure options, it does not have an impact in the categorisation of those options regarding the O&M cost.

With all these considerations, the following table shows the categorisation of the options regarding the O&M cost.

Option	O&M cost estimate
Option 1	High
Option 2	Medium
Option 3	Medium
Option 4	Medium
Option 5	Very high
Option 6	Very high
Option 7	High
Option 8	Very high
Option 9	Low

Table 6.3: Categorisation of the options regarding the O&M cost

6.1.6 Assessment of Options

A detailed assessment of the suitability of all options described above is the subject of this section, results in a reduction of the number of options finally considered for the implementation of the 1435mm network in Ukraine and Moldova.

A basic principle for the development of the new 1435mm network, is to separate operations of the new network as much as possible from the operations on the existing 1520mm network, to minimise the crossing between both and reduce the interfaces and redundancies (e.g., possibility to implement different signalling systems in both networks).

Conclusion regarding the use of variable gauge rolling stock

The use of variable gauge rolling stock is not to be relied upon as a long-term solution, considering the current uncertainties regarding its suitability for freight wagons, the additional operational and maintenance cost of the vehicles and the need to train the personnel in the use of those technologies. However, in the short-term it might be a feasible option for specific cases.

Another possibility is to use this solution in the transition while the 1435mm network corridors are being developed, e.g., when the 1435mm line is built from the Polish border to Kyiv, international passenger services to Kharkiv could be operated with variable gauge vehicles, which would change from 1435mm to 1520mm in Kyiv, before the 1435mm network is extended to Kharkiv.

Conclusions regarding Options 1 and 2

Options 1 and 2 do not foresee development of a 1435mm track. Consequently, they are only relevant for those corridors/sections in which a transformation to 1435mm is not envisaged in the short to mid-term. Option 1 should be limited to specific interventions to maintain the system operational (mainly repair of war damages), but option 2 is recommended, when possible, as it would improve the performance of the lines/corridors in a more comprehensive way. As mentioned above, in some cases, implementation of these options using polyvalent sleepers is recommended to facilitate a potential future transformation to 1435mm.

Conclusions regarding Option 3

This is the cheapest option to implement a 1435mm gauge track, excluding Option 9. It is also one of the cheapest in O&M cost and has very low implementation risks, as there is no need to add an additional track or purchase land.

However, it reduces the existing operational 1520mm gauge capacity significantly (circa 70% lower), while providing only a single-track for 1435mm. Thus, this option should mostly be considered in sections with existing and future 1520mm traffic but with a low-capacity utilisation since the overall section capacity would be significantly reduced. It also implies possible issues regarding operational reliability, efficiency, and safety since the mix of traffic from different gauges would be expected to occur in certain areas.

A high impact on operations during implementation could be envisaged for this option.

Conclusions regarding Option 4

This option is the only one that implies a future double-track 1435mm gauge. Thus, it provides the highest capacity for the functionalities foreseen for that gauge at a low implementation and O&M cost. As Option 3, it has very low implementation risks as there is no need to add an additional track o purchase land. It also implies a good operational reliability, efficiency, and safety since no mix of traffic from different gauges would occur.

However, it eliminates the existing 1520mm tracks from these sections and thus, it should only be considered for sections in which 1520mm is not expected to be relevant in the future (or where an alternative corridor for the 1520mm traffic exists) and where significant 1435mm traffic is envisaged.

A high impact to operations during implementation could be envisaged for this option.

Conclusions regarding Options 5 and 6

Dual-gauge tracks are far more expensive to implement, operate and maintain, as shown in the previous chapters. Moreover, there are other aspects that make operation of dual gauge tracks less efficient:

- For the same number of tracks, they provide a lower capacity than single-gauge tracks
- Dual-gauge sleepers are circa 30% heavier than polyvalent sleepers
- In dual-gauge sections, only axle counter systems are recommended to be used for train protection
- Switches and turnouts:
    - Are very complex and need to be designed specifically. In addition, speed restrictions on the main and side tracks are likely to be needed in those areas

    - They require continuous maintenance as they lose their needed geometry very easily

- It is likely that, due to the significant difference in the centre-line for both gauges, the installation of Eurobalises would not be possible

- In stations in which passenger trains of both gauges would stop, the distances between the train and the platform would be different for both gauges, which can be an issue for the trains of one of the two gauges

- The maximum speed in dual-gauge sections is circa 180 km/h, according to the Spanish experience

On the positive side, dual-gauge solutions allow operation of rolling stock of two gauges with less space requirement, which can be useful in certain cases such as urban areas or already existing engineering structures. In those areas, extending the width of the platform would imply significant additional costs and long procedures for the purchase of the relevant land.

Conclusions regarding Option 7

This option increases the overall capacity of the section, as it keeps the existing 1520 mm double-track, with an increased capacity due to the improvements to the signalling system, while offering additional capacity for the 1435mm traffic with the new single-track. It is the least costly option with a triple-track configuration.

Implementation risks for this option are higher than for options 3, 4 and 9, since an additional track is added, but not significantly higher, since it is foreseen to be constructed next to the existing two tracks, thus with minimum land purchase needs. It also implies possible issues regarding operational reliability, efficiency, and safety since a mix of traffic from different gauges would be expected to occur in certain areas.

Some impact on operations during implementation could be envisaged for this option, but not a significant one.

Conclusions regarding Option 8

This option increases the overall capacity of the section, as it keeps the existing 1520 mm double-track, with an increased capacity due to the improvements to the signalling system, while offering additional capacity for the 1435mm traffic with a new single-track. It is the only option that allows for a significant increase of the design and operational speed, beyond the one provided by the improvements to the signalling system.

It is one of the most expensive options. Implementation risks for this option are the highest, since an additional track is added outside of the existing railway land envelope thus inducing significant land purchase. It also implies possible issues regarding operational reliability, efficiency, and safety since a mix of traffic from different gauges would be expected to occur partially in the areas where the three tracks would run in parallel.

Some impact to operations during implementation could be envisaged for this option in areas where the three tracks would run in parallel, but not a significant one.

Conclusions regarding Option 9

This option is the least costly way to develop a 1435mm gauge track. As for Options 3 and 4, it has very low implementation risks as there is no need to add an additional track or purchase land. It also implies a good operational reliability, efficiency, and safety since no mix of traffic from different gauges would occur.

However, it eliminates the existing 1520mm track from these sections while providing only a single 1435mm track. Thus, it should only be considered for sections in which 1520mm is not expected to be relevant in the future or where an alternative corridor for the 1520mm traffic exists.

A high impact to operations during implementation could be envisaged for this option.

The preferred way forward

The use of variable gauge rolling stock (Option 0) is considered feasible only as a short-term solution for passengers to extend the benefits of the 1435mm network further in Ukraine. For Moldova, it is not a feasible option, due to the low level of passenger traffic beyond Chisinau.

The options that consider implementation of 1 or 2 dual-gauge tracks - Options 5 and 6 - are not recommended for implementation on long rail sections for the reasons mentioned above. However, they can be useful on shorter sections to reduce investment costs (for example at bridges or tunnels, to connect industrial sites and logistic facilities, and in border-crossing areas).

Option 8 is not considered in this study for long sections and is envisaged more as a variant of Option 7 in specific areas in which a significant speed increase is necessary for the relevant 1435mm functionalities. For example, on parts of a line in which there is a significant number of curves providing connectivity to a large number of municipalities. Any proposals to deviate from existing alignments or development of new rail lines would be subject to specific feasibility studies, that are beyond the scope of this assignment.

As Options 1 and 2 do not include development of a 1435mm track, only Options 3, 4, 7 and 9 are considered further as possible options for the implementation of 1435mm track gauge corridors in Ukraine and Moldova. The corridors assessed and the different alternatives proposed for each of them are described and analysed in section 7 of this study. While none of these four options is considered as a preferred one in general, each option could be applied for various sections and corridors, depending on the capacity utilisation of existing corridors, availability of space, existence of alternative corridors, speed profile of the existing lines, etc. Thus, section 7 presents, an assessment for the relevant corridors on a sectional basis.

6.1.7 Future role of 1520mm lines in the EU (in Poland and Slovakia)

The study has also assessed whether there is a need to ensure access to the 1520mm rail lines in the EU. In particular, the following two lines are concerned:

- Polish PKP Broad Gauge Metallurgical Rail Line (PKP LHS) which connects Silesia (ending in Slawkow terminal in Zaglebie Dabrowskie – 25 km from Katowice) and the Polish/Ukrainian border Hrubieszow/Izov. This is the westernmost 1520mm gauge track in Europe with a length of circa 400 km

- 1520mm rail line connecting the U.S. Steel factory in Kosice (Slovakia) to Ukraine, near Uzhhorod

The Slovak line has a very specific focus linked to the transport of materials to the steel factory in Kosice, which is the largest integrated steel producer in Central Europe, and a key pillar of the economy in Slovakia, with 8 000 employees. Significant quantities of iron ore in Slovakia are transported from Kryvyi Rih to U.S. Steel on this rail line.

The PKP LHS line has a regional range (it runs through the area of South-Eastern Poland) allowing the possibility to transport freight from/to Ukraine without the need to reload goods at the border and to run heavy block trains. It also provides direct access to/from Ukrainian to other Polish areas via the intermodal terminal located in Slawkow. Moreover, the PKP LHS line has been used during the war for the transport of passenger trains.

In conclusion, both lines are relevant for the future and therefore, it is a study objective to keep the 1520mm operational capacities towards both lines in Ukraine. Moreover, specific feasibility studies should assess whether the 1520mm lines in Ukraine providing access to the Kosice and PKP LHS lines should be modernised and whether a capacity increase is needed. In that sense, in June 2022, JSC UZ completed the electrification of 90 km of the line from Kovel to Izov, increasing the capacity of the line on the Ukrainian side (and indirectly of the whole PKP LHS corridor).

The need for additional investments on both lines on the EU side, should be assessed by the relevant countries. In particular, investments aiming at the increase of the operational capacity, which could be relevant even in the short term.

6.2 Assignment of functionalities to each network

As mentioned in the previous section, one of the basic principles for the development of the future 1435mm network is to separate as much as possible the operations of the new network from the operations on the existing 1520mm network.

Moreover, since in the short to medium-term the new 1435mm network will be developed mostly in single-track sections, it should be implemented and operated with the objective of maximising the available capacity. From the operational perspective, the best way to achieve this is by ensuring that the speed profile of the trains operating in the 1435mm network is as homogeneous as possible.

In addition, most of the future investments for the modernisation of the rail network in both countries with support from EU funds are likely to be linked to the development of the 1435mm network. Thus, considering the bad condition of the infrastructure and the low operational speed of the existing network in both countries, the proposal is to assign fast services to the 1435mm network, which will offer a higher operational speed and reliability.

With that in mind, the following division of functionalities between both networks in the short to mid-term, in corridors having both available, is proposed.

1435mm network functionalities

- Passenger International
- Passenger National
- Freight Fast

1520mm network functionalities

- Passenger Local/Regional
- Passenger Night trains
- Freight Slow/heavy

Until the number of corridors with a 1435mm track is enough to develop a network effect, the functionalities assigned to the 1435mm network will also continue to be operated in the 1520mm network for some O/D pairs. For example, freight container traffic between Dnipro and L'viv will continue in the 1520mm network until the 1435mm network reaches Dnipro.

Similarly, if in the future several 1435mm corridors are developed with more than one track, additional functionalities could be operated in that network, too (e.g., passenger Local/Regional).

6.3 Catenary, power supply and alternative fuels

The current power supply is different in several parts of the rail network in Ukraine. Between L'viv and the Polish, Hungarian and Slovak borders, the electrified lines have a 3kV DC system. East of L'viv, including the regions around Kyiv, Odesa and Poltava, the electrified lines have a 25kV 50Hz AC system. In the eastern regions of Ukraine: Kharkiv, Dnipro, Zaporizhzhia, Donetsk, Luhansk and Mariupol, the electrified lines have again, with some exceptions, a 3kV DC system. In Moldova, the entire network is non-electrified.

In the neighbouring countries, the situation also varies. In Romania and Hungary, rails are electrified with a 25kV 50Hz AC system. In Poland, the electrified lines have a 3kV DC system, while rail Baltica will also be electrified with a 25kV 50Hz AC system. Finally, in Slovakia, both electrification systems co-exist, however, the electrified lines connecting to Ukraine all have a 3kV DC system.

Therefore, based on the current situation, and having in mind that the TSI do not impose any specific voltage system, different options are possible for the further development of the traction power supply networks.

6.3.1 Description of the two existing power supply systems in Ukraine

6.3.1.1 3kV DC system

In this type of system, three-phase power received from the power grids is de-escalated to low voltage and converted into DC by the rectifiers and power-electronic converters. The electric sub-stations for DC systems must be relatively close to each other, because of the lower voltage. A larger cross section of the wires is needed, requiring the use of double contact wiring.

DC systems are powered by two electric stations simultaneously. In double-track sections, their wiring can be connected to avoid greater voltage decrease. This system requires the use of so-called "normal" catenaries, which have one supporting and two contact wires.

Compared with AC systems, DC power supply is less efficient and requires a higher number of substations and a heavier catenary, making it more expensive to implement and maintain than the 25 kV AC system. On the other hand, at high voltages, it is less dangerous to work with DC than AC and, it causes less interferences with communication lines.

6.3.1.2 25kV 50Hz AC system

In this system 25 kV AC power supply is collected from the overhead conductor and stepped down by a transformer within the locomotive. This reduced voltage supply is then converted into DC supply and used for traction application. The single phase 25kV at 50Hz is the most commonly used configuration, since it does not require frequency conversion.

Unlike for DC systems, powering of the catenary is one-sided, i.e., each electric sub-station powers the locomotive only half the way to the next station. In the middle, there is an isolated neutral conductor separating the two power areas. For this system, "light" catenaries, consisting of one supporting and one contact wire are used.

This system causes more interferences to communication lines and being a single-phase system, it imposes an imbalance effect on the supply system. However, it has several advantages compared to the DC systems:

- It has lower energy consumption
- It requires less substations
- The 25kV AC substation has higher capacity
- The catenary and supporting structure are lighter
- The transmission losses are smaller when supplied at high voltages
- The starting efficiency of AC locomotives is higher

6.3.2 Operation of non-electrified lines with rolling stock powered with alternative propulsion technologies

Continuing the operation of some of the existing non-electrified lines in the future is also a possibility for sections with low expected demand. This option represents the least costly solution to implement.

Currently, non-electrified lines are operated with diesel traction. However, rolling stock with alternative fuel traction, such as batteries or hydrogen is already in use in some EU countries. These alternative propulsion technologies are developing fast and might become a feasible alternative for the operation of some of the non-electrified lines in the mid to long-term.

If the use of alternative propulsions is envisaged, the system needs to be properly planned. Among other aspects, charging/fuelling stations need to be implemented and depots and workshops need to be adapted. It is also essential to check/ensure the capacity of the electric grid in the areas where the charging stations will be implemented.

The use of diesel vehicles, although not recommended for the mid to long-term due to the significant emissions produced, is the only option for the operation of non-electrified lines in the short-term. It could also be an alternative to safeguard the operations in the short-term for electrified sections in Ukraine, in the event of continued hostilities, or if the power supply remains unstable immediately after the war.

6.3.3 Preferred way forward for Ukraine

Considering the advantages and disadvantages of the existing electrification systems in Ukraine described above, the following recommendations are proposed.

In the long-term, a homogenisation of the electrification system would be desirable. Considering the long list of advantages of the AC system, in particular the lower implementation and maintenance cost, it is **recommended that further electrification of the Ukrainian system is performed with the 25kV 50Hz AC system**.

In the 1520mm network, to achieve the desired homogenisation, conversion of the existing DC powered corridors to AC is recommended in the mid to long-term. Regarding the non-electrified sections, each Feasibility Study for their modernisation would have to assess whether it is better to electrify them with the 25kV 50Hz system or operate them with rolling stock powered with alternative propulsion technologies.

The recommendation is to **electrify the new 1435mm network using the 25kV 50Hz AC system**.

Even if the entire 1435mm network in Ukraine is electrified with a 25kV 50Hz AC system, the issue of different electrification systems would remain in certain international relations (e.g., to/from Poland and Slovakia). This has significant implications regarding the selection of the rolling stock to be operated on international lines.

For passengers, the most suitable solution is to consider dual-voltage rolling stock, to prevent any loss of time at the border crossing points. For freight, the use of dual-voltage locomotives is also an option. However, it implies a significant cost increase and hence, it needs to be counterbalance against the real delay that changing the locomotive at the border crossing point would imply, considering all the other procedures that need to be performed (customs, sanitary, etc.).

6.3.4 Preferred way forward for Moldova

In Moldova, the starting situation is completely different, since the entire network is non-electrified. With that in mind, it is also recommended that **any electrification is developed with the 25kV 50Hz AC system**. The considerations regarding the implications to the rolling stock for international traffic mentioned for Ukraine would apply for Moldova, too.

Electrification of the 1435mm track gauge network corridors to be developed is recommended. In particular, electrification of the corridor connecting the Romanian border at Ungheni to Chisinau is encouraged. The possibility to electrify the rest of the network needs to be assessed on a case-by-case.

In any case, as none of the existing lines are electrified, electrification in Moldova will also be subject to an assessment of the ability of the Moldovan energy system and grid to accommodate it.

6.4 Signalling and communications

As shown in the analysis, the current signalling systems in Ukraine and Moldova are outdated, operating primarily on relay based interlockings, even with some sections operated manually. For example, in Ukraine, only very few stations are equipped with electronic interlockings. There are several reasons for this situation including, among others, lack of investments and maintenance, and market protection, which makes it difficult to introduce new technologies.

EU integrated rail systems need to be based on modern and interoperable signalling systems. The possible options are assessed independently for the 1520mm and the 1435mm networks.

6.4.1 1520mm track gauge network

With the proposed division of functionalities for the rail systems in Ukraine and Moldova, the international traffic will either operate in the 1435mm network or be transhipped at the border-crossing areas. Thus, interoperability and compliance with the Control Command and Signalling TSI for the 1520mm network is not deemed essential in the short-term.

In addition, with the proven difficulties for the implementation of new technologies and the lack of expertise among the existing staff of the rail companies in both countries, aiming at a transition to ETCS in the 1520mm network might be too demanding. Moreover, the existing 1520mm rolling stock is not equipped with ETCS on-board units.

Thus, for the 1520mm network, the recommendation is to keep the existing national legacy signalling systems in the short to mid-term. Its modernisation and transformation to a system based on electronic interlockings is, nevertheless, encouraged.

6.4.2 1435mm track gauge network

The proposal to separate operations in the 1435mm network and the 1520mm network to the extent possible and to assign different functionalities to each network, allows the possibility of developing the signalling system for the 1435mm network independently of the 1520mm network. Hence, the recommendation is not to install the existing national legacy system in the future 1435mm network.

The signalling system for the new 1435mm network should be a modern system based on electronic interlocking. In line with the TSI requirements, it needs to be based on the ERTMS system. Different options are then possible regarding the ETCS level to be implemented and the communication sub-system to be used.

Since this new modern and TSI compliant signalling system would be the only system installed on the 1435mm network, availability of sufficient rolling stock equipped with on-board ETCS needs to be ensured. Therefore, the purchase of new rolling stock and possible retrofitting of existing vehicles, should be strategically planned, ensuring enough resources.

ETCS

Considering that the planned 1435mm network will be independent from the existing rails and purpose-built, implementation of the highest standards is recommended. Deployment of the ETCS system is recommended at corridor level, preferably as part of the works for the last section of the corridor (no stand-alone installations are recommended).

Since no interoperability with National legacy systems will be required and to avoid the necessity to install lineside signals or train detection systems on the trackside, recommendation is to assess the possibility to install ETCS Level 3 (currently it has only been implemented at prototype level). This system would allow to operate the 1435mm network with the maximum capacity, which is very relevant since in the short to mid-term, most of the 1435mm network in both countries would be composed mainly of single-track sections.

The possibility to implement ETCS Level 3 needs to be confirmed via a Feasibility Study to be developed during the preparatory phase for the development of the new network. If it is proven unfeasible or the risks are too high to implement it, ETCS Level 2 should be implemented, instead.

Communication sub-system

A modern GSM based communication sub-system should be installed in the 1435mm network. Currently, ERTMS Level 2 operates with GSM-R for safety and communication. However, the UIC is already developing the Future Rail Mobile Communication System (FRMCS) as the successor of GSM-R.

Despite FRMCS being still under development, as end of support for GSM-R is planned by 2030 onwards, it is not unrealistic to consider this technology as the potential one to be used for the development of the 1435mm network in Moldova and Ukraine.

In order to develop the 1435mm network in both countries as a highly functional and modern system, implementation of FRMCS is recommended. Moreover, implementation of the communication system in the 1435mm network is likely to occur beyond 2030 for the following reasons:

- The ongoing war in Ukraine makes it difficult to realistically forecast when the development of the 1435mm network could start
- Relevant standards for the development of the 1435mm network need to be developed in both countries and the regulatory network needs to be updated

- For rail projects, in excess of 5 years is generally necessary from the project concept stage to implementation, considering preparation of project documentation and completion of relevant procedures (e.g., environmental procedures, public procurement procedures)

- To reduce the number, or avoid, interfaces in the installation of the communication sub-system, the recommendation is to install it at network level. In this case, a unique deployment for the entire network is unrealistic, since a phased development of the 1435mm network is envisaged. However, waiting until a certain level of network development is achieved is recommended. In Ukraine, for example, this could mean installing the first wave of the communication sub-system only once the 1435mm network has been implemented in some of the major nodes such as L'viv and Kyiv

6.5 Infrastructure management

The development of a 1435mm network in Moldova and Ukraine is envisaged as a core part of EU integration of their rail systems. Section 6.2 outlines different functionalities will be assigned to the 1435mm and the 1520mm networks, with the aim of operating them as independently as possible. Thus, in this section an analysis of possible options regarding the management of the new network for both countries is developed.

As indicated in section 6.1, the EU integrated rail system in Ukraine will consist of co-existing 1435mm and 1520mm networks, with the length and density of the existing network significantly hindering full transformation to 1435mm. However, this situation may also bring opportunities to implement different management models for each network.

Achieving interoperability as per TSI goes far beyond the track gauge. Other elements such as signalling, traffic management, requirements for PRM, adaptation of legislation and standards, etc. are equally relevant for EU integration.

Ukraine is in the process of aligning the organisation and legislation of the sector with the directives and regulations contained in the Association Agreement with the EU, including the separation of the Infrastructure Manager from any Rail Undertaking.

For the new 1435mm network to be successful, it should be operated in a dynamic way, with equal and indiscriminate access for different Rail Undertakings (e.g., clear and coherent track access charges). It should also be equipped with the latest technologies on signalling and traffic management to ensure that a significant level of operational capacity and safety is provided.

A specific study will need to be developed to define all the necessary aspects, including required changes to the current legal framework. The interfaces at the stations, marshalling yards and any other areas in which both networks would co-exist (e.g., certain engineering structures), should also be identified and assessed in the study.

6.6 Polyvalent sleepers with baseplate-based fastening system

As mentioned above, the possibility to use polyvalent sleepers when modernising sections of the 1520mm network would allow the possibility to change the gauge to 1435mm in the future relatively fast and with very limited additional costs.

Polyvalent sleepers have been used, for example, in Spain during the last circa 20 years in the modernisation of the rail sections in Iberian gauge. The additional cost of the polyvalent sleeper is not significant and allows an easy transition to 1435mm gauge, keeping the centre-line of the track. This has the following advantages:

- The sleeper will have a similar stress as both rails would be moved
- The kinetic envelope would be kept
- There would be no need to make specific interventions on the catenary
- Minimum to no impact on the distance between the train and the platforms

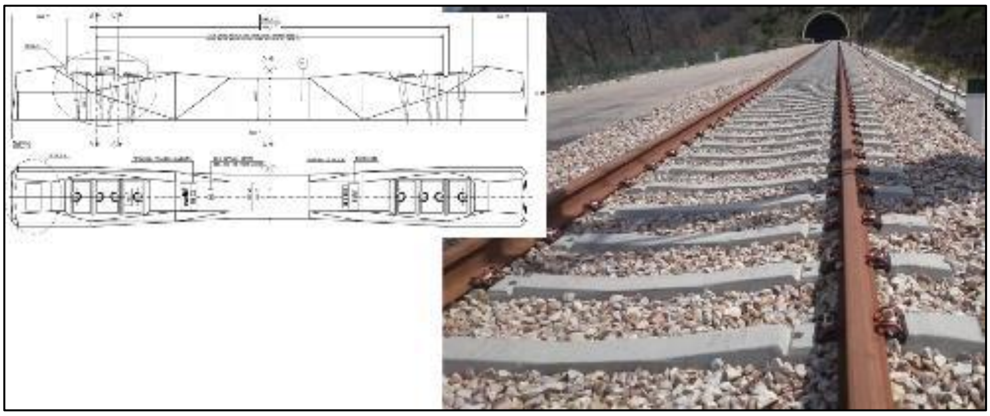


Figure 6.3: Polyvalent sleepers in Spain. Source: Spanish Ministry of Transport and Adif

However, the difference in gauge between the Ukrainian/Moldovan rails and the 1435mm gauge is lower than in the Spanish case. Hence, a specific study, developed in coordination with the producers of sleepers would have to be developed to identify whether a similar design can be developed for Ukraine and Moldova.

Another possibility would be to use baseplate-based rail fastening system on sleepers, as it is already the case in several rail systems. On a standard sleeper only two screws are enough to fix the baseplate on the sleeper. In this case, four holes would be needed in the sleeper to: a) fix initially the base plate for the 1520mm gauge with two holes and, b) fix the baseplate with the other two holes for the 1435mm gauge.

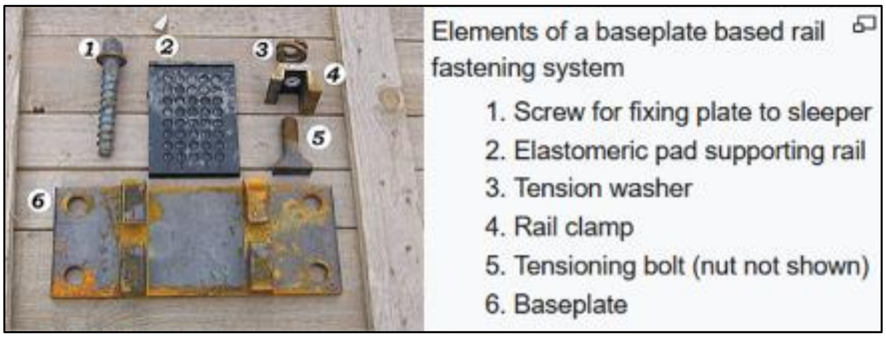


Figure 6.4: Elements of a baseplate rail fastening system. Source: prepared by Egis for JASPERS

The sleepers are prefabricated, and the cost is very similar to that of a standard sleeper with saddles. There are factories that can produce such sleepers in the EU, for example, in Poland. However, it would be possible to produce them in Ukraine, with the installation of prefabrication chains to an existing factory, as was done in Algeria. Such sleepers would then be installed in the relevant lines which are modernised. More than 1000 m per day can be installed, including tamping and levelling.

The transition to the new gauge consists of “shifting workshops”. A basic manual output would be 300 m per day. The process can be, however, mechanised with limited resources, such as small self-propelled machines, making it possible to achieve a yield similar to a factory train. Moreover, the process can be done in parallel in several sections of the same line, to increase the speed of the change. The cost of this manual intervention is relatively low and does not require skilled experts. During the gauge change, the sleepers are not affected. There is, therefore, no tamping/levelling operation to be planned.

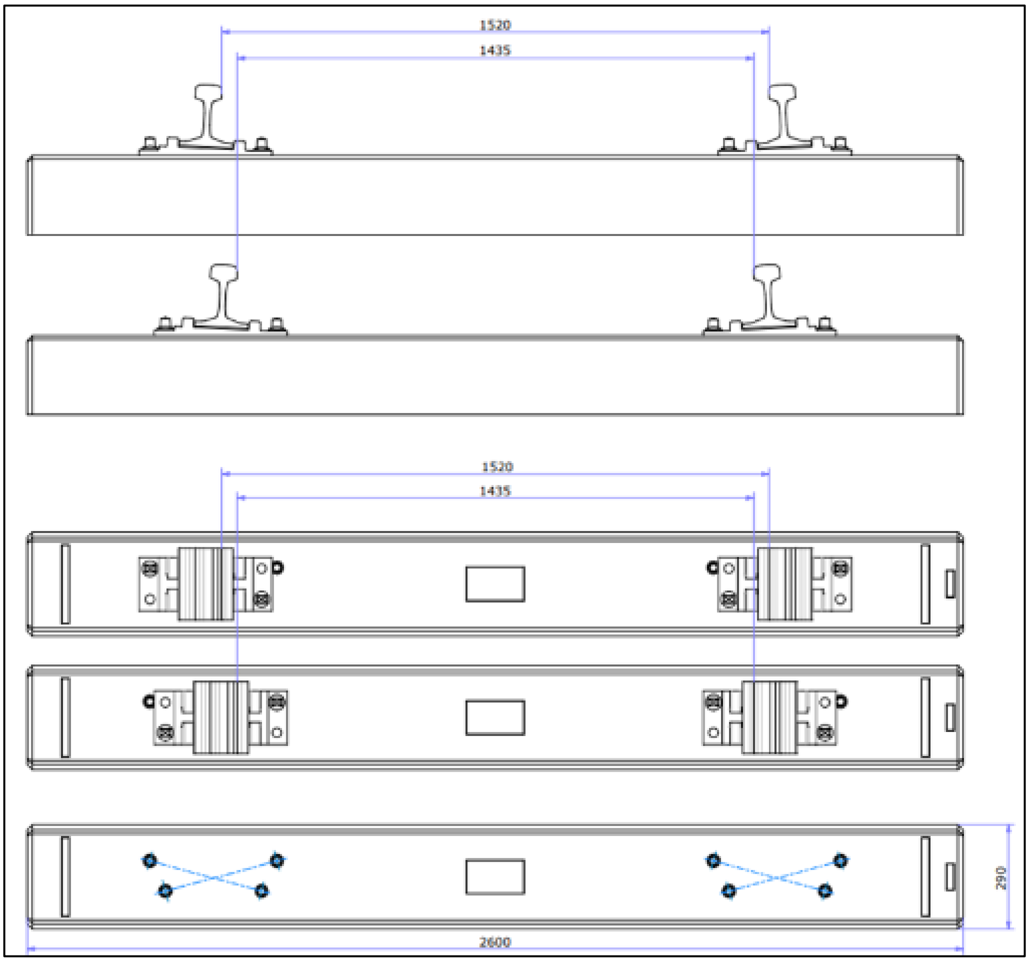


Figure 6.5: Example of a baseplate polyvalent sleeper. Source: prepared by Egis for JASPERS

The use of this technology has several advantages:

- Limited additional cost (although it is likely that all crossings and turnouts will need to be replaced when the gauge is changed):
    - Baseplate cost is estimated at 75 000 EUR per km and track
    - Sleeper cost will be very similar to the cost of a 1520mm sleeper
- Easy to install, manually or mechanised, with a relatively low cost and a high speed
- It is a proven technology currently in use in several rail-based transport systems
- Easy and fast change of gauge

6.7 Parameters that are not subject to a specific options analysis in this study

For certain parameters, there is no need to develop an options analysis as they are either already defined by policy requirements (e.g., TSI), or they should be developed to be compatible to the existing network (interoperability). For other parameters, the options analysis should be developed in the Feasibility Studies for each corridor.

6.7.1 Axle load and structure gauge

The axle load is considered a “Hard” parameter in the TSI and thus, its minimum value is defined there, depending on the traffic category of each rail line.

For rail lines with a track gauge of 1520mm, the minimum axle load is 22.5 t for dedicated passenger lines and 25 t for freight or mix traffic lines. In both cases, as a minimum the structure gauge S defined in the TSI should be applied.

Regarding the future 1435mm lines, most of them will be envisaged for mixed traffic. Consequently, recommendation is to develop them with an axle load of 22.5 t and structure gauge GB or GC, depending on the envisaged traffic category. If in the future some 1435mm rail lines are planned to be developed for passenger use only, the axle load and structure gauge requirements should be assessed in a Feasibility Study, depending on the traffic category.

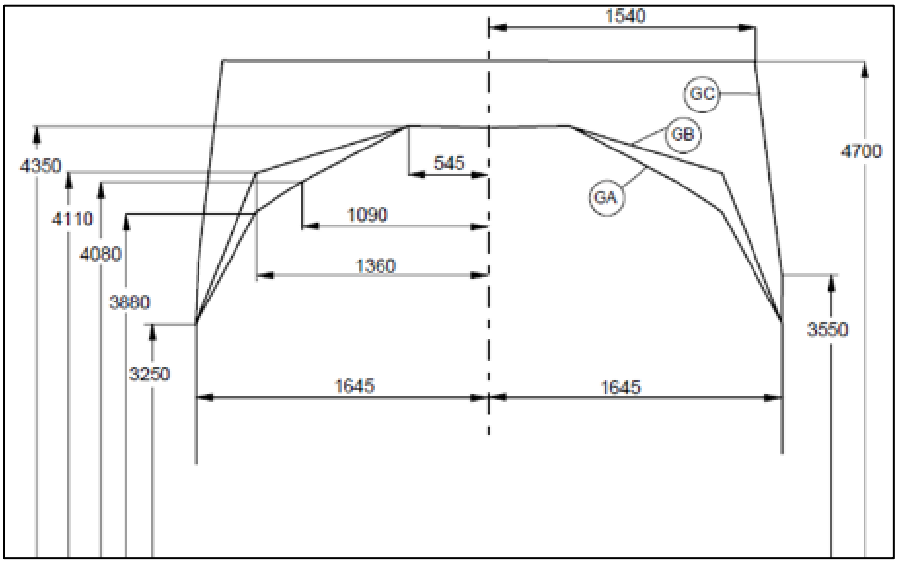


Figure 6.6: Structure gauge profiles GA, GB and GC. Source: TSI

The rolling stock to be purchased for the future 1435mm network in Ukraine and Moldova should then be adapted to those axle load and structure gauge requirements, 22.5 t and GB or GC profile. The TEN-T corridors in the EU are, or will be after modernisation, adapted to the TSI requirements. However, if it is anticipated that the 1435mm rolling stock will be used in non-TEN-T lines in the neighbouring countries, the axle load and structure gauge requirement should be checked, as they might be more restrictive.

The axle load and structure gauge requirements for the 1435mm network (TSI) are more restrictive than those for the 1520mm network. Hence, 1435mm wagons could, in principle, be used in the 1520mm network with a change of bogies. On the contrary, the use of 1520mm wagons in the 1435mm network might not be possible, especially due to the structure gauge requirements.

6.7.2 Siding length

Unlike the axle load and the structural gauge, the siding length for freight or mixed traffic lines is a “Soft” parameter in the TSI. For that reason, in most of the cases a range of values for each traffic category is provided in the TSI.

The only exception to this is traffic category F1520, for which the minimum train length in the TSI is defined as 1050m. Thus, when modernising the 1520mm network in Ukraine and Moldova, as a minimum, siding possibilities for trains of 1050m length should be developed in the relevant stations and marshalling yards.

When the foreseen 1435mm track gauges are developed in both countries, they should be designed to allow the operation of trains with a minimum length of 740m for lines envisaged for traffic category F1 and of 600m for those of traffic category F2. In both cases, the upper value of the range of minimum train lengths is 1050m.

To save implementation cost and considering that significant international freight with EU countries is expected, the recommendation is to keep the siding length for the 1435mm network limited to 750m, in line with most of the EU countries.

In any case, it is important to highlight that it is not necessary to provide this siding length in every station. The number and location of stations in which this siding length should be applied will depend on the operational plan. This should be considered also bearing in mind the need to ensure the sustainability of the operations in incidental situations. Specific Feasibility Studies will identify the necessary siding lengths for each station.

6.7.3 Platform length

The platform length is also a “Soft” parameter in the TSI. A range of values is provided for each traffic category. Although the final decision is to be taken in every Feasibility Study for each line, a few recommendations can already be provided. For stations in which international passenger trains are foreseen to stop, it is suggested to build some platforms with a usable length of 400m. For the other platforms in those stations and for the rest of stations and stops, the platform length should be lower, 200m or less.

6.7.4 Number of stations and stops and stations layout

The number of stations and stops and the layout of each station should be defined in the Feasibility Studies for the development or modernisation of each rail line or corridor. To define them, it will be necessary to understand the expected functionalities and to forecast the demand for both passengers and freight.

7. Alternatives analysis for the implementation of 1435mm gauge corridors in Ukraine and Moldova

The first step of the integration of the Ukrainian and Moldovan rail systems into the European transport system is the establishment of a backbone 1435mm network in both countries. Once the backbone network is established, further development/extension of the 1435mm network could be considered. However, this would need to be assessed based on the functionality of the 1435mm and 1520mm networks, the required capacity of each of them, the expected demand in the 1435mm and 1520mm networks, and the desired level of service of the 1435mm network.

In Ukraine, co-existence of the 1435mm and 1520mm gauge networks is expected even in the long-term, while in Moldova, a complete long-term switch to 1435mm is a realistic option.

Considering the significant investment that the transition to 1435mm implies, the limited available capacities for project preparation and implementation in both countries and the uncertain conditions and environment due to the ongoing conflict, several alternatives for the implementation of the 1435mm in the selected corridors have been carefully defined and assessed.

7.1 General principles for the implementation of the 1435mm network

The general principles considered for the implementation of the 1435mm network are:

Minimisation of investment cost

Given the size of the rail network to be integrated, the efficient use of financial resources is the primary objective. This requires, among other solutions, the use of flexible technical solutions (e.g., polyvalent sleepers), dual gauge in limited parts of the network and the use of land currently in rail company ownership to avoid significant new land purchase.

Operational separation between 1435mm and 1520mm networks (fast corridor traffic and slow bulk and network traffic)

To reach a competitive level of service (LOS), the new 1435mm network would be developed according to high standards, including electronic interlocking and modern traffic management systems. With the differences in operations, the operational frictions between the two systems would need to be minimised by reducing the interfaces between the 1435mm and 1520mm systems.

Maintaining operational capacities of the existing 1520mm network

The 1520mm system is currently the backbone of the Ukrainian transport system for certain functionalities. Therefore, the operational capacities need to be safeguarded. Only after development of the backbone 1435mm network, with subsequent shifting of traffic to the 1435mm system, and/or after the expected shift of part of the current 1520mm demand to alternative transport modes, should reduction of operational capacities be assessed.

Efficient use of existing transhipment facilities

In order to increase the economic interaction between Ukraine/Moldova and the EU, the use of existing transhipment facilities is crucial. With the development of the 1435mm network, economic cohesion will significantly increase. The construction of additional transhipment facilities inside Ukraine (for example around L'viv) in line with the proposed 1435mm system extension will be also necessary.

Control operational costs

Complex technical solutions usually lead to higher operational cost. Therefore, the use of dual-gauge tracks (four-rails) on longer parts of the rail network should be avoided. Technical synergies between the rail systems, for example related to power supply and homogenisation of electrification with neighbouring rail systems, should be investigated.

Minimisation of rail system performance disturbances during implementation

In order to avoid reduction of the rail system capacity during implementation, shifting traffic to parallel corridors or rehabilitation of existing tracks should be considered only after construction of the additional line capacity.

Ensure coherence with ongoing project preparation

Ongoing project developments should preferably not be altered, and if necessary, then minimally. This would allow creation of a pool of projects, which could be swiftly implemented as soon as the geopolitical situation allows it.

Creating 1435mm network as development axes for economic and social development

The ongoing war has had a significant impact on the social and economic structure in the whole of Europe. Ukraine is suffering from the consequences of the war on society and the economy. Large parts of the industry have been destroyed. Reconstruction of previously existing industry on its own would not necessarily allow Ukraine to foster a successful economic development. Therefore, new industries and a fundamentally new economic system will need to be developed. The future 1435mm rail system naturally provides a development axis for the future industrial development of Ukraine and Moldova, which will be strongly interlinked with the EU economy. With its positive environmental and climate change balance compared to other transport modes, the rail sector will play a fundamental role in European and Ukrainian development.

Refining options analysis to the extent possible

The time for preparation for economic development including the transport system and the resources for project development and implementation are limited. Therefore, it is the ambition of this strategy to narrow down the number of options, to reduce the burden on the following development steps and to speed up the project development process.

The study has been developed with strong support of and interaction with the Ukrainian, Moldovan, Polish, Slovak, Hungarian, and Romanian authorities. Through regular discussions and interaction with the national authorities, the options and alternatives have been reduced as much as possible.

Ensure coherence with infrastructure and operations in EU member states to reach the key origins and destinations

Improving the transmissibility of border crossing points (transhipment, border procedures, traffic management, etc.) and the development of a 1435mm system in Ukraine and Moldova would significantly improve the rail operations across their borders with the EU. To complement these developments, it will be necessary to also consider the available rail capacities inside the EU along the main axes of current and future economic and social interaction. Therefore, is it advisable that EU countries review their national rail development strategies, implementation and investment plans, and project under preparation, in view of facilitating the expected increase of rail traffic related to Ukraine and Moldova.

Stress test for the Ukrainian and Moldovan rail systems

The future performance of the Ukrainian and Moldovan rail systems will be jeopardised by the development of competitive transport modes. In that regard, lessons should be learnt from rail sector developments in other EU countries.

The road infrastructure will be a beneficiary of large investment and the availability of private cars will increase with the improving economy. Moreover, the liberalised road sector and the related private investments will put the Ukrainian and Moldovan rail systems under heavy pressure. After reopening of the airports, longer distance journeys (international and IC) will also be threatened. The opening of inland and, especially, maritime ports will have a significant impact on the rail mode split for certain freight commodities.

Hence, the development of a modern and high-level 1435mm rail network could be key for the future performance of the rails in both countries.

Assessment scope starting from the Ukrainian and Moldovan borders with the EU

The gradual integration of the Ukrainian and Moldovan rail systems into the EU transport system will naturally start from the borders with the EU. In this context, it was assessed whether to develop a backbone 1435mm network reaching deep into Ukraine and covering the main areas benefiting from an improved fast rail traffic segment, or to transform entire rail areas from 1520mm to 1435mm, starting from the Polish/Slovak/Hungarian borders. With the proposed specialisation of the 1435mm system on fast traffic, it is evident that the backbone approach provides the largest benefits to the Ukrainian economy.

Rail lines in the border region to Belarus and Russia do not require early integration into the 1435mm system. However, based on the future traffic development (development of demand across the borders, shifting of traffic from 1520mm to 1435mm, etc.), secondary rail lines may be transformed to 1435mm at an earlier stage.

For Moldova, due to the strong interaction with the Romanian economy and the current inaccessibility of Transnistria, the long-term transformation of the Moldovan rail system to 1435mm, if economically justified, is recommended.

Avoiding significant land acquisition

Land purchase has a significant impact, not only on project cost, but also on the project development timeframe. Therefore, priority is given to brown field solutions utilising the existing rail infrastructure and rail property. This will also have a positive impact on the environment, as this will decrease demand for new property for transport line infrastructure.

Ensure highest levels of rail security

The Ukrainian rail system is under particular security threat. The development of a fully automatised new 1435mm system requires a high level of protection against sabotage and other hostile activities from the outset.

Relations with Russia and Belarus

History shows that policies are change with time and, even in case of war, in the mid to long-term, economic and social interaction can improve. The study recommends to monitor the relational situation and to reassess strategic decision-making accordingly.

Extended rail infrastructure as a vehicle for future economic development

New line infrastructure is usually very costly and difficult to develop. The extended existing rail line infrastructure including sections not currently in operation, should only be sold or transferred after careful assessment of the potential use for the future rail system. Additionally, existing transport line infrastructure can be used, in parallel, for pipelines (natural gas, H2, etc.), optical and electric cables, or other public utilities.

If the decision is to finally offload existing rail property, any generated income should be reinvested in the modernisation of the remaining rail network.

Future- network development steps

After implementation of the backbone network, several further development options should be considered:

- Extension of the backbone system to other centres of population, including Zaporizhzhia or Black Sea and river ports
- The possibility to further transform lines to 1435mm should be assessed on a case-by-case basis. Some secondary lines are mainly for heavy freight bulk traffic, for example access to power plants or quarries. Hence, the transformation of such lines may not be economically feasible
- Further extension of the 1435mm capacity in a corridor. This could be done by constructing an additional 1435mm track or, in mixed 1520mm and 1435mm corridors, by transforming one (or more) of the 1520mm tracks to 1435mm. The need for additional 1435mm capacity may be triggered by an increase in demand on the 1435mm lines due to new traffic (e.g., new industries and economic interactions) or by shift of traffic from 1520mm to 1435mm due to the higher level of service of the 1435mm network
- Construction of new rail infrastructure with higher design speed. Many of the existing lines of the Ukrainian rail system have an alignment which permits operational speeds of up to 200km/h. The recommendation is to exploit this potential, before aiming at the construction of separate alignments for higher speeds

7.2 Preparation for the implementation of the 1435mm network

Prior to investment in 1435mm rail infrastructure in Ukraine and Moldova, preparation activities should start as early as possible with three pillars being developed in parallel:

- System set-up. This includes preparation of the relevant legislative background, development of protocols, procedures and standards, definition of the interfaces for electronic interlocking and centralised traffic centres. the recommendation is to assess different protocols and standards existing in the EU and implement in Ukraine the one that is found most suitable. This would save time and address potential future issues with interfaces
- To prepare for the implementation of the first 1435mm tracks in Ukraine and Moldova (priorities 1 and 2), the Feasibility Studies for the priority corridors identified below, should already be developed

- In parallel, development of rail node studies for the major nodes should start (e.g., L'viv, Kyiv, and Chisinau, etc.)[35]. In the major nodes most of the functionalities will play a role and both gauges will co-exist, so they are essential for the future functioning of the rail systems

- In addition, in accordance with the study recommendation from the previous section, the first step for the development of a 1435mm network would be the creation of a new, independent, infrastructure management unit Size and staffing of the new infrastructure management unit would increase progressively, considering the relevant expertise needed at each stage of its development. The initial task to be performed by the new infrastructure manager would be the system set-up, as described above

7.3 Ukraine

To identify the corridors in which the 1435mm network is proposed to be developed in Ukraine, the main nodes to be connected are first established. For this, the proposed functionalities that would operate in the 1435mm have been considered and from the passenger perspective, the largest agglomerations are the most relevant. For freight, the main container hubs and areas where future development of modern industry centres can be envisaged represent the priorities.

7.3.1 International freight connectivity with a 1435mm corridor

Ukraine needs to be linked to the main logistics nodes in the EU to ensure its fast and reliable connectivity with the principal European logistics hubs. Due to the relatively small container market, Ukrainian ports would continue to serve feeder services from a short sea network, with Turkish and European hub ports. Thus, the direct rail connectivity with the European sea getaways would enable Ukraine to be integrated into the global container supply chains, resulting in shorter transport times for container shipping and potentially lower transportation costs. The establishment of regular block container train services with EU markets would be therefore essential for Ukraine to reduce the time of its export and import of goods with the EU and Western markets. This would also support the development of reliable and cost-efficient supply chains which would support the country's integration into the global network.

In terms of connectivity to Ukraine, the main container hubs in North Europe are Rotterdam, Hamburg, Bremerhaven, Gdansk, Gdynia, Szczecin, and Klaipeda, which should be connected to Ukraine's hinterland with 1435mm rail gauge, via Poland. The connectivity with those hubs is important as they are connected with the North American market, maintaining direct container line services.

Central and South Europe can be served by the Adriatic ports of Rijeka, Trieste, and Koper. The advantage of north Adriatic ports over the ports mentioned above is linked to the relations between Europe and the near, middle, and far East with shorter maritime links (e.g., Suez – Rijeka: 1254 nm vs. Suez – Hamburg: 3552 nm), resulting in up to 7 days shorter transit times on the maritime side for the Northern Adriatic ports compared to the Northern European ports.

<u>Rail network issues on the EU side</u>

There are no substantial physical infrastructure constraints on the EU rail network in terms of further connectivity of Ukraine to the main European logistics hubs via Poland. Some limitations however exist in the rail connectivity via Hungary and Slovakia.

[35] Since the aim is to also increase the use of rails for international traffic, the situation of the major nodes in the neighbouring countries is also a relevant aspect to be considered. However, assessing in detail the nodes in the EU countries is not part of the scope of this study.

Hungary

The main infrastructure bottleneck emerges in the rail network of Budapest, which serves as one of the main consolidation points of rail freight from South-Eastern Europe. The rail network in and around Budapest has limited throughput capacity, which does not allow for a smooth movement of goods through the Budapest rail node. In the short term (2023-2027), the Budapest Rail Node Strategy focuses on the implementation of the Southern Rail Ring project, which would allow to expand the capacity of the major rail crossing over the Danube in Budapest. Other short-term measures for the development of rail freight traffic were considered in this strategy and are being defined in the ongoing National Rail Freight Concept. In the longer-term, the strategy considers increasing the throughput capacity of the core network in Budapest by eliminating Nyugati and Déli as terminal stations, connecting them with a tunnel. In addition, it is defined that when rail freight traffic reaches a certain level, the development of the Southern Rail Ring will not be sufficient, and it would be necessary to construct the “V0” to bypass the Budapest node for transit freight trains (the Feasibility Study for the “V0” is currently ongoing).

After the completion of those improvements in Hungary and other Member States, Rijeka, Koper, and Trieste ports will be very well connected to the Eastern European hinterland by rail, which would help these ports to position themselves as the main container hubs for Central and South Europe. Consequently, rail connectivity between Ukraine and the Northern Adriatic ports via Hungary in 1435mm gauge is essential to improve the accessibility of Ukraine to the ports.

Poland

Time limited capacity constraints are expected during the implementation of projects in the main corridor from L’viv via Krakow/Katowice towards Brno/Praha/Vienna/Bratislava and via Warsaw towards the East and North Sea ports in Germany, the Netherlands, Poland, and the Baltic States.

Slovakia

On the Slovak side, the current bottlenecks are being mostly addressed by the ongoing rail modernisation projects. However, the Slovak authorities also acknowledged that the proposed development of the rail network in Ukraine would change the status quo of traffic and goods flows between the EU and Ukraine. From the Slovak perspective this would have impacts, for example, the role of Cierna nad Tisou is likely to undergo significant change.

This represents a challenge that will need addressed in the planned study on the cross-border area between Hungary, Slovakia, and Ukraine, but only partly. Hence, the Slovak authorities foresee the need to develop a more detailed study on the level of, at least, the Eastern part of the territory of Slovakia. This process will require significant stakeholder engagement to avoid omitting significant considerations.

Romania

The Romanian authorities have identified the following operational and capacity constraints, and related measures, on their network, linked to the suggested approach in this study:

- Electrification and limited modernisation (e.g., installation of ERTMS if also implemented in the relevant Ukrainian and Moldovan corridors) for relevant sections which are not currently subject of any planned or ongoing modernisation project:
    - Section Giurgiulesti (MD) – Galati (RO). This would ensure the electrified rail connection between both Danube ports

    - Section Halmeu – Satu Mare – Oradea. This line section is connected to the Oradea – Cluj Napoca section, which is currently under modernisation. This would ensure the fully electrified connection between Halmeu and Constanta

- Modernisation and acquisition of new transhipment equipment for the BCPs that will not be connected to the planned 1435mm network in Ukraine and Moldova

- Purchase of new rolling stock (locomotives and wagons) to ensure that the necessary capacities are available

Other issues

The main weaknesses in the connectivity of Ukraine with the EU are seen in the rail border crossing points, which require further improvement of hard as well as soft infrastructure. Insufficient border-crossing infrastructure and complex procedures result in increased transhipment time of trains. Increase of rail border crossing capacities and simplification of cross-border procedures are needed to speed up the transhipment time and improve the cross-border rail services.

Conclusions

The main priority for Ukraine regarding the international freight connectivity of the 1435mm network is the connection to Poland, followed by the connection to Hungary/Slovakia, with the connection to Moldova and Romania less essential.

7.3.2 National freight nodes to be connected with a 1435mm corridor

On the freight side, fast freight is to be assigned to the 1435mm network. In general terms fast freight can be understood as freight transported in containers (or that can feasibly be containerised), car transport and intermodal semi-trailer transport.

It is a study assumption that containerised trade will increase between Ukraine and the EU, requiring adequate intermodal connectivity between European and Ukrainian logistics nodes, as described above. Presumably, manufacturing production activities will take place in the Western part of Ukraine along the main transport corridors, to ensure the efficient connectivity of production and logistics facilities to the transport network.

There are several logistics nodes in Ukraine which should be connected to the EU transport system to allow smooth movement of goods. To prioritise these nodes, several factors should be taken into consideration, for example contribution of the region to GDP, industry and trade located in the catchment area, traffic, and logistics demand, etc. It has also been considered that freight can be easily consolidated within a 150-300km radius by trucks in intermodal facilities, which would enlarge the catchment area of the 1435mm rail network significantly.

GDP serves as a proxy for the development of freight traffic, especially containerised traffic. According to the Ukrainian Statistics Service, in 2021, the share of Kyiv Oblast in the country's GDP amounted to around 23%. The second largest Oblast in terms of GDP was Dnipropetrovsk (11%) followed by Kharkiv (6%) and L'viv (5%). The container market assessment confirms that Kyiv, Dnipro, Kharkiv and L'viv will be the main logistic chains in Ukraine for container traffic:

- **Kyiv** Oblast serves as the main consumer market in Ukraine, where the main consolidation and distribution centres of goods are located. In fact, Kyiv serves as the main distribution centre of the country where the main freight flow is consolidated (including from ports) and distributed to the regional warehouses. Because of its large population, well-developed manufacturing, and trade sectors, as well as the availability of qualified staff, the dominance of Kyiv as the main logistic node will remain and potentially even increase in the future

- **Dnipropetrovsk** Oblast is Ukraine's second-largest region in terms of both territory and population. It is also the second-largest logistic market in Ukraine. Dnipropetrovsk is one of the major industrial centres of the country, which offers a unique opportunity for the development of high-value production. In the region, the major suppliers of steel, chemical goods and construction materials are located. Due to its well-developed transportation network and short access to raw materials resources, the region can be positioned as the second-largest logistic chain in the country

- Other important logistics nodes would be **Kharkiv** and **L'viv** Oblasts. Kharkiv was the traditional producer of industrial as well as household electronics and equipment, all requiring fast and reliable supplies of spare parts and components. All these materials represent high-value containerised goods for which intermodal connectivity is vital to ensure the fast supply of needed components for assembling and delivery of final goods to the customers. For that reason, Kharkiv Oblast will be another important logistic chain in Ukraine, which will require fast and reliable intermodal connectivity to the European transport network

- During the war, **L'viv** Oblast has assumed greater importance as one of the major logistics nodes. Because of its proximity to the EU (Poland and Hungary/Slovakia), L'viv will be positioned as a main transhipment hub for Ukraine. This offers unique possibilities for value-adding to the goods transited through the Oblast. It can be assumed that the position of L'viv as one of the main logistics hubs of the country will gain in relevance in the upcoming years

With the Ports of Odesa and Chornomosrk, **Odesa** Oblast is the main sea gateway and transhipment point of Ukraine. The main export of agricultural products and raw materials is transhipped through these ports. Nevertheless, the main function of the ports is the domestic distribution of imported goods and the transhipment of exports on the sea. The relevance of Odesa's connectivity to the EU transport network will depend on its potential function as a future regional transit hub. Before the war, two international block container trains were crossing Odesa Oblast: (1) Viking Train from Draugiste (Lithuania) – Odesa/Chornomorsk Port – Varna Port – Sofia (Bulgaria) and (ii) Train Zubr – Chornomorsk/Odesa/Yuzhnyi Ports – Riga Port – Muuga (Estonia). However, the container volumes shipped were relatively low. In 2019 the Viking train shipped 9107 TEUs through Odesa and Chornomorsk and the Zubr train 2210 TEUs. The connectivity of Odesa and the Ukrainian hinterland to Baltic ports with regular block container services is important for the development of the North-South transit corridor through Ukraine. This connection would allow Ukraine to access Baltic Ports, which are well connected to North America with regular shipping services.

Odesa Oblast is well connected to the regional and intraregional rail and road networks. The rail speed of regular block container trains from Odesa to the main destinations in Ukraine (Dnipro, Kyiv and Kharkiv) was already 750 km a day before the war, which is significantly faster than the average speed of normal freight trains in Ukraine, which used to be 250 km a day. Based on these facts, it is important to ensure Odesa's efficient connectivity to the domestic logistics nodes on the existing rail network (1520mm gauge) and to enhance the maximum speed of the rail from 750 km to 1000 km a day. The connectivity of Odesa with L'viv with the 1435mm gauge would allow the development of a fast transit corridor toward the Baltic ports, but it is not considered a priority compared to the connection of the areas mentioned above in the existing 1520mm network.

In conclusion, in the short to mid-term, the 1435mm network should connect, from the National freight perspective, Kyiv to L'viv, Kharkiv and Dnipro areas.

7.3.3 Passenger nodes to be connected with a 1435mm corridor

The passenger functionalities to be assigned to the 1435mm network are International and National passengers. Those functionalities are characterised by connecting major nodes with high speed and very few stops. Thus, the biggest demand potential is in the bigger agglomerations.

The Ukrainian cities with more than 700 thousand inhabitants are, in order of population: Kyiv – Kharkiv – Donetsk – Odesa – Dnipro – Zaporizhzhia – L'viv.

L'viv is the closest of the biggest cities to Poland and Hungary/Slovakia. In addition, there is significant road traffic between L'viv and Poland, which could be partially shifted to rail if a fast and reliable service is offered. Therefore, connecting L'viv to the Polish border with the 1435mm network is one of the main priorities for the passenger segment.

Kyiv is by far the most populated city in Ukraine, and it is the main economic and cultural centre of the country. Connecting Kyiv to Poland and L'viv with the 1435mm network is also a clear priority.

Kharkiv has more than 1.4 million inhabitants and **Dnipro** close to 1 million. Moreover, both share a big part of the rail corridor connecting them to Kyiv, via Poltava. Hence, connecting Kyiv to both in the 1435mm network has been considered a priority, too.

Currently Donetsk is separated. Thus, notwithstanding its size, it has not been considered as one of the nodes to relate to a 1435mm rail network in the short to mid-term.

Despite being one of the cities with the highest number of inhabitants, Odesa seems to be more a seasonal destination in Ukraine. In addition, it is very far from Kyiv and L'viv, requiring a significant investment to connect it to the 1435mm network. Therefore, the connection of Odesa to Kyiv and L'viv, has not been considered as one of the priority nodes for the implementation of the 1435mm network in the short to mid-term.

Zaporizhzhia is less than 90 kilometres away from Dnipro by road, while by rail the distance increases to more than 120 km. Then, it has been considered that in the short to mid-term extension of the 1435mm network from Dnipro to Zaporizhzhia is not a priority from the passenger perspective.

In conclusion, in the short to mid-term, the 1435mm network should connect, from the National passenger perspective, Kyiv to L'viv, Kharkiv and Dnipro. Regarding International passenger traffic, the connections from Poland to Kyiv and L'viv are the priorities.

7.4 Moldova

In Moldova the rail network is much less extensive than in Ukraine and there are no big cities beyond Chisinau. Thus, from the passenger perspective, the 1435mm network connection would be mostly relevant regarding the connectivity of Chisinau with Romania.

Regarding freight, the main export and import goods transported by rail are mainly low-value bulk commodities (e.g., cement, iron, gravel, fertilisers, grains, and liquid fuels) and building materials. Moreover, due to the blockade of the Ukrainian Black Sea ports, the traffic of cereals from Ukraine to the Danube ports via Moldova has increased significantly, so the transition to 1435mm in Moldova should ensure that this traffic, which is linked to the existing 1520mm network, is not jeopardised.

Odesa and Chornomorsk served also as the main sea gateway for Moldova. The short distance between the ports and the Moldavian main container market, Chisinau, allowed for the establishment of a cost-efficient container route between the ports and the Moldovan market. The alternative container port is Constanta. However, the distance to Constanta is much longer and shipping costs twice as costly compared to Odesa and Chornomorsk. In 2019, the entire Moldovan container market amounted to 22 thousand TEUs. Around 8 thousand of that was shipped through the Moldovan river port Giurgiulesti.

Most of the remaining containers (14 thousand TEUs) were shipped from Odesa and Chornomorsk. Last-mile transportation from these ports could be provided only by road, as the existing rail link crosses the Transnistrian region and required additional arrangements, resulting in increased transit costs. Development of a fast train connection between Odesa/Chornomorsk, Chisinau and Constanta ports would ensure the establishment of a new rail transit corridor connecting one of the largest Black Sea ports with others. In addition, it would allow Moldova's integration into the regional transportation network. This would help Moldova to reduce container shipment costs and allow efficient diversification of traffic between Odesa/Chornomorsk and Constanta ports.

In terms of the development of North-South transit potential, the development of a 1435mm gauge rail link between Chisinau, Odesa and Constanta would be essential for the Moldovan market.

7.5 Analysis of alternatives for the implementation of the 1435mm network in the selected corridors

Based on the outcomes of the options analysis and the assessment of the relevant nodes to be connected to the 1435mm network presented above, the following corridors/sections have been identified as the most relevant for the transition to 1435mm in Ukraine and Moldova:

- Krakow to L'viv
- MD/RO border to Chisinau
- Warsaw to Kyiv
- L'viv to Kyiv
- SK/HU to L'viv
- Kyiv to Kharkiv/Dnipro
- Warsaw to L'viv
- L'viv to UA/RO border
- Odesa to Chisinau

Below, the possible options for implementation of the 1435mm network in each of those corridors/sections, including an indicative implementation cost estimate for each alternative, are presented.

As indicated in the conclusions of the options analysis, only four of the original nine options are considered for option analysis:

- Option 3: 1520mm single-track upgrading; 1520mm to 1435mm single-track transformation
- Option 4: 1520mm to 1435mm double-track transformation
- Option 7: 1520mm double-track upgrading; 1435mm single-track parallel new construction
- Option 9: 1520mm single-track to 1435mm transformation

7.5.1 Selection criteria for the implementation of the 1435mm network

The selection criteria for the implementation of the 1435mm network in Ukraine and Moldova are described in section 5 of this document. Below, it is indicated how each of the criteria is evaluated.

<u>Operational capacity 1520mm in % of the original capacity</u>

This criterion indicates the change of capacity for the 1520mm network operations. However, a reduction of 100% (no 1520mm functionality) is acceptable in case the 1520mm functionality is not needed any more (for example: rerouting to a parallel line is possible, or the line will not require 1520mm operations anymore).

<u>Operational capacity 1435mm in % of the minimum solution</u>

The minimum solution is the least costly solution possible under the required 1520mm and 1435mm functionality. However, solutions of higher 1435mm capacity and higher operational speed have been calculated.

<u>Operational speed 1435mm network in km/h</u>

The operational speed is an average speed with which the network section can be operated. The operational speed is dependent on the alignment, the signalling and track protection system, level crossings, etc.

<u>Operational reliability, efficiency, and safety in % of optimal solution</u>

The optimal solution is the solution with the highest performance in this criterion. The criterion is dependent on crossing train paths, complexity of technical solutions, maintenance requirements, etc.

<u>Project development time in % of minimum solution</u>

The minimum solution is the solution with the shortest project development time.

<u>Project implementation time in % of minimum solution</u>

The minimum solution is the solution with the shortest project implementation time.

<u>Interruption of operations 1520mm during implementation in % of minimum solution</u>

The minimum solution is the solution with the least interruption of 1520mm operations during implementation. The interruption during implementation is dependent on the vicinity of the construction to the 1520mm operation and the possibility of rerouting 1520mm traffic during implementation.

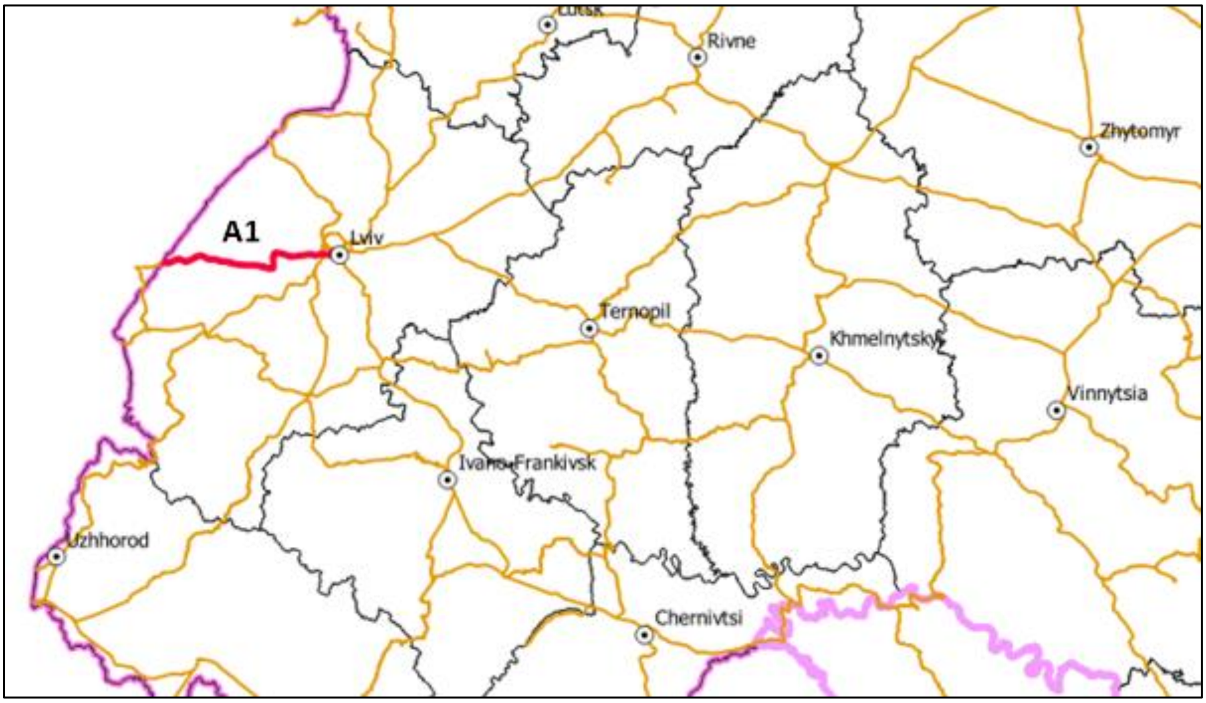
<u>Implementation cost CAPEX</u>

The implementation cost CAPEX is calculated based on unit cost of recent projects, considering recent trends in unit cost (inflation, etc.). The implementation cost does not include project development cost (Feasibility studies, etc.).

7.5.2 Priority I

The extension of the first 1435mm connections from adjoining EU countries to a significant node in both Ukraine and Moldova is identified as a priority. Considering the potential demand, relevance and location, the connection from Medyka/Mostyska (UA/PL border) to L’viv in Ukraine and the connection between Ungheni (MD/RO border) to Chisinau in Moldova have been identified.

Medyka/Mostyska (UA/PL border) to L'viv (segment A1)



For this connection, there are no alternative corridors possible. However, three options to implement the 1435mm track in the existing corridor have been assessed, options 3, 4 and 7. The estimated cost for each option is (not including the cost of the transformation of the L'viv node):

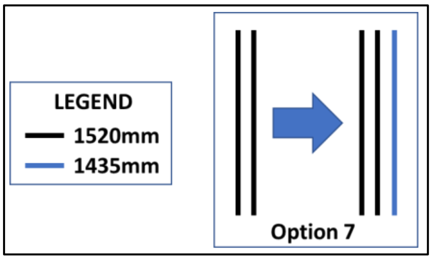
- Option 3: 323.347 Mio EUR
- Option 4: 335.746 Mio EUR
- **Option 7: 434.018 Mio EUR**

The level of traffic in this section is significant and thus a reduction of the existing 1520mm gauge capacity is not advisable. Therefore, Option 7 is the preferred option for this connection. If a Feasibility Study shows that the future 1520mm demand in this section would be significantly lower, Option 3 could be implemented as an alternative. Option 4 is not recommended since it would eliminate the 1520mm connectivity between L'viv and the border.

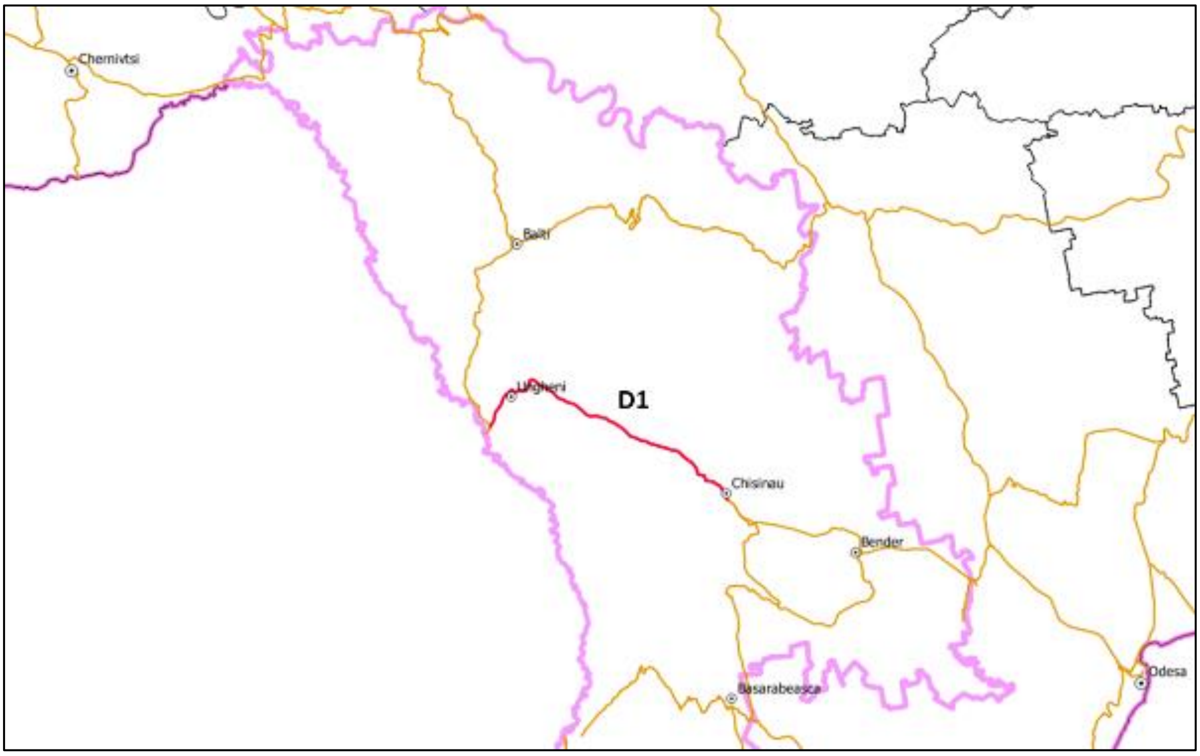
Proposed configuration

A1: Medyka/Mostyska (UA/PL border) to L'viv

Single 1435mm track and double 1520mm track.



Ungheni (MD/RO border) – Chisinau – Moldovan backbone (segment D1)



The Moldovan backbone system will connect Chisinau to the Romanian network and will serve passenger and freight transport. In the future, the Moldovan backbone system would be extended to Bender and Tiraspol, when issues with Transnistria are resolved, connecting to the line towards Odesa.

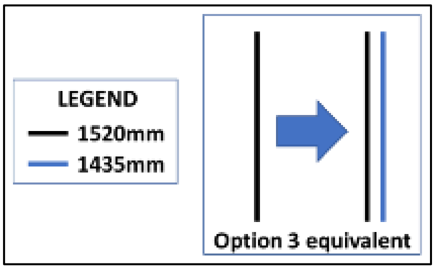
For this connection, there are no alternative corridors possible. To safeguard the full operation of the Moldovan 1520mm system it is recommended to construct a 1435mm track parallel to the existing 1520mm track. No investment in the 1520mm track is considered, beyond those already planned by the Moldovan authorities, for which financing appears to be already secured. The estimated cost (not considering any investment in the existing 1520mm track) is **264.808 Mio EUR**.

For reference, the estimated cost including the modernisation of the 1520mm track would be 473.017 Mio EUR.

Proposed configuration

<u>D1: Ungheni (MD/RO border) – Chisinau – Moldovan backbone</u>

Single 1435mm track and single 1520mm track.



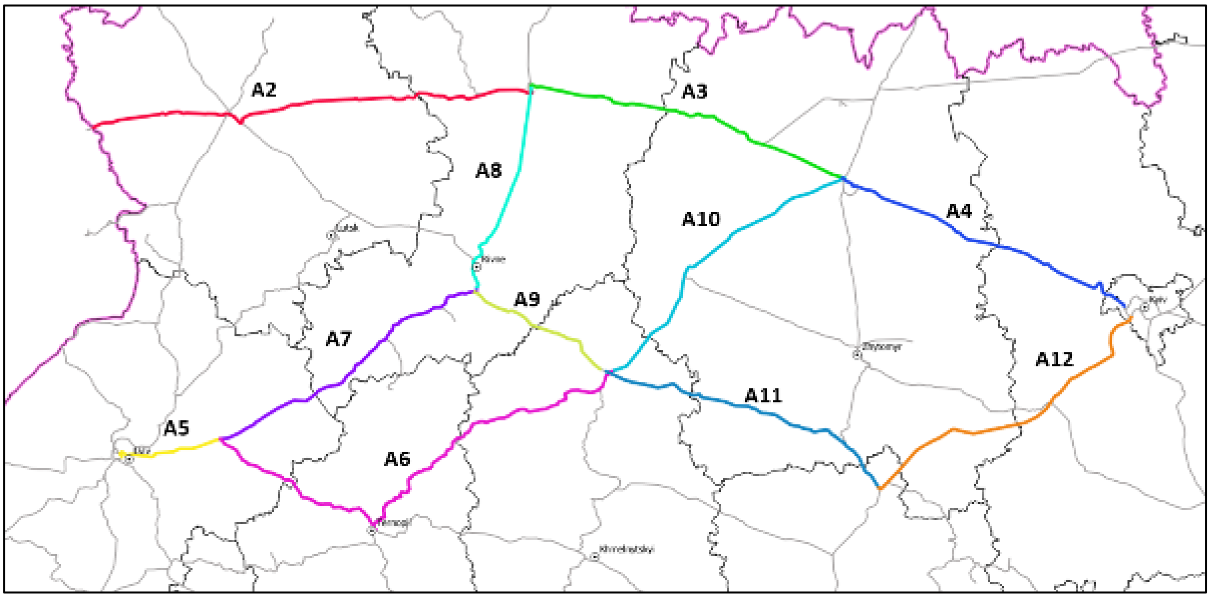
<u>Total cost of priority I: 698.825 Mio EUR.</u>

7.5.3 Priority II

The second priority is the connection of L'viv and Kyiv, plus the provision of additional 1435mm corridor connections between Ukraine and the EU. Other connections identified as most relevant are Poland to Kyiv and L'viv to Hungary/Slovakia/Romania. The connection between Kyiv and Poland is predominantly for passengers, though with the potential to develop also as a significant connection for container traffic. The connection between L'viv and HU/SK/RO is predominantly for freight, where speed parameters are less relevant.

While assessing the connections between Poland and Kyiv and between L'viv and Kyiv, synergies between both corridors have been identified. Therefore, the alternative assessment for both connections has been developed jointly.

Dorohusk (PL/UA border) – Kyiv and L'viv – Kyiv



To develop the two connections to Kyiv, from the Polish border and from L'viv, several alternatives have been identified by combining different existing rail sections. In a first step, the options analysis for each section is performed separately. Subsequently, the different options are combined to define the four alternatives.

<u>Dorohusk – Kovel – Sarny (segment A2)</u>

Between Dorohusk and Kovel, there is an existing single 1435mm track and a parallel 1520mm track. Thus, the cost of Option 3 has been assumed for this section.

Between Kovel and Sarny, there is a single 1520mm track. It is important that1520mm accessibility is retained to provide access to the power plant connected to this section. Consequently, the cost of an equivalent of Option 3 has been considered (modernisation of the existing 1520mm track and development of a new parallel 1435mm track).

The total estimated implementation cost for this entire section is **839.541 Mio EUR** (not including the cost of the transformation of the Kovel and Sarny nodes).

In the detailed Feasibility Study, the potential demand of the power plant and any other industry in this section needs to be verified, to assess the possibility to only partially retain the 1520mm track, hence reducing the implementation cost.

Sarny – Korosten (segment A3)

Currently, segment A3 is a single-track section. However, as a network section it could function as a combined segment for both connections, in addition to Option 9, the cost for an equivalent of Option 4 (in this case transformation of the existing 1520mm track to 1435mm and development of a new parallel 1435mm track) has also been estimated. Additionally, an equivalent of Option 3 has been also considered in this case to provide an option that keeps the 1520mm connectivity. The estimated cost for each option (excluding the cost of the transformation of the Sarny and Korosten nodes) is:

- **Option 3: 644.457 Mio EUR**
- Option 4: 668.330 Mio EUR
- Option 9: 359.840 Mio EUR

Since the proposal for segments A2 and A4 considers retaining 1520mm connectivity, Option 3 is considered the preferred option, in order to maintain the homogeneity of the corridor. Depending on the outcome of a detailed demand forecast, to be conducted as part of a Feasibility Study, the possibility to implement either Option 9, or Option 4, should be considered.

Korosten – Kyiv (segment A4)

Currently this section is double-track and thus several options are possible. In this case, Options 3, 4 and an equivalent of Option 7 (modernisation of one of the existing 1520mm tracks, transformation of the other track to 1435mm and development of a new parallel 1435mm track) have been considered. The estimated cost for each option is (not including the cost of the transformation of the Korosten and Kyiv nodes):

- Option 3: 595.441 Mio EUR
- Option 4: 617.861 Mio EUR
- **Option 7: 795.555 Mio EUR**

Safeguarding the 1520mm connectivity is deemed relevant for this section. Therefore Options 3 or 7 are preferred to Option 4. In this case, the cost of Option 7 is taken forward to ensure that the cost is not underestimated. A detailed demand assessment as part of a Feasibility Study should identify whether Option 7 would be required and if there is not sufficient projected demand to maintain 1520mm connectivity, Option 4 may be considered.

L'viv – Krasne (segment A5)

This section is currently double-track. Being the main corridor connecting L'viv with Kyiv and Odesa a reduction of the 1520mm operational capacity would not be practicable. Consequently, only Option 7 is assessed as an appropriate option for the integration of a 1435mm track. The estimated cost is **217.052 Mio EUR** (not including the cost of the transformation of the L'viv node).

Krasne – Ternopil – Shepetivka (segment A6)

This section is double-track between Krasne and Ternopil and single-track between Ternopil and Shepetivka, except in the vicinity of Shepetivka.

The section Krasne – Ternopil is on the main corridor connecting L'viv and Odesa, thus safeguarding operational capacity for the 1520mm network is necessary. Regarding the connection between L'viv and Kyiv, an alternative main corridor exists and only Options 3 and 7 have been considered. However, as the connection between L'viv and Odesa in 1520mm gauge is deemed to be very relevant for future operations, reduction of the 1520mm operational capacity is not recommended and therefore, Option 7 has been selected.

For the section Ternopil – Shepetivka, only Option 9 has been considered since there are alternative corridors to overtake the 1520mm traffic. If the Feasibility Study shows the need to keep the 1520mm connectivity in certain parts of this section, partial implementation of the 1435mm track parallel to the existing 1520mm track should be considered.

The total estimated implementation cost for this entire section in the selected configuration is **842.372 Mio EUR** (not including the cost of the transformation of the Shepetivka node).

<u>Krasne – Zdolbuniv (segment A7)</u>

This section is currently double-track. In this case, Options 3, 4 and 7 have been assessed as relevant options to implement 1435mm. The estimated cost for each option is:

- **Option 3: 590.181 Mio EUR**
- Option 4: 613.003 Mio EUR
- Option 7: 793.879 Mio EUR

As there is an alternative main corridor connection between L'viv and Kyiv in 1520mm, Option 3 has been considered as the most appropriate, due to it being significantly cheaper than Option 7. Option 4 is not preferred as it would eliminate 1520 operations. Should the demand forecast as part of a Feasibility Study demonstrate that the 1520mm future traffic would be of higher importance in this section than currently envisaged, Option 7 could be reconsidered.

<u>Zdolbuniv – Rivne – Sarny (segment A8)</u>

There are two tracks between Zdolbuniv and Rivne and safeguarding operational capacity for the 1520mm network is necessary. Thus, only Options 3 and 7 have been considered. The estimated cost for each option is:

- **Option 3: 61.461 Mio EUR**
- Option 7: 82.760 Mio EUR

As the 1520mm section between Rivne and the Polish border is only double-track until Kivertsi, it is assumed that a single-track 1520mm between Zdolbuniv and Rivne would suffice in the future, thus Option 3 is the preferred one.

Between Rivne and Sarny there is only one track. In this study, only Option 9 has been considered, with an estimated cost of **203.089 Mio EUR**.

The total estimated cost for the Zdolbuniv – Rivne – Sarny section in the selected configuration is **264.549 Mio EUR** (not including the cost of the transformation of the Sarny node) .

<u>Zdolbuniv – Shepetivka (segment A9)</u>

There are two tracks between Zdolbuniv and Shepetivka. In this case, Options 3, 4 and 7 have been assessed for implementation of 1435mm: The estimated cost for each option (not including the cost of the transformation of the Shepetivka node) is:

- **Option 3: 286.348 Mio EUR**
- Option 4: 297.187 Mio EUR
- Option 7: 383.088 Mio EUR

As there is an alternative main corridor connection between L'viv and Kyiv in 1520mm, Option 3 has been considered as the most appropriate, due to it being significantly cheaper than Option 7. Option 4 is not preferred as it would eliminate 1520 operation. If the Feasibility Study demonstrates that the 1520mm future traffic would be of higher importance in this section than currently envisaged, Option 7 could be reconsidered.

Shepetivka – Korosten (segment A10)

In this case, although there are some small double-track sections, only the cost of transforming a single 1520mm track to 1435mm (Option 9) has been considered, for simplification. A more detailed assessment in a Feasibility Study could explore other options. The estimated cost is **332.178 Mio EUR** (not including the cost of the transformation of the Shepetivka and Korosten nodes).

Shepetivka – Berdychiv - Koziatyn (segment A11)

This section is currently double-track. In this case, three options to implement the 1435mm track have been assessed, options 3, 4 and 7. The estimated cost for each option (not including the cost of the transformation of the Shepetivka and Koziatyn nodes) is:

- **Option 3: 571.284 Mio EUR**
- Option 4: 593.201 Mio EUR
- Option 7: 766.908 Mio EUR

As there is an alternative main corridor connection between L'viv and Kyiv in 1520mm, Option 3 has been considered as the most appropriate, due to it being significantly cheaper than Option 7. Option 4 is not preferred as it would leave this section with no 1520mm tracks. Should the demand forecast as part of a Feasibility Study demonstrate that future traffic on the 1520mm network would be of higher importance in this section than currently envisaged, Option 7 could be reconsidered.

Koziatyn – Fastiv – Kyiv (segment A12)

There are two tracks between Koziatyn and Kyiv and it is the main corridor connecting Kyiv and Odesa, thus safeguarding operational capacity for the 1520mm network is necessary. Therefore, only options 3 and 7 have been considered. The estimated cost for each option (not including the cost of the transformation of the Koziatyn and Kyiv nodes) is:

- Option 3: 582.798 Mio EUR
- **Option 7: 784.769 Mio EUR**

Option 3 is much cheaper than option 7. However, as the connection between Kyiv and Odesa in 1520mm gauge is deemed to be very relevant for the future, reduction of the 1520mm operational capacity is not recommended. Therefore, Option 7 has been selected.

Major nodes

The cost of the transformation of the nodes is also relevant for the comparison between alternatives. Although a more detailed assessment in specific rail node studies is needed, a preliminary estimate of the cost of the reorganisation of the relevant nodes has been considered, to help in the selection of the preferred alternative. The cost of Kyiv node is not included in this priority, since it is considered that the complete transformation of a node is only necessary once the relevant node is not an edge for the 1435mm network.

The nodes relevant for these connections, with the indicative cost estimate for their transformation, are:

- L'viv node: 419.393 Mio EUR
- Kovel node: 92.267 Mio EUR

- Sarny node: 124.054 Mio EUR
- Korosten node: 196.490 Mio EUR
- Shepetivka node: 145.390 Mio EUR
- Koziatyn node: 139.798 Mio EUR
- Fastiv node: 100.654 Mio EUR

Alternatives

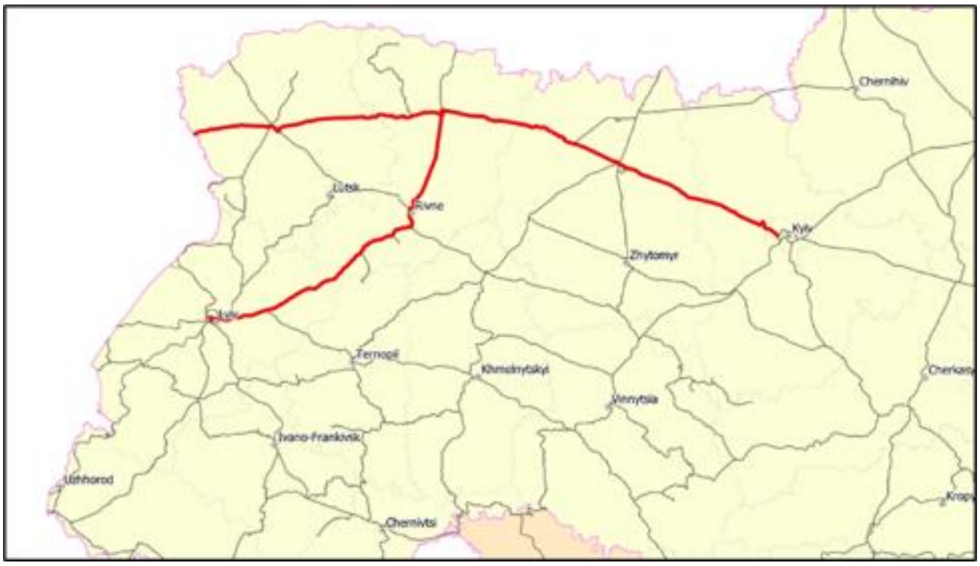
To identify the best 1435mm gauge connection from Kyiv to the Polish border and to L'viv, the segments from A4 to A14 have been combined to define four possible alternatives.

The connection from the Polish border to Kyiv is proposed via Sarny and Korosten in all the alternatives (segments A2, A3 and A4). Likewise, all alternatives for the connection between L'viv and Kyiv have the segment L'viv – Krasne in common (A5).

The alternatives are presented from the least costly (Alternative I), to the most costly (Alternative IV).

Alternative I

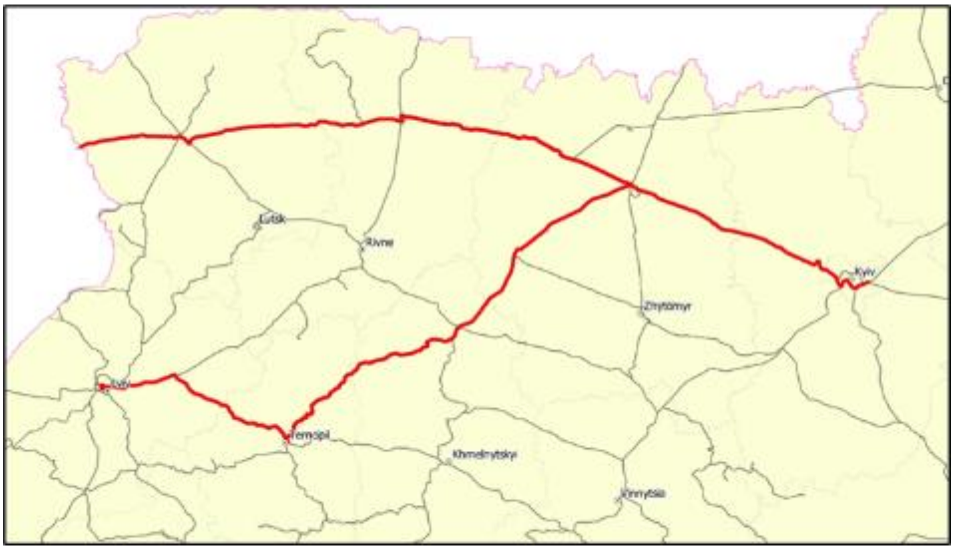
This alternative uses the synergies of both connections as much as possible. From Krasne, the 1435mm corridor towards Kyiv continues to Zdolbuniv, Rivne and Sarny, where it joins the proposed 1435mm corridor between the Polish border and Kyiv.



This alternative is composed of segments A2, A3, A4, A5, A7 and A8 and the L'viv, Kovel, Sarny and Korosten nodes. The total estimated cost is **4183.541 Mio EUR**.

Alternative II

In this alternative from Krasne the 1435mm corridor towards Kyiv continues to Ternopil, Shepetivka and Korosten, where it joins the proposed 1435mm corridor between the Polish border and Kyiv.

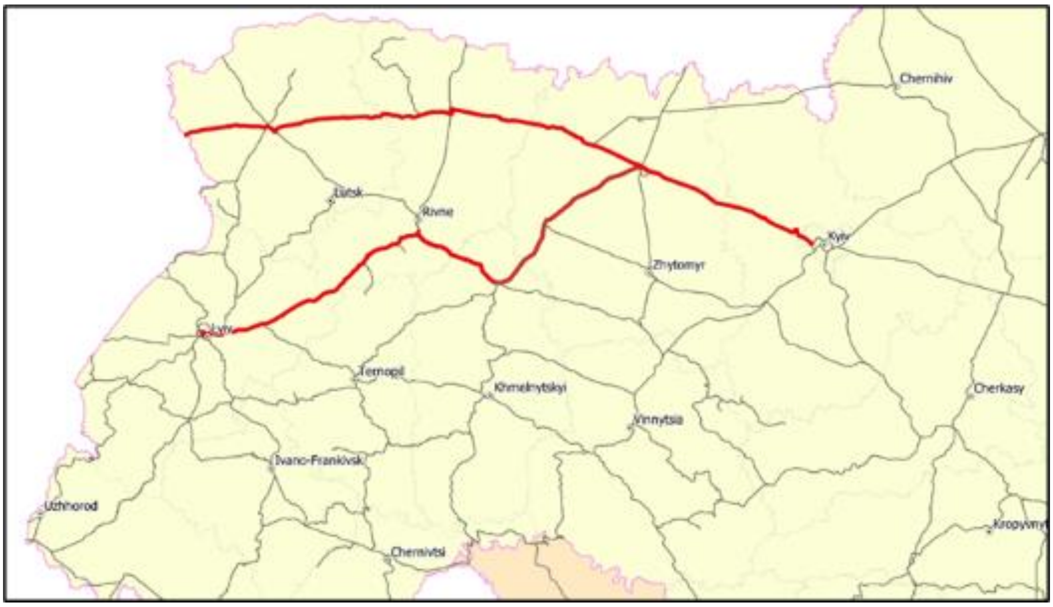


This alternative is composed of segments A2, A3, A4, A5, A6 and A10 and the L'viv, Kovel, Sarny, Shepetivka and Korosten nodes. The total estimated cost is **4648.749 Mio EUR**.

One of the biggest advantages of this alternative is that it has the least impact on the main corridors connecting Kyiv and L'viv. The alignment is suitable for high speeds and conflict points in case of both functionalities (1435 and 1520) are minimised. In addition, no specific bulk dependent facilities such as coal power plants are located along this alternative. The connection between Kyiv and L'viv is expected to have significant demand in the future for both networks.

Alternative III

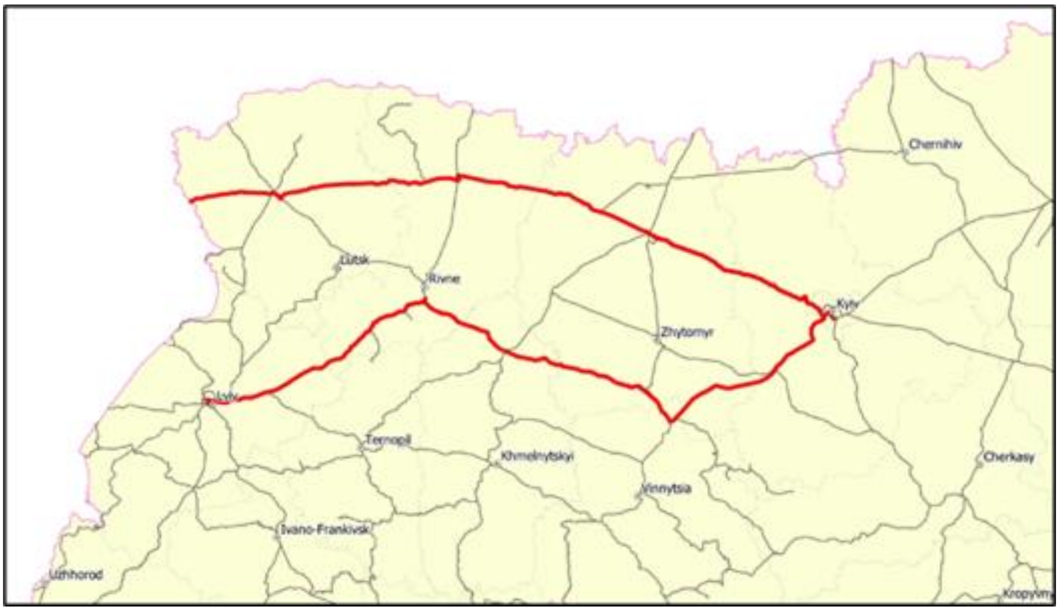
In this alternative from Krasne the 1435mm corridor towards Kyiv continues to Zdolbuniv, Shepetivka and Korosten, where it joins the proposed 1435mm corridor between the Polish border and Kyiv.



This alternative is composed of segments A2, A3, A4, A5, A7, A9 and A10 and the L'viv, Kovel, Sarny, Shepetivka and Korosten nodes. The total estimated cost is **4682.907 Mio EUR**.

Alternative IV

Alternative IV provides the fastest connection between L'viv and Kyiv. In this alternative from Krasne the 1435mm corridor towards Kyiv continues to Zdolbuniv, Shepetivka, Koziatyn and Fastiv, to reach Kyiv.



This alternative is composed of segments A2, A3, A4, A5, A7, A9, A11 and A12 and the L'viv, Kovel, Sarny, Shepetivka, Korosten, Koziatyn and Fastiv nodes. The total estimated cost is **5947.235 Mio EUR**.

Conclusions on the proposed alternatives:

- Alternative I is the least costly, but provides the longest connection between L'viv and Kyiv and impacts the main corridor between L'viv and Kyiv more than Alternative II
- Alternative II and Alternative III have a very similar cost estimate and length. Alternative II is preferred because it has a lower impact on the main corridor between L'viv and Kyiv
- Alternative IV provides the fastest possible connection but is significantly more costly than the other alternatives and has the biggest impact on the main corridor between L'viv and Kyiv

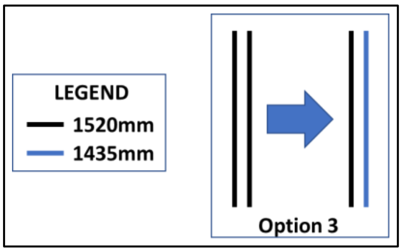
Consequently, <u>Alternative II is the proposed alternative to be developed in subsequent Feasibility Studies</u>.

Proposed configuration

A2: Dorohusk – Kovel – Sarny

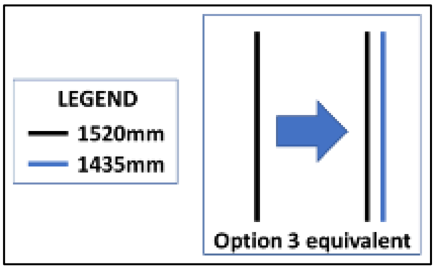
Dorohusk – Kovel

Single 1435mm track and single 1520mm track.



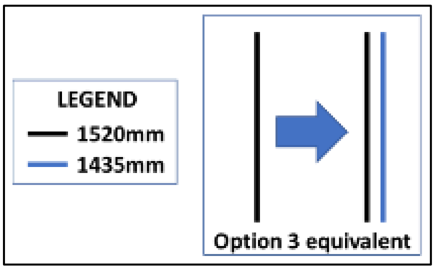
Kovel – Sarny

Single 1435mm track and single 1520mm track.



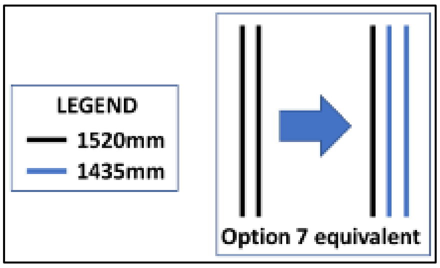
A3: Sarny – Korosten

Single 1435mm track and single 1520mm track.



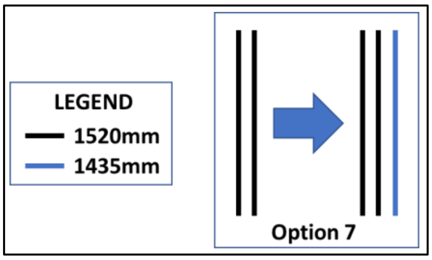
A4: Korosten – Kyiv

Double 1435mm track and single 1520mm track.



A5: L'viv – Krasne

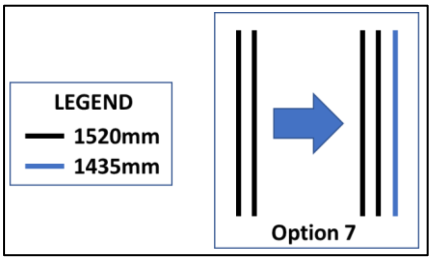
Single 1435mm track and double 1520mm track.



A6: Krasne – Ternopil – Shepetivka

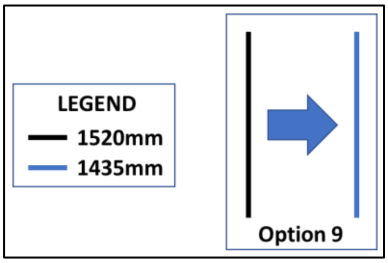
Krasne – Ternopil

Single 1435mm track and double 1520mm track.



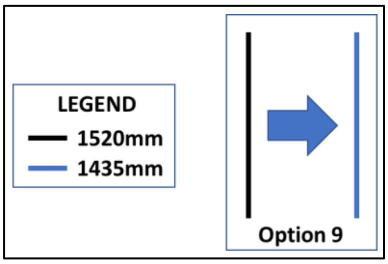
Ternopil – Shepetivka

Single 1435mm track.

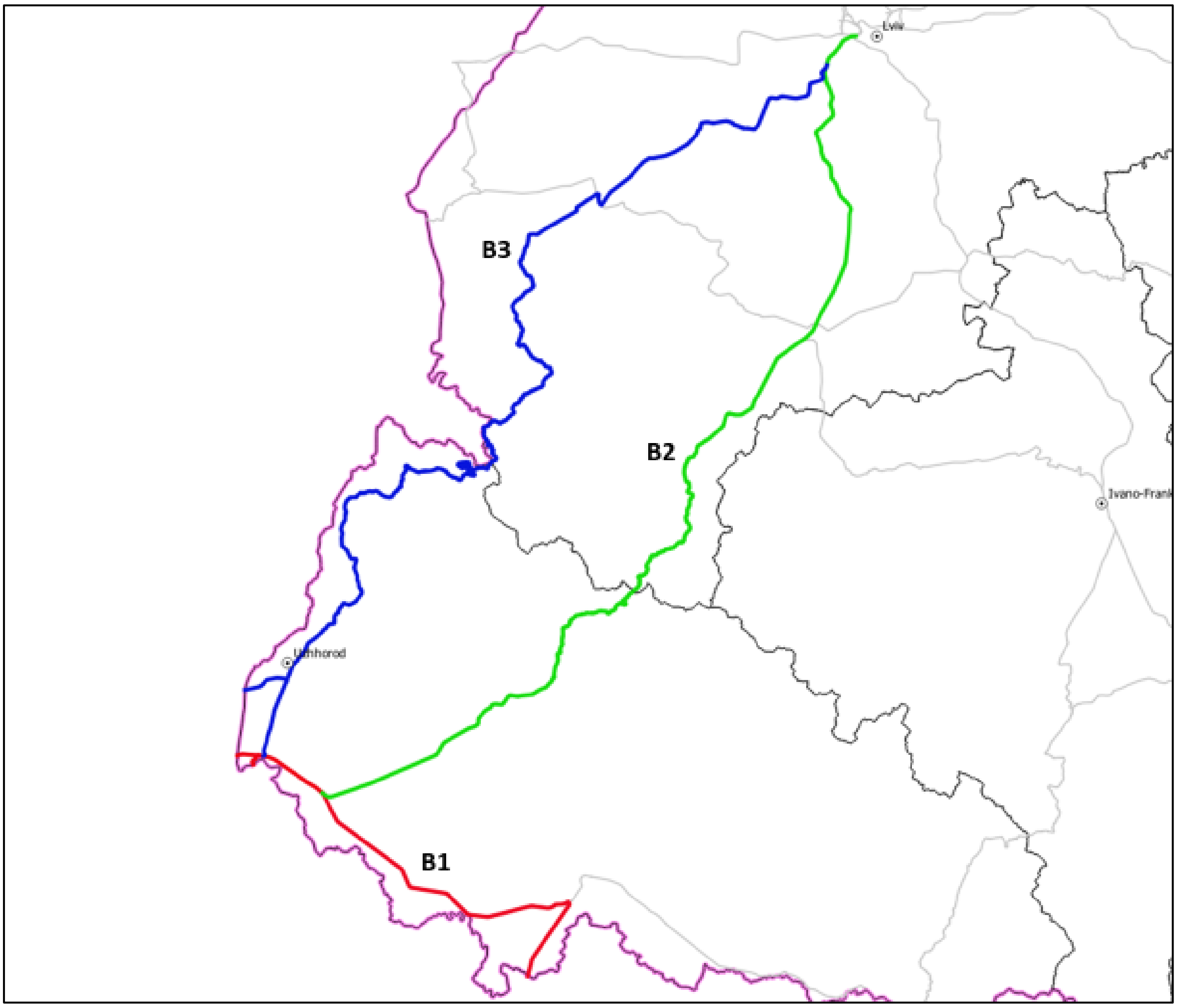


A10: Shepetivka – Korosten

Single 1435mm track.



Chop (SK/HU/RO border) – L'viv



To develop this connection, it would be necessary to cross the Carpathian Mountains entailing significant investment to achieve a horizontal alignment for higher operational speed. However, as mentioned above, this connection is predominantly for freight, thus speed is not so relevant.

Two alternative corridors for this connection have been identified, Chop – Bat'ovo – L'viv and Chop – Uzhhorod – Sambir – L'viv. Both corridors share common sections between the UA/SK-HU-RO borders and Chop.

<u>UA/SK-HU-RO borders – Chop – Bat'ovo (segment B1)</u>

The connection from Bat'ovo and Chop to the Hungarian, Romanian and Slovak borders is characterised by several tracks with varying track gauges and transhipment facilities. For simplification, the cost estimate of Option 7 (modernisation of a 1520mm double-track and construction of a 1435mm single-track) has been predominantly used for these sections. However, the cost of Option 9 has been applied, for simplification, for the connection to the Romanian border in Halmeu, which is only single-track dual-gauge.

The necessary connections include the sections:

- UA/HU border (Záhony) to Chop – 27 Mio EUR
- UA/SK border (Cierna nad Tisou) to Chop – 32 Mio EUR

- UA/HU border (Eperjeske) to Petrivka – 43 Mio EUR
- Chop / Petrivka to Bat'ovo – 87 Mio EUR

Total investment cost for segment B1 is hence **189 Mio EUR**. Along the Chop – Petrivka – Bat'ovo section there is sufficient space for the development of a parallel system (1520mm and 1435mm). Some tracks are currently non-operational.

A Feasibility Study should assess in detail the status of the entire border crossing area and identify, based on the potential demand for each border crossing point, which sections and tracks need to be upgraded and which ones not.

In this study, modernisation/reorganisation of all sections has been considered in the cost estimate.

The cost for the line from Bat'ovo to Halmeu at the UA/RO border would be 352 Mio EUR if the dual-gauge is kept and 212 Mio EUR if it were transformed to a 1435mm track. As the current traffic is very low, the cost has not been factored into this study and would need justification as part of a dedicated Feasibility Study.

Alternative I: Bat'ovo – L'viv (segment B2)

The section between Bat'ovo and L'viv is currently double-track. In this case, options 3, 4 and 7 have been assessed to implement 1435mm. The estimated cost for each option is (not including the cost of the transformation of the L'viv node):

- Option 3: 1333.116 Mio EUR
- Option 4: 1372.996 Mio EUR
- **Option 7: 1702.676 Mio EUR**

Considering the significant transhipment capacity in the border areas, it is not recommended to reduce the existing 1520mm capacity. Therefore, despite being the most costly option, Option 7 is recommended for the development of the 1435mm corridor in this section if this is the selected alternative.

Alternative II: Chop – Uzhhorod – Sambir – L'viv (segment B3)

The entire section between Chop and L'viv is currently single-track. Thus, between Uzhhorod and L'viv, only Option 9 has been considered for the implementation of the 1435mm track. The estimated investment cost is 933.474 Mio EUR (not including the cost of the transformation of the L'viv node).

However, between Chop and Uzhhorod, it would be necessary to retain the existing single-track 1520mm connection, to safeguard the connectivity to the 1520mm line going from Ukraine to the area of Kosice in Slovakia. A new parallel 1435mm single-track would have to be implemented in this section. For the cost estimate, the same cost has been assumed as for Option 3, resulting in an estimate of 84.354 Mio EUR for this section.

Finally, the modernisation of the existing 1520mm connection between Uzhhorod and Mat'ovce (UA/SK border) has been included in the cost estimate for this alternative. As it is a very short section, the suggestion is to modernise the existing 1520mm track and build a parallel single 1435mm track, to ensure accessibility for both gauges. For simplification, the cost of Option 3 has been assigned to this section, in total 41.528 Mio EUR.

If this alternative is selected, the possibility to modernise and transform to 1435mm on the section between Sambir and the two border crossing points with Poland via Khyriv should be assessed, depending on the potential relevance of those border crossing points in the future.

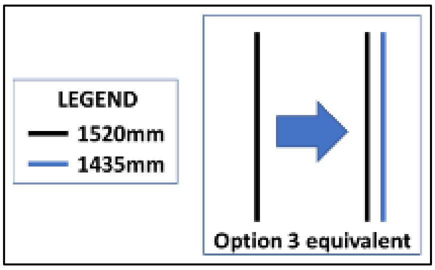
The total cost of Alternative II with the stated assumptions is 1059.355 Mio EUR.

Alternative II is significantly less costly than the selected combination of options for Alternative I. It has a lower speed profile but does not require the development of a new track across difficult terrain. Hence, Alternative II is the proposed alternative for the implementation of the 1435mm corridor in this connection.

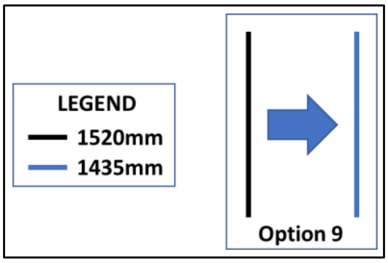
The total estimated cost of Alternative II, including the cost segment B1 is **1248.316 Mio EUR**.

Proposed configuration

Chop / Mat'ovce – Uzhhorod
Single 1435mm track and single 1520mm track.



Uzhhorod – L'viv NODE
Single 1435mm track.

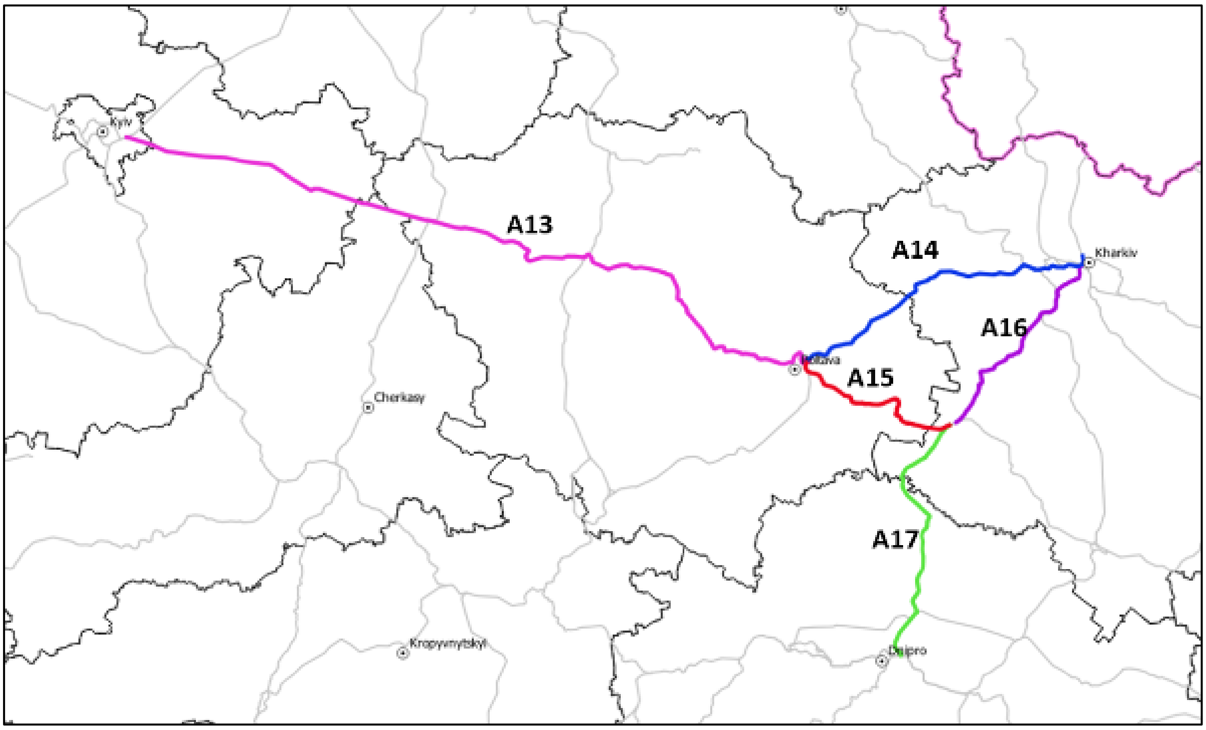


Total cost of priority II: 5897.066 Mio EUR.

7.5.4 Priority III

Priority III includes the remaining relevant connections identified in this study relating to the development of the backbone 1435mm network in Ukraine and Moldova.

Kyiv – Kharkiv/Dnipro



The next priority is the extension of the 1435mm network from Kyiv to Kharkiv and Dnipro, two of the biggest cities in Ukraine, and both considered very relevant for future container traffic potential. For the first part of this connection, between Kyiv and Poltava, only one alternative is assessed. However, beyond Poltava, two alternatives are considered to connect to Kharkiv and Dnipro. The cost of the transformation of Kyiv node is considered part of this connection, however the cost of the total transformation of Kharkiv and Dnipro nodes is not included, as both cities would be at the outer periphery of the 1435mm network.

Kyiv – Poltava (segment A13)

Between Kyiv and Hrebinka, the corridor is double-track while between Hrebinka and Poltava, it is double-track in some sections and single-track in others. For the integration of the 1435mm track in the existing corridor Options 3, 4 and 7 have been assessed. The estimated cost for each option is (not including the cost of transformation of the Kyiv node):

- **Option 3: 1410.667 Mio EUR**
- Option 4: 1464.274 Mio EUR
- Option 7: 1889.143 Mio EUR

Considering that there are alternative corridors connecting Kyiv and Kharkiv/Dnipro in 1520mm, Option 3 is considered the preferred option in this case, as it is significantly cheaper to implement than Option 7. If the Feasibility Study shows that the 1520mm future traffic would be of lower importance than currently envisaged and that it would be enough to reroute it via alternative corridors, Option 4 could be considered instead.

Poltava – Kharkiv/Dnipro

In this case two alternatives are considered. The first one includes the continuation of the development of the 1435mm corridor between Poltava and Kharkiv following the main corridor (via Kolomak) and then the connection between Kharkiv and Dnipro via Krasnohrad. The second considers the connection between Poltava and Kharkiv via Krasnohrad and the connection between Krasnohrad and Dnipro.

Poltava – Kharkiv (segment A14)

The entire section is already double-track. Options 3, 4 and 7 have been assessed to implement the 1435mm track in the exiting corridor. The estimated cost for each option is (without the cost of the transformation of the Kharkiv node):

- **Option 3: 565.932 Mio EUR**
- Option 4: 587.393 Mio EUR
- Option 7: 757.483 Mio EUR

Since this is the more direct connection between Kharkiv and Odesa, Option 4 is not recommended as it would eliminate both 1520mm tracks. However, as an alternative route to Odesa via Dnipro would still be available, Option 3 is preferred to option 7, due to the lower implementation cost.

Poltava – Krasnohrad (segment A15)

In this case, although there are a number of short double-track sections, for simplification purposes only the cost of transforming a single 1520mm track to 1435mm (Option 9) has been considered. A more detailed assessment in a Feasibility Study could explore other options in case significant future 1520mm demand is envisaged. The estimated cost is **201.182 Mio EUR**.

Kharkiv – Krasnohrad (segment A16)

As this is a single-track section (except in the vicinity of Kharkiv), only Option 9 has been considered. A more detailed assessment in a Feasibility Study could explore other options in case significant future 1520mm demand is envisaged. The estimated cost is **224.082 Mio EUR**.

Krasnohrad – Dnipro (segment A17)

As this is a single-track section (except between Novomoskovsk and Dnipro), only Option 9 has been considered. A more detailed assessment in a Feasibility Study could explore other options in case significant future 1520mm demand is envisaged. The estimated cost is **296.794 Mio EUR**.

Kyiv Node

Although a more detailed assessment in a rail node study is needed, a preliminary estimate of the cost of the transformation of the Kyiv node has been considered. The estimated cost is **498.099 Mio EUR**.

Total cost of the alternatives

Considering the above, the total cost of the alternatives is the following.

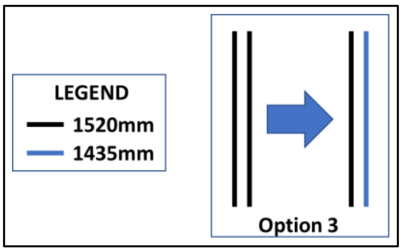
- Alternative I (connecting Poltava and Kharkiv directly – A13/A14/A16/A17/Kyiv node) → **2995.574 Mio EUR**
- Alternative II (connecting Poltava and Kharkiv via Krasnohrad – A13/A15/A16/A17/Kyiv node) → **2631.535 Mio EUR**

Alternative II is less costly and offers a more direct connection between Kyiv and Dnipro. On the contrary, Alternative I offers a shorter and faster connection between Kyiv and Kharkiv, but reduces the 1520mm operational capacity between Kharkiv and Odesa. Because of the lower cost and impact to the 1520mm operational capacity between Kharkiv and Odesa, Alternative II is considered the preferred one.

Proposed configuration

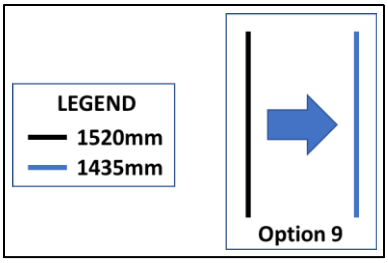
A13: Kyiv – Poltava

Single 1435mm track and single 1520mm track.

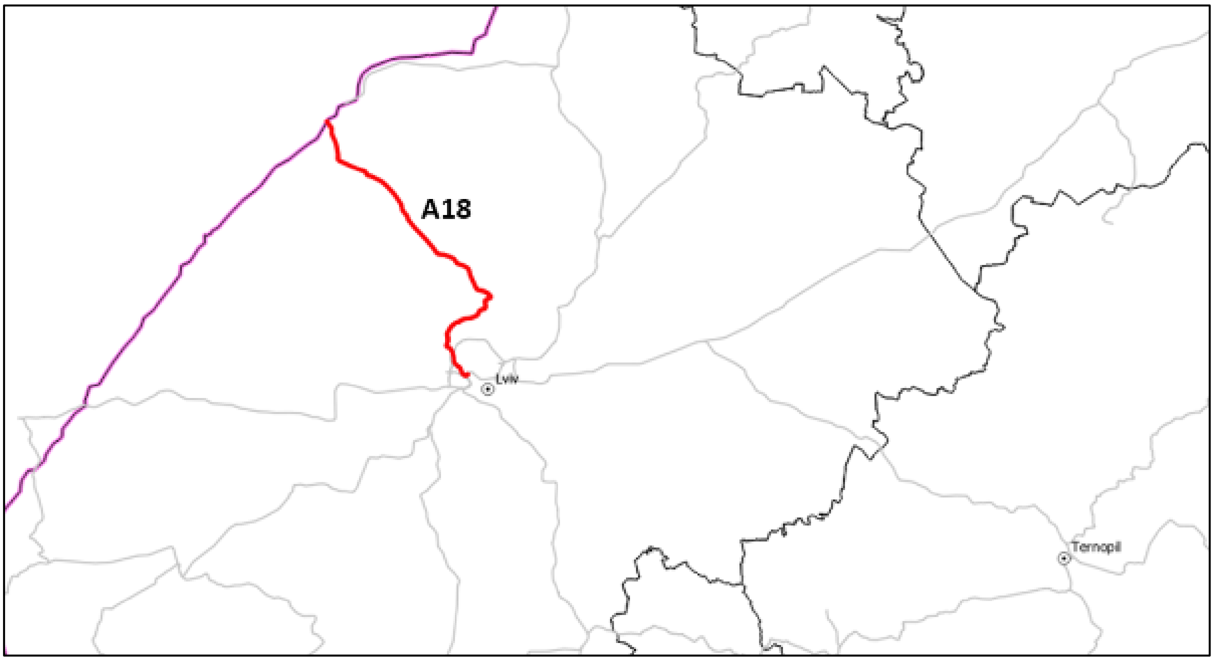


A15 – A16 – A17: Poltava – Kharkiv/Dnipro via Krasnohrad

Single 1435mm track.



Rava Ruska (UA/PL border) – L’viv (Warsaw – L’viv corridor) / segment A18



For this existing single-track connection, there are no alternative corridors and only Option 9 has been considered. Between Rava Ruska and the UA/PL border in Hrebenne, there is already a 1435mm track. In the detailed Feasibility Study, it should be assessed whether a full modernisation of that section would be needed. For the purposes of this study, the cost of the full modernisation has been included. The estimated cost is **154.273 Mio EUR** (without the cost for the transformation of the L’viv node).

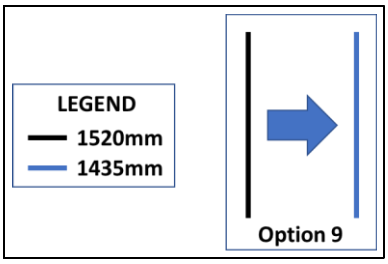
There is an agreement between the Polish and Ukrainian authorities to develop a high-speed connection Warsaw – Lublin – L’viv via Rava Ruska, whose Feasibility Study is ongoing. Due to the limited scope of this study, and since for a big part the current alignment between Rava Ruska and L’viv seems adequate for higher speeds, no option with a completely new alignment to increase the speed has been considered. Hence, the cost estimate for Option 9 has been assigned to this section for this study.

This ongoing Feasibility Study will also assess alternative alignments to reach higher speeds. According to the results of the study “Assessment of unit costs (standard prices) of rail projects (CAPital EXpenditure)” from the European Commission, total investment and construction unit cost for new high-speed lines was estimated at an average circa 14 Mio EUR per kilometre, while considering only the base infrastructure, the average unit cost per kilometre was less than 9 Mio EUR. However, a detailed analysis in the Feasibility Study should be developed to have a more accurate cost estimate, especially if speeds of 200 km/h or more are envisaged.

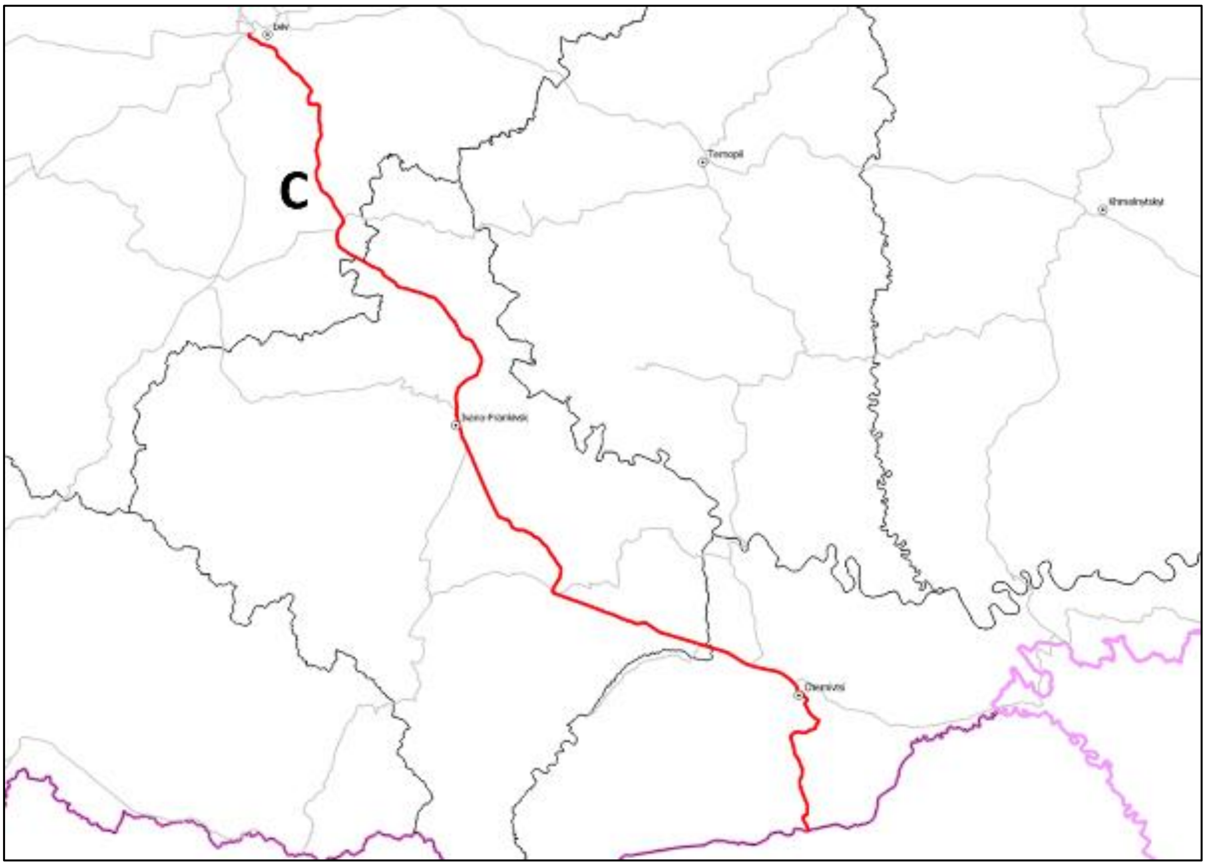
Proposed configuration

A18: Rava Ruska (UA/PL border) – L'viv

Single 1435mm track.



L'viv – Bahrynivka (UA/RO border) (segment C)



For the connection between L'viv and Romania, several alternatives were initially considered. However, none of the other alternatives were suitable, either because of the alignment or because they entail a significantly higher implementation cost without additional benefits. Hence, only the corridor between L'viv and Vadul Siret/Bahrynivka via Khodoriv, Ivano-Frankivsk and Chernivtsi has been assessed.

As it is currently a single-track corridor and the 1520mm functionality must be provided to the Burshtynska power plant and to the secondary 1520mm lines until Chernivtsi, for this part of the corridor Option 3 has been considered. From Chernivtsi to the UA/RO border at Bahrynivka, Option 9 has been considered. The estimated implementation cost is **1234.476 Mio EUR** (without the cost for the transformation of the L'viv node).

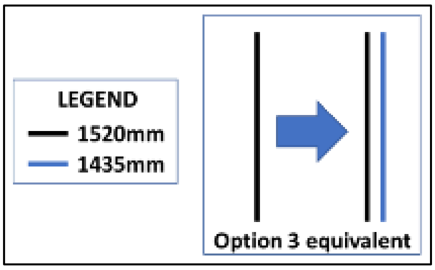
A detailed Feasibility Study should assess whether on other parts of the corridor between the power plant and Chernivtsi, it would be possible to eliminate the 1520mm track to reduce the cost. This would depend on the potential demand of the secondary lines connecting to the main corridor, as they would remain isolated if the corridor is totally converted to 1435mm.

Proposed configuration

C: L'viv - Bahrynivka (UA/RO border)

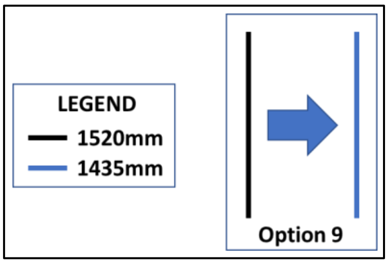
Lviv NODE – Chernivtsi

Single 1435mm track and single 1520mm track.

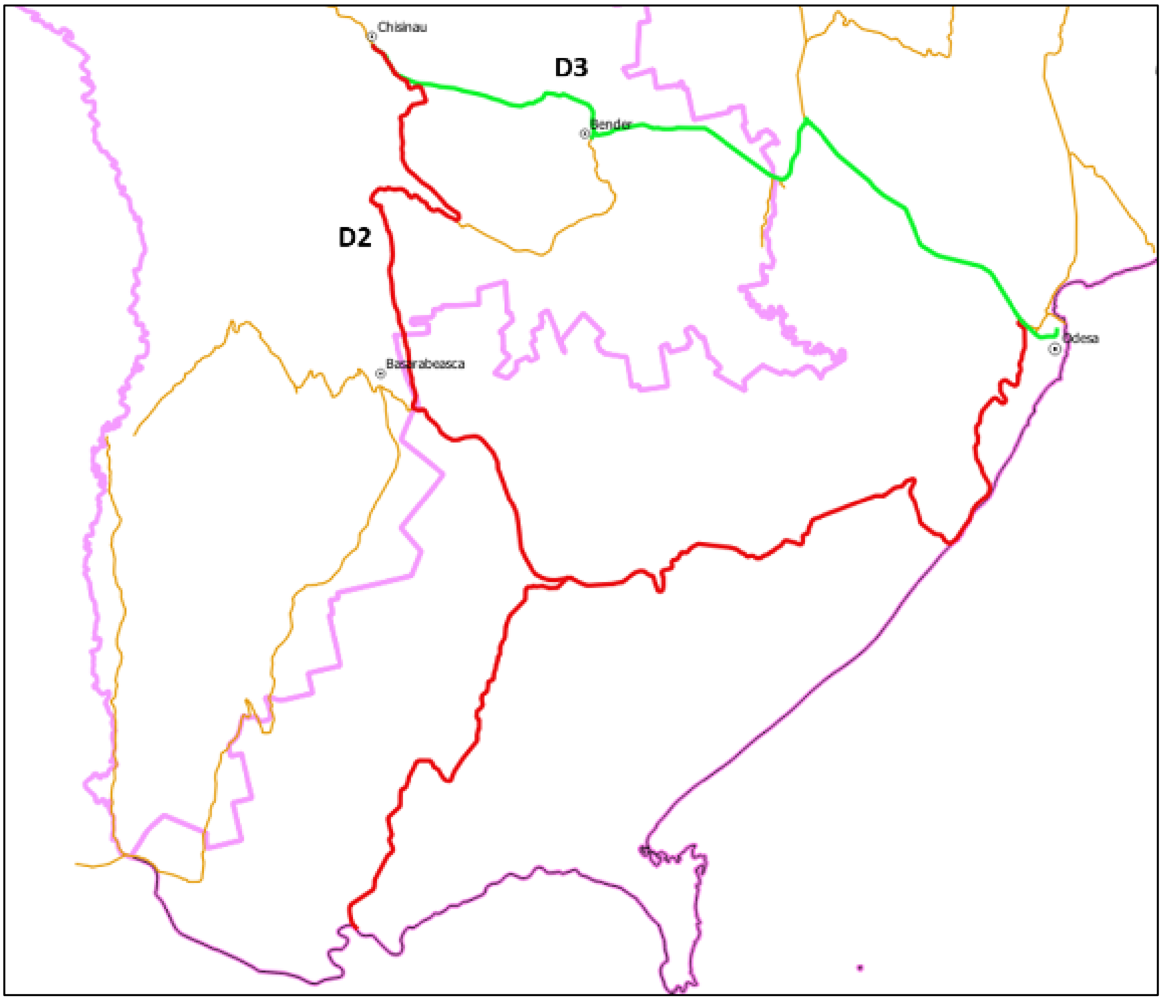


Chernivtsi – Bahrynivka (UA/RO border):

Single 1435mm track.



Odesa – Chisinau



The more direct, and fastest, connection between Chisinau and Odesa is currently not accessible as it goes via Transnistria. For this reason, the corridor connecting both cities via Basarabeasca (which is slower and crosses a highly populated area close to Odesa) is proposed as an alternative. Should the situation in Transnistria be resolved, an alternative to connect Odesa and Chisinau via Bender and Tiraspol would be recommended.

Alternative I: Chisinau – Cainari – Basarabeasca – Odesa (segment D2)

The proposed transformation of the existing 1520mm single-track between Chisinau and Odesa via Cainari and Basarabeasca to 1435mm (Option 9) is proposed for this alternative. The implementation cost for this option also includes the connection to the Izmail river port, as otherwise it would be isolated. The cost does not include an estimate of the transformation of the Odesa node. Accordingly, the total cost estimate for this connection is **1084.459 Mio EUR**.

In the Moldovan part of this connection, the proposal would be to construct a 1435mm track parallel to the existing 1520mm track to ensure the connectivity of the rest of the network. No investment in the 1520mm track has been considered, beyond those already planned by the Moldova authorities, for which financing appears to be already under discussion.

If a Feasibility Study would identify a significant potential for 1520mm traffic on the entire connection, Option 3 could be considered for the whole section (although in the vicinity of Odesa, it would most likely be difficult to build a second track). The estimated cost for such option is 2099.016 Mio EUR.

Alternative II: Chisinau – Bender – Tiraspol – Odesa (segment D3)

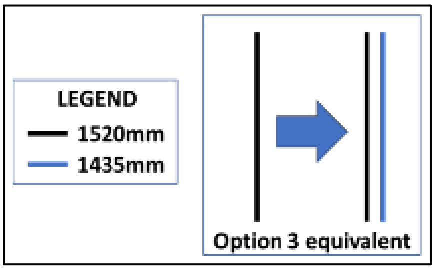
This connection is double-track between Bender and Odesa. Only the section between Chisinau and Bender is single-track. Bearing in mind that between Chisinau and Ungheni, a new 1435mm track parallel to the existing 1520mm track has been proposed, it would make sense to propose the same solution (1 track 1520mm and 1 track 1435mm) for the entire connection between Chisinau and Rozdil'na in Ukraine i.e., Option 3. Between Rozdil'na and Odesa, the connection would be via the main corridor connecting Odesa with L'viv and Kyiv, where a reduction of the existing 1520mm capacity would not be recommended. Thus, Option 7 is proposed for this section. The total cost of this combination of options, not considering the cost of the transformation of Odesa node, is **875.903 Mio EUR**.

Proposed configuration

D3: Chisinau – Bender – Tiraspol – Odesa

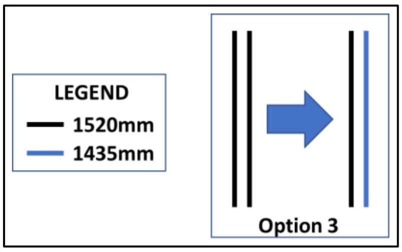
Chisinau – Bender

Single 1435mm track and single 1520mm track.



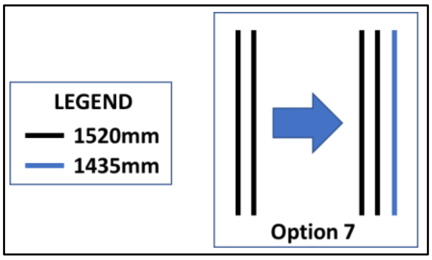
Bender - Rozdil'na

Single 1435mm track and single 1520mm track.



Rozdil'na – Odesa

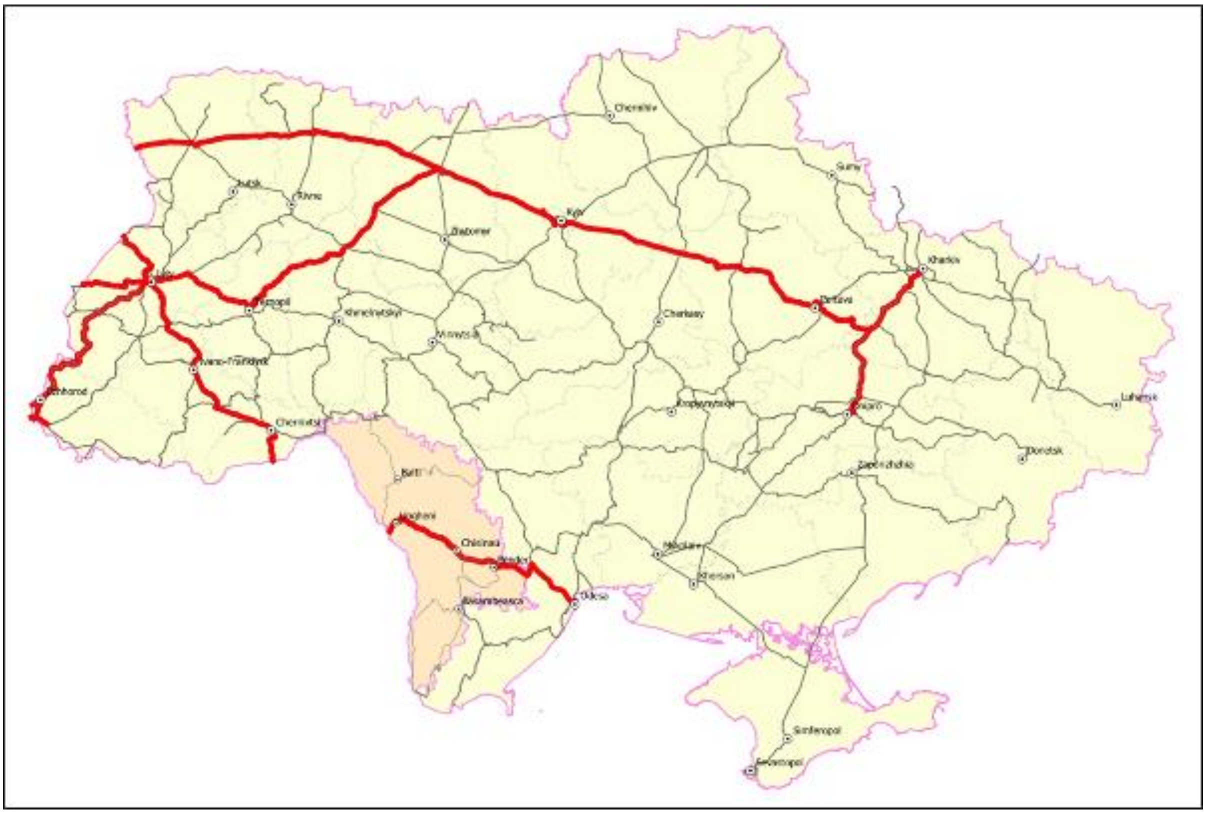
Single 1435mm track and double 1520mm track.



Total Cost priority III (considering the connection to Odesa via Bender and Tiraspol): 4896.187 Mio EUR.

7.5.5 Backbone 1435mm network in Ukraine and Moldova

The combination of the three priorities described in the previous sections defines the identified backbone 1435mm network in Ukraine and Moldova, as shown in the figure below in red colour.



Considering the proposed solutions for each priority, the total estimated cost, at this stage, for the implementation of this 1435mm backbone network is summarised in the following table:

Priority	Cost (Mio EUR)
Priority I	698.825
Priority II	5897.066
Priority III	4896.187
Total backbone	**11492.079**

Table 7.1: Estimated cost for the implementation of the backbone 1435mm network in Ukraine and Moldova

Experience shows that preparation and implementation of large infrastructure projects takes a significant amount of time. Moreover, in the project preparation phase there are often unexpected delays due to unforeseeable events, discontinuities in the geopolitical or socio-economic contexts, problems with the procedures, etc. Hence, the recommendation is to start the preparation of all the projects for the backbone network as soon as possible, included those listed in priority III, provided enough funds and capacity are available.

This would allow effective implementation of the 1435mm network in Ukraine and Moldova even if there are delays in some of the proposed corridors.

7.5.6 Further development of the 1435mm network in Ukraine and Moldova

Moldova

Preparation for the rehabilitation of the existing 1520mm network are ongoing. The study identifies the line between the MD/RO border at Ungheni and Chisinau as the backbone 1435mm network in Moldova. In the first development step, this line will be single 1520mm and single 1435mm, allowing for the continuous operation of the Moldova 1520mm system. By the time the development for the 1435mm connection between Chisinau and Odesa will start, the geopolitical situation should be reassessed, as the favourable route is running via Bender and Tiraspol towards Odesa. In case this alternative is not possible, the connection via Basarabeasca should be pursued. With the transformation of the line between Ungheni and Balti into a single 1435mm line, the transformation of the mixed line between Ungheni and Chisinau into a double 1435mm line could be assessed. Another section to be assessed for transformation/extension to 1435mm in the future is Basarabeasca – Giurgiulesti, further to Galati and Constanta ports in Romania. In the long-term, the final goal is the full transformation of the Moldovan rail network into 1435mm.

Ukraine

The Ukrainian backbone 1435mm network is defined by the lines from:

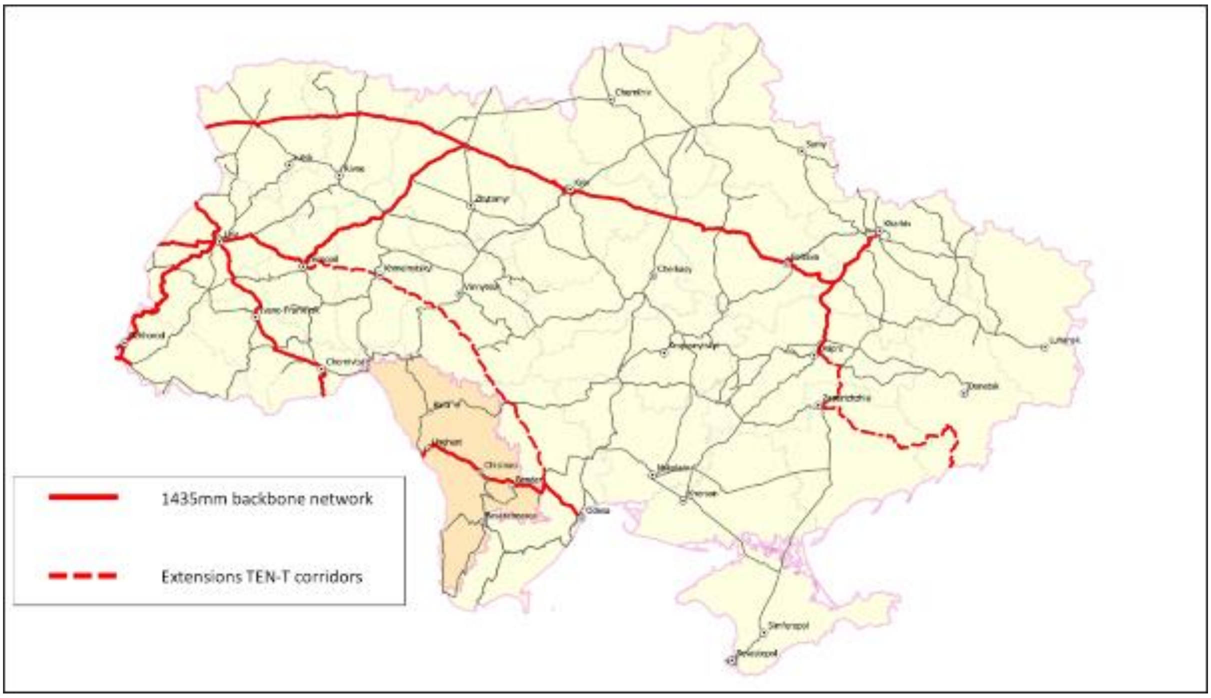
- UA/PL border Medyka/Mostyska to L’viv
- UA/PL border Dorohusk – Kovel – Sarny – Korosten – Kyiv
- L’viv – Krasne – Ternopil – Shepetivka – Zviahel – Korosten
- UA/SK/HU border Chop – Uzhhorod – Sambir – L’viv
- Kyiv – Poltava – Krasnohrad – Kharkiv/Dnipro
- UA/PL border Hrebenne – Rava Ruska – L‘viv
- L‘viv – Ivano-Frankivsk – Chernivtsi – Bahrynivka UA/RO border

Upon implementation of the backbone network, the future configuration of the Ukrainian rail system should, amongst other factors, be assessed against:

- The geopolitical situation
- Development of new industries in Ukraine (preferably the new industries shall be located along the 1435mm network)
- Shifting demand from 1520mm to the 1435mm system
- Mode share of the rail system
- Network developments in the neighbouring EU countries (PL, SK, HU, RO)
- Network and demand developments in Moldova due to the transformation of the existing 1520mm system into 1435mm
- Completion of the TEN-T corridors

Extension of the 1435mm network with the aim of completing the proposed TEN-T corridors and connecting other important cities such as Zaporizhzhia, Mariupol, Kherson, Mykolaiv, Donetsk, Luhansk, Sevastopol and Moldova should be assessed. In due course and, depending on the share of traffic between the 1520mm network and the 1435mm network, the transformation of the 1520mm track to 1435mm could be justifiable. The goal is to develop a 1435mm network inside Ukraine connecting to the EU neighbouring countries, connecting the population centres and the new industrial and economic centres.

The figure below shows the proposed 1435mm backbone network in Ukraine and Moldova together with the possible future extensions to complete the TEN-T corridors.



8. Complementary measures

Implementation of new 1435mm corridors in Ukraine and Moldova is not sufficient of itself to ensure the EU integration of their rail systems. Numerous complementary measures are necessary, including some that focus on the modernisation of the existing 1520mm corridors and the integration of both networks.

Due to time and resource constraints, a detailed definition of the complementary measures has not been developed in this study. Such measures should be comprehensive and holistic in nature, covering organisational and operational aspects in addition to infrastructure developments.

A non-exhaustive list of complementary measures for the EU integration of the Ukrainian and Moldovan rail systems is provided below, without a detailed assessment of each.

Organisation

Organisational measures include the development and implementation of concepts/strategies for rail system organisation. They are typically done for the entire Ukrainian and Moldovan network and are a prerequisite for successful integration of operational measures. Implementation of such measures is time consuming and in order to avoid delays in the short to medium-term, operational and infrastructure measures should be developed in parallel.

Some examples of organisational measures are:

- Harmonisation of the legislation with the EU legal framework
- Development of Public Service Contracts (PSC)
- Concept for the implementation of the 1435mm rail system
- Financial sustainability concept
- Maintenance concept

Operation

Operational measures include all activities necessary to successfully exploit infrastructure measures (infrastructure investment and purchase rolling stock and equipment), based on operational considerations. It further includes the purchase of rolling stock and equipment itself. Some examples of such measures are:

- Development of concepts/strategies for rail operation (including Railway Node Studies
- Operational rules for the 1435mm network, operational concept for the 1435mm network
- Simplification of border and custom procedures
- Implementation/financial plans – Feasibility Studies – project design – purchase of rolling stock – equipment of depots and workshops and purchase of maintenance equipment – ticketing system – communication and IT system – implementation of centralised communication and traffic management system

Infrastructure

Infrastructure measures include, among others:

- Modernisation of existing 1520mm lines (including repair of war damages in Ukraine)
- Modernisation of the existing 1520mm tracks in the EU (in Poland and Slovakia)
- Development of the backbone 1435mm network as defined in section 7
- Modernisation and development of new depots, stations, and marshalling yards (including the necessary transhipment facilities) – development of inland intermodal terminals and logistic centres

The budgetary envelope for the overall interventions of each priority, including an initial estimate of the cost for the complementary measures is summarised in the table below:

COST Summary							
Development phases	Strategies /Concepts /FS/FA (Mio EUR)	Infrastructure inlcuding PD infrastructure (Mio EUR)	Rolling Stock/Maintenance equipment (Mio EUR)	Marshalling yards and transshipment facilities including equipment and PD (Mio EUR)	ERTMS/IT/Ticketing (Mio EUR)	Administrative Facilities and assets (Mio EUR)	SUM (Mio EUR)
Immediate	11	n.a.	0	0	0	0	11
Priority I	13	698.825	250	200	0	0	1161.825
Priority II	2	5897.066	300	1000	200	300	7699.066
Priority III	5	4896.187	250	300	900	0	6351.187
Total	31	11492.078	800	1500	1100	300	15223.078

Table 8.1: Summary of the estimated costs including complementary measures