TwinForHope
The University of Birmingham standing
with their counterparts to support
Ukraine's Ivan Franko National University of Lviv

White Paper

Cross-border resilience of critical transport infrastructure in Ukraine and impact on the economy and society

Workshop 5: held on 28 July 2023, Warsaw, Poland
and online

April 2024

UNIVERSITY OF BIRMINGHAM

#TwinForHope

Львівський національний
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Foreword

In the framework of the TwinForHope capacity building, the University of Birmingham (UoB) twined and stood with their counterparts to support Ukraine's Ivan Franko National University of Lviv (IFNUL) and co-organised a workshop to strengthen the resilience of the war-torn country. The workshop: ***Cross-border resilience of critical transport infrastructure in Ukraine and impact on the economy and society,*** took place in Warsaw, Poland on the 28th of July 2023. The workshop was attended in-person and online by 29 academics from the University of Birmingham and the Ivan Franko National University of Lviv, as well as decision makers and consultants from the UK and Ukraine and representatives from the local government of the city of Lviv.

The theme of the TwinForHope capacity building is on 'Identify, Sovereignty and Resilience', and this workshop is part of a broader series of academic development workshops that directly contribute to Ukraine's reconstruction and development. The workshop achieved its aim which was to bring IFNUL and UoB academics and researchers together with NGOs and community organisations to build capacity for addressing post-conflict reconstruction.

This White Paper includes the facts and opinions expressed during the workshop. For each summary there is a visualisation representative of the position paper of the workshop. The White Paper also includes the main outcome of the workshop: Ukraine's post-war recovery journey necessitates resilience, sustainability, and digitalisation. The Lviv region, with its strategic location and connections to the EU, holds a significant role in the nation's rebuilt and progress. Particular emphasis should be given on the railway sector, roads and bridge in the area as well as incentives for strengthening IT services and software engineering.

Acknowledgement: *Universities UK (UUK) has been awarded funding by Research England, on behalf of UK Research and Innovation (UKRI), to deliver the UK-Ukraine R&I twinning grants scheme. This grant is funded via the UK's Official Development Assistance (ODA) funding (project code #11120).*

1 Introduction

In the framework of the TwinForHope capacity building for Ukraine's Universities the following workshop was co-organised "*Cross-border resilience of critical transport infrastructure in Ukraine and impact on the economy and society*", between the University of Birmingham, UK (UoB) and the Ivan Franko National University of Lviv, Ukraine (IFNUL). The workshop was attended in-person and online by 29 academics from the University of Birmingham and the Ivan Franko National University of Lviv, as well as decision makers and consultants from the UK and Ukraine and representatives from the local government of the city of Lviv.

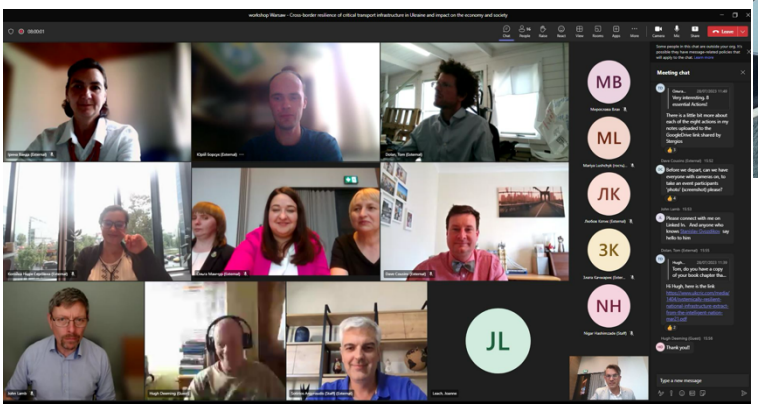
The participants explored challenges identified in advance of the workshop by Ukrainian partners in consultation with local authorities relating to post-war recovery. This is highly multi- and cross-disciplinary endeavour that requires collaborations and alliances between different sectors. Experience and lessons learnt from the operation and management of the UK infrastructure sector can facilitate this endeavour in Ukraine. What was also established on the day is that Lviv is a key region which can be established as a benchmark and a reference point for Ukraine that will play a very important role in Ukraine's recovery and indeed ways to support Lviv should be sought to bounce back quickly and facilitate the recovery of the entire country and strengthening the neighbouring countries of the Eastern EU region.

The workshop provided a platform to highlight the potential role that research evidence and expertise from practitioners and policy and decision-makers can play in the post-war reconstruction. The workshop enabled participants to contribute to bilateral discussions about specific priorities to strengthen infrastructure and community recovery in Lviv region and beyond.

This White Paper is not a verbatim record, but a summary of the positions of the speakers, the discussions that took place during the workshop, the feedback collected after the workshop and the areas identified for future action. Therefore, the paper reflects the views and opinions of individuals and participants and do not necessarily reflect those of UoB, IFNUL or any other organisation being represented by the attendees of this workshop.

2 Position papers

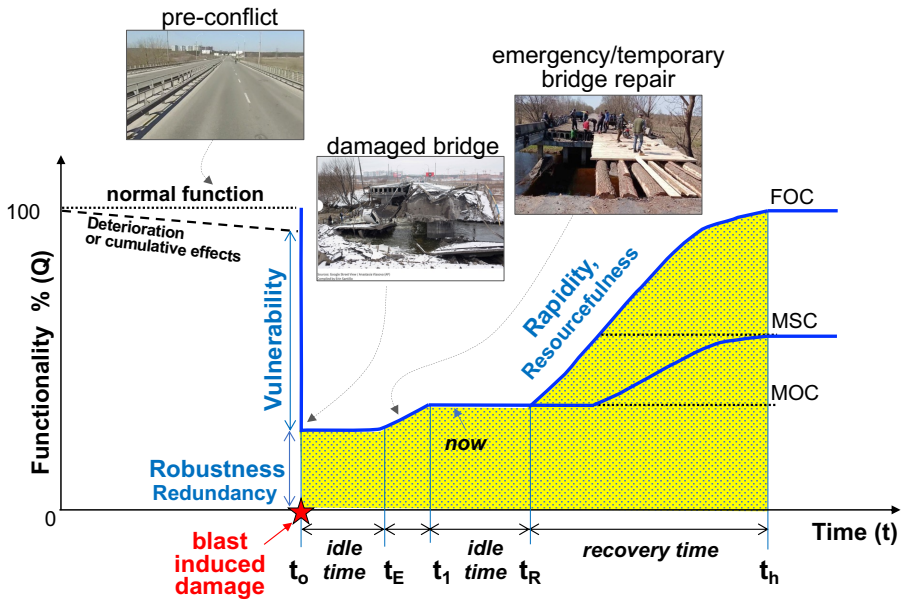
This section includes the summary of the position papers. The order of the presentation follows the agenda of the workshop (see Appendix A). For each presentation, a representative figure is also included. A total of 21 talks were delivered by 18 speakers.



Session 1 – Opening

Title: Conflict-resilience framework for critical infrastructure peacebuilding, the bridgeUkraine.org perspective
Speaker: Stergios-Aristoteles Mitoulis
Time: 9:15-9:35

Summary: Apart from security issues, war-torn societies and countries face immense challenges in rebuilding damaged critical infrastructure. Existing post-conflict recovery frameworks mainly focus on social impacts and mitigation. Also, existing frameworks for resilience to natural hazards are mainly based on design and intervention, yet they are not fit for post-conflict infrastructure recovery for a number of reasons explained in this paper. Post-conflict peacebuilding can be enhanced when resilience by assessment (RBA) is employed, using standoff observations that include data from disparate remote-sensing sources, e.g. public satellite imagery, forensics, and crowdsourcing, collected during the conflict. This presentation discusses why conflicts and warfare require a new framework for achieving post-conflict infrastructure resilience. It then introduces a novel post-conflict framework that includes different scales of resilience with a focus on asset and regional resilience. It considers different levels of knowledge, with a focus on standoff observations and data-driven assessments to facilitate prioritisation during reconstruction (Figure 1). The framework is then applied to the transport network of the area west of Kyiv, Ukraine to demonstrate how resilience by assessment can support decision-makers, such as governments and multilateral financial institutions, to address infrastructure needs and accelerate financial and humanitarian assistance, absorb shocks, and maximise infrastructure recovery after conflict.



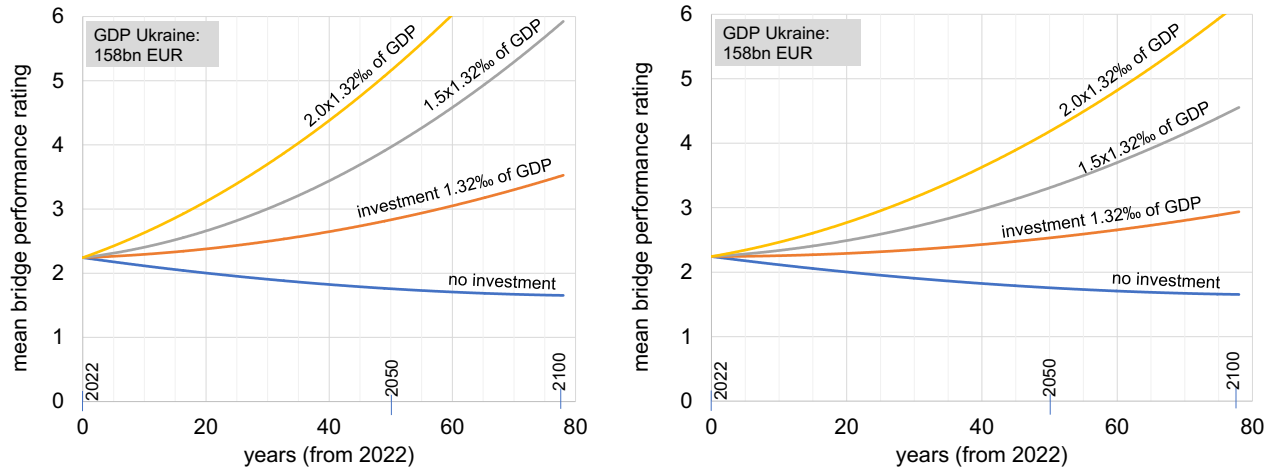
t_o : time of damage occurrence; t_E : commencement of temporary bridge repair
t_1 : time that MOC is achieved; t_R : time of recovery commencement
t_h : time when target capability is achieved (end of recovery)

Figure 1. Resilience framework for rebuilding critical infrastructure after conflict.

Title: Trade-offs between resilience and sustainable solutions in infrastructure climate adaptation: the case of bridges in Ukraine
Speaker: Sotirios Argyroudis
Time: 9:35-9:55

Summary: The crux of the world's constructed ecosystems lies in delivering and sustaining infrastructure that is efficient, resilient to climate change and natural disasters, and supports economic activities while being environmentally sustainable. However, there's a recognised shortage of private finance for this purpose, and international financing bodies prioritise interventions over design and preparedness. This creates a capability gap, leaving the private sector uncertain about the commercial relevance and direct impact of resilience building activities. In this presentation, the enablers and barriers to climate-resilient and sustainable infrastructure were addressed, aiming to quantify trade-offs and synergies in development and adaptation. Focusing on transport infrastructure, particularly in Ukraine, it sets a benchmark case study for bridges, encompassing highways and railways, considering climate projections.

The results of the study led to the conclusion that for the case study it is mainly bridges located at moderate and low environments that will require more investment in order to improve the resilience of the infrastructure network, as there are significantly less bridges in severe and benign environments. Total emissions which are the result of bridge recovery and repair follow the same patterns. The bridge environments are expected to change and bridges are expected to deteriorate at a slower pace due to the environmental conditions, because the environment becomes drier and hence the parameters that led to the deterioration of the bridge stock seem to be less severe. As a result, in the future resilience building investment will be directed mainly towards bridges located in low, i.e., drier, environments. Regarding the evolution of bridge performance rating, which is the measure of resilience, the analyses showed that a total of 2.64‰ of the GDP of the country would be adequate to fully restore the resilience of the entire stock of bridges within 78 years, i.e. by 2100 (Figure 2). This is true for the case where conventional recovery strategies with traditional materials, methods and techniques are employed, as opposed to low carbon methods. However, considering the higher cost of greener and more sustainable materials, larger investments would be required per year from the country's GDP to fully restore the entire bridge stock.



(a) (b)

Figure 2. Mean bridge performance rating over the years for different investment strategies for (a) conventional materials and methods of reconstruction and (b) sustainable methods.

Session 2 - External contributions & Round table

Title: Lviv territorial community: place in Ukrainian wartime economy and goals of post-war reconstruction
Speaker: Oleh Veklyn
Time: 9:55-10:05

Summary: The role and place of Lviv in the economic and social development of Ukraine is very important. Enterprises with Ukrainian and foreign capital are actively developing in Lviv. Over the past year, the number of enterprises displaced from the war zone has also increased in the city. This has contributed to the creation of new economic zoning objects, including industrial parks. The largest of these industrial zones is Syhnivka. The advantage of this site is its proximity to major transportation routes and freight railroad stations (Figure 3).

(a) (b)

Figure 3. (a) The importance of IT sector in Lviv and (b) Lviv share of GDP in the country's economy

Title: A quick overview of structural health monitoring and load testing for bridges and civil infrastructure
Speaker: Dave Cousins
Time: 10:05-10:15

Summary: An outline of the general methods used in the UK and other countries for the management of physical structures a transportation network. The speaker gave a short description of their career to date in the management of bridges, having worked in roles of design, fabrication, installation and demolition before latterly focussing on condition investigations through the use of structural health monitoring and load testing. A typical sequence was used for following bridge management from network wide visual inspections, seeking to determine bridges are 'safe for use' and 'fit for purpose' (pass/fail) involving where appropriate proof load testing, supplementary load testing and remote condition monitoring (Figure 4).

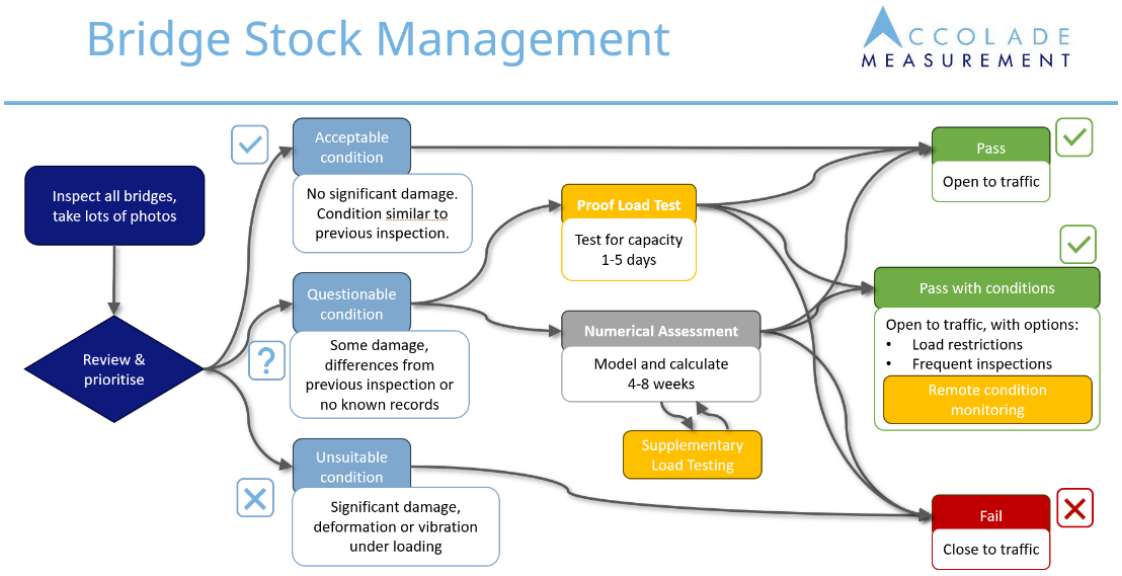


Figure 4. Bridge stock management (Accolade Measurement, UK)

Title: Bridges as the part of critical transport infrastructure in Ukraine. Monitoring and prolongation of service life
Speaker: Nadiia Kopiika
Time: 10:15-10:25

Summary: Bridges are integral to Ukraine's transport infrastructure, with 16,155 bridges connecting key geopolitical centres. The assessment of their stress-strain state was a pre-existing topical concern, as approximately 35% of bridges faced unsatisfactory conditions, and less than 20% were in normal condition even before the beginning of conflict in Ukraine. The majority (81%) of bridges were constructed before 1981, with over 60 years in age (Figure 5). The Russian invasion exacerbated the deterioration of Ukraine's transport infrastructure, disrupting logistic connections and causing significant economic and social repercussions. Restoring bridges is a time and resource-intensive process, particularly challenging in limited access conditions. To address this, innovative and contactless monitoring approaches are recommended. Digital Image Correlation (DIC) stands out as a widely used method for its reliability, accuracy, and applicability to long-term measurements, providing a comprehensive view of strains and deformations, even up to the point of destruction. DIC has proven its effectiveness in global engineering practices for bridge monitoring.

Figure 5. The issue of ageing of the most critical bridges as the part of critical transport infrastructure in Ukraine.

Title: Transport infrastructure of the city of Ternopil: challenges of development
Speaker: Ivan Rudakevych
Time: 10:25-10:30

Summary: The city of Ternopil is located in the western part of Ukraine, about 200 km from the borders with the EU countries. Important international road and railway routes pass through the city of Ternopil. These roads lead from the city of Ternopil to the borders of Ukraine with EU countries. Two pan-European transport corridors No. 3 and No. 5 pass near the city of Ternopil. Ternopil is a railway hub, so the railway is also a traditional form of transport for the city. The railway station has an average daily capacity of 17,000 passengers. An average of 65,000 tons of cargo passes through the Ternopil freight station. The trolley bus network of the city has 9 lines, on which 50 trolley buses depart daily. Ternopil has significant transit potential, as the city is located at the intersection of international highways and important railways. However, the logistics potential of the city is not fully used. In order to improve the transport situation is the construction of a bypass road away from the city, as well as expansion (increase of traffic lanes) on international highways (Figure 6).

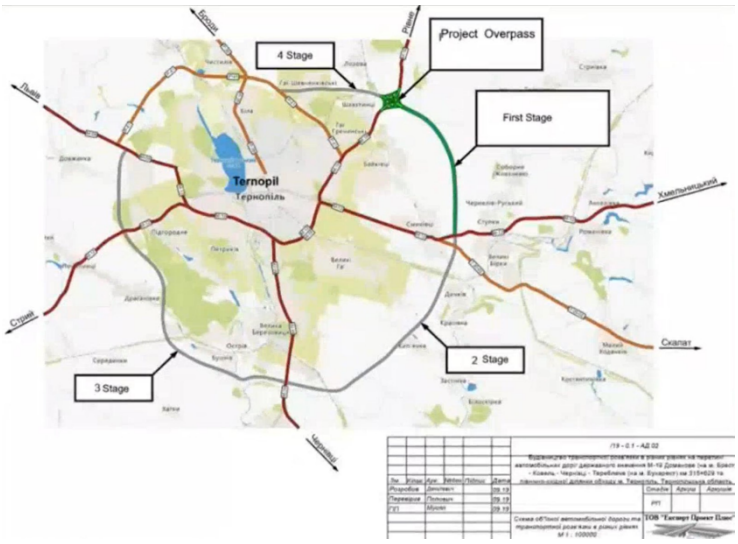
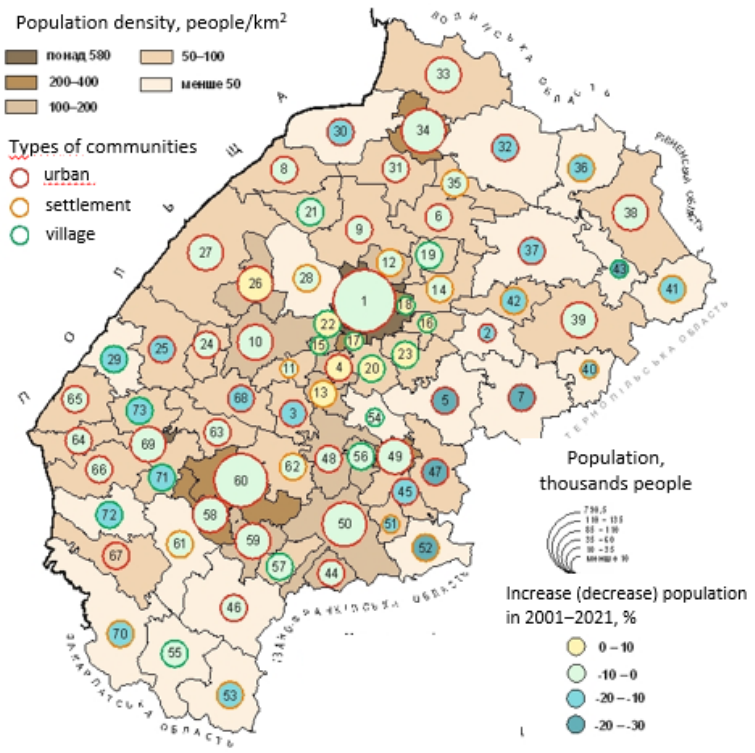


Figure 6. The extension of road system of Ternopil city.

Session 3

Title: Human-geographical problems of development of the Lviv region: Demographic-geographical
Speaker: Iryna Hudzelyak
Time: 11:30-11:42

Summary: The Western region of Ukraine covers 8 oblasts - Lviv, Volyn, Rivne, Ternopil, Ivano-Frankivsk, Khmelnytsky, Zakarpattia and Chernivtsi. Lviv is a regional centre. The Western region is home to 10.4 million people, or 25% of the population of Ukraine. In 2022, the population of Lviv oblast was 2,5 million people. The city of Lviv has 717,000 inhabitants. Before the war, Lviv ranked seventh in Ukraine in terms of population. Among other regions of Ukraine, the Western region is quite densely populated. In the Lviv oblast, the population density is 115 people per 1 square km. Whereas in Ukraine - 75 people per 1 square km. The demographic weight of the Western region in the population of Ukraine is increasing. The rate of depopulation is the lowest in the country. The population aging rate is the lowest in Ukraine. The birth rate is the highest in Ukraine. The level of urbanization in the Western region remains the lowest in Ukraine - only 49%, but the rate of urbanization increase over the past 20 years has been the highest in the country, with the exception of the capital region. Border regions with Poland and territories within the Lviv agglomeration have a better demographic situation (Figure 7).



Hromadas:
1–Lvivska, 2–Glynyanska, 3–Komarnivska, 4–Pustomytivska, 5–Bibrska, 6–Kamyanka-Buzka, 7–Peremyshlyanska, 8–Rava-Ruska, 9–Zhovkivska, 10–Horodotska, 11–Velikolyubinska, 12–Kulikivska, 13–Shyretska, 14–Novoyarychivska, 15–Obroshinska, 16–Pidberiztsivska, 17–Sokilnytska, 18–Murovanska, 19–Zhovtanetska, 20–Solonkivska, 21–Dobrosynsko-Magerivska, 22–Zymnovodovsk, 23–Davydivska, 24–Sudovyshnianska, 25–Mostyska, 26–Novoyavorivska, 27–Yavorivska, 28–Ivano-Frankivska, 29–Shegynivska, 30–Belzka, 31–Velikomostivska, 32–Radehivska, 33–Sokalska, 34–Chervonogradska, 35–Dobrotvirska, 36–Lopatynska, 37–Buska, 38–Brodivska, 39–Zolochivska, 40–Pomoryanska, 41–Pidkaminska, 42–Krasnenska, 43–Zabolotsivska, 44–Morshinska, 45–Zhidachivska, 46–Skolivska, 47–Khodorivska, 48–Mykolayivska, 49–Novorozdilska, 50–Stryyska, 51–Hnizdychivska, 52–Zhuravnenska, 53–Slavska, 54–Trostyanetska, 55–Kozivska, 56–Rozvadivska, 57–Hrabovetska-Dulibivska, 58–Borislavska, 59–Truskavetska, 60– Drohobytska, 61–Skhidnytska, 62–Medenitska, 63–Novokalynivska, 64–Khirivska, 65–Dobromilska, 66–Starosambirska, 67–Turkivska, 68–Rudkivska, 69–Sambirska, 70–Borynska, 71–Ralivska, 72–Strilkivska, 73–Biskovytska).

Figure 7. Population of territorial communities (hromadas) of Lviv oblast, 2021.

Title: Human-geographical problems of development of the Lviv region: Social and economical-geographic
Speaker: Liubov Kotyk
Time: 11:42-11:54

Summary: The Lviv oblast is characterized (2020) by high indicators: the absolute number of employed people, gross regional product, the volume of manufactured construction products and housing commissioned, exports and imports of goods, and exports of services; has average values of unemployment, average monthly wages of employees, volume of sold industrial products and imports of services. This allows the oblast to be positioned as a region of Ukraine with a high level of social and economic development. The structure of the gross regional product of oblast is changing: 1995 - industry, agriculture, forestry and transport prevailed, 2021 - industry, real estate transactions, wholesale and retail trade. In terms of the territorial concentration, the biggest number of businesses are working in the centers of transformation of Lviv oblast's economy: the city of Lviv, former Pustomyty district and Stryi district, Truskavets, Drohobych district. Have been created: clusters - IT, of wood and furniture production, a tourism; the industrial park "Riasne-2"; Sygnivka industrial zone. To restore the region's economy, it is important to return labor resources abroad, use the transit and transportation potential of the oblast, reduce tax pressure on businesses and private entrepreneurs, empower local communities, and stimulate domestic investment (Figure 8).

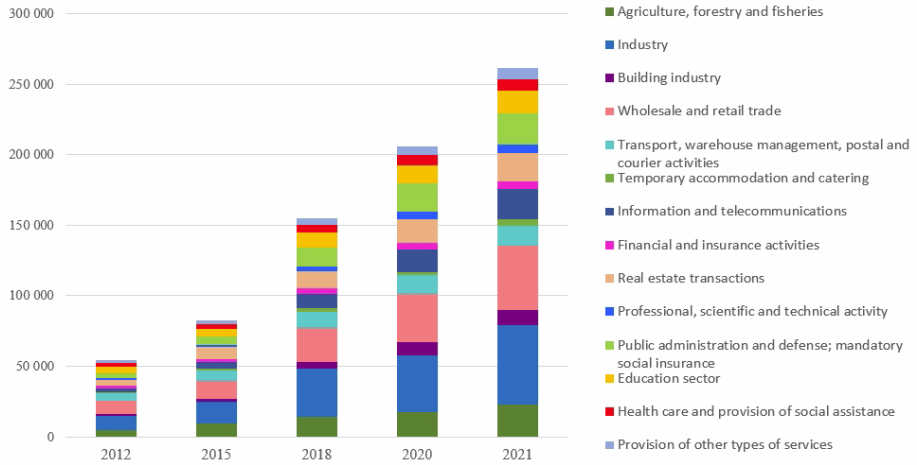
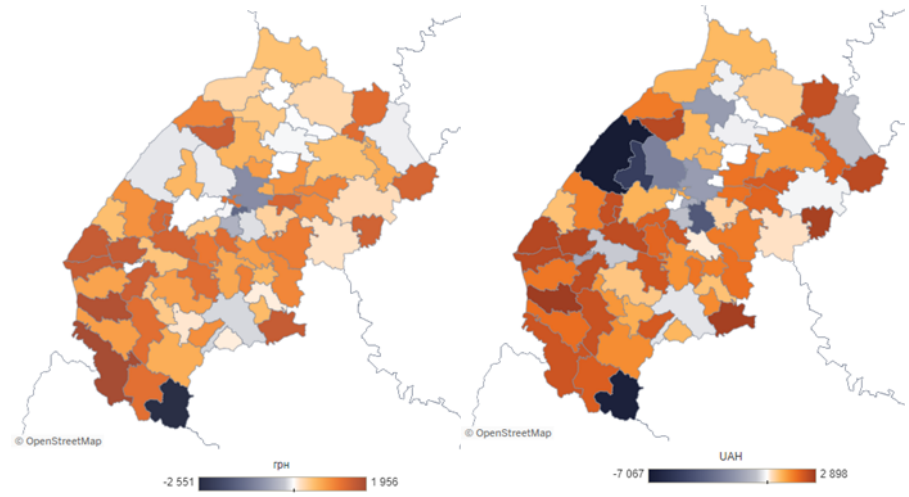


Figure 8. Gross value added by type of economic activity of Lviv oblast, 2012–2021.

Title: Human-geographical problems of development of the Lviv region: Decentralisation and local economic development
Speaker: Iryna Vanda
Time: 11:54-12:06

Summary: Decentralisation in Ukraine (since 2014) consists of territorial (formation of amalgamated communities (hromada) and new districts (rayon), administrative (redistribution of powers, increasing the scope of responsibility of local self-governments) and financial (changes in inter-budgetary relations, growth of the revenue base of local budgets) components. The range of powers that should be vested in public authorities at the rayon level remains unclear defined.
Public spending per person is regarded as one from the indicators of local economic development: reverse spending (blue colour at the map) is transferred by "successful" hromadas to the state budget as part of the horizontal equalisation, basic spending (orange colour at the map) is transferred from the state budget to local budgets to increase their fiscal capacity and ensure the performance of functions). The most communities in the Lviv region, as well as in Ukraine, have received (2021) and continue to receive (2023) a basic spending, which determines the relevance of introducing additional tools to stimulate local economic development (Figure 9).



Source: Бюджети територіальних громад України (2024). *https://public.tableau.com/*

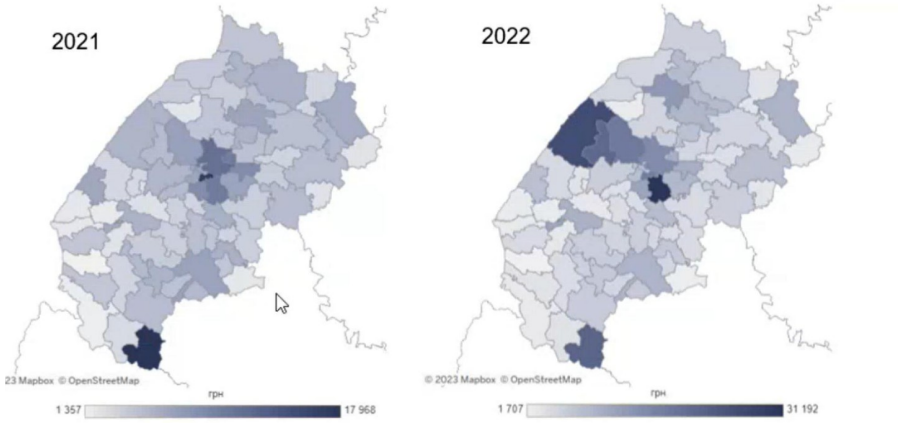


Figure 9. (a) Public spending per person of local budgets per capita (UAH). (b) Dynamics of income into the general budget of local communities (UAH/person)

Title: Economic efficiency of the use of railway passenger routes of the Western region of Ukraine
Speaker: Yuriy Borsuk
Time: 12:10-12:30

Summary: Geographically, we will consider the regional branch of Lviv Railway (Figure 10). The territory of operation of this business entity covers seven oblasts of the Western region (except Khmelnytskyy Oblast). The economic indicators used to evaluate intercity passenger routes include the average ticket price from the start to the end station, distance, and current cost. The cost is calculated as the ratio of the average price of all seats in the train to the distance of the route. The economic activity will be profitable if the cost of the train is more than 0,50 UAH/km. This study identifies very profitable, actually profitable, low-profitable, low-loss, actually unprofitable, and very unprofitable trains. The study found that: There are different categories of long-distance trains by cost, including very profitable (mainly to Pshemyshl), and very unprofitable (mainly to Chernivtsi). Also, there is a need to launch profitable trains for international traffic and trade, especially to and from Poland. There is a growth of alternative long-distance trains instead of highly unprofitable suburban trains. The ideas for implementing "Public Service Obligation" in partnership with local governments for suburban services were highlighted. Finally, a high depreciation of rolling stock among electric trains in Lviv depot and diesel trains in Korolevo depot was indicated.

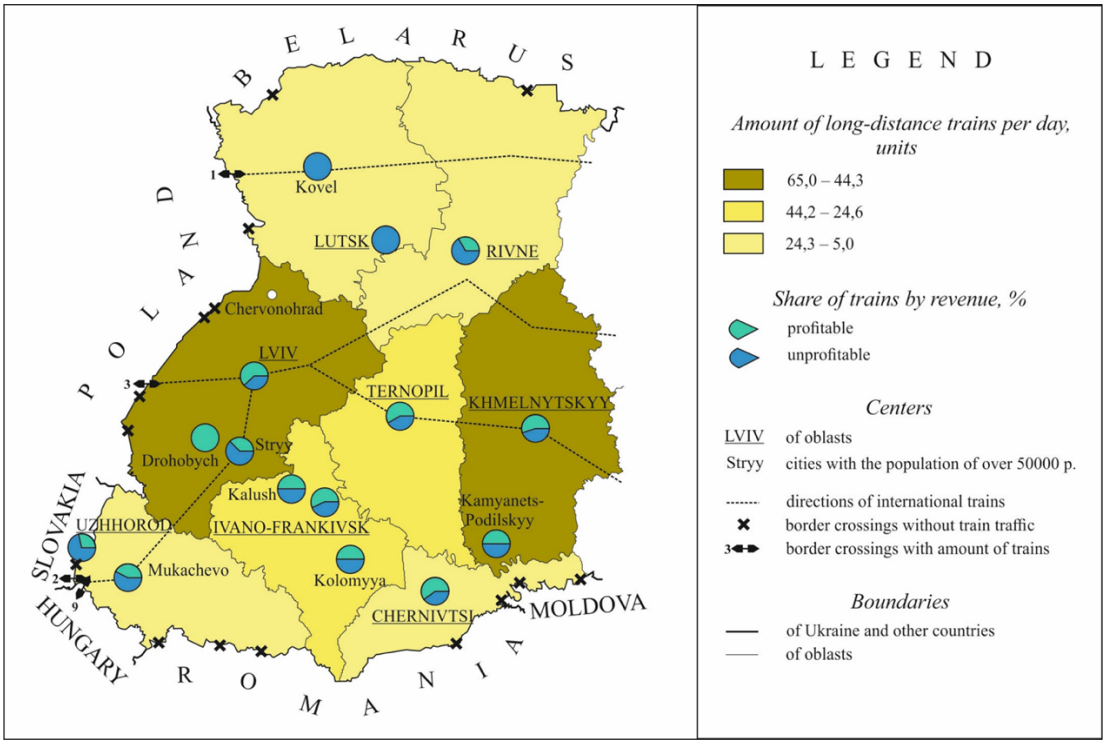


Figure 10. Long-distance passenger rail routes in the Western region of Ukraine.

Session 4 - External contributions & Round table

Title: Resilient infrastructure systems: The foundations for a safe, secure, sustainable, and prosperous future
Speaker: Tom Dolan
Time: 12:30-12:45

Summary: Once the conflict has finally ended, the rapid restoration of Ukraine's infrastructure systems will be a high priority. Ensuring that infrastructure systems, once restored are, prepared for, and resilient to, the next disruptive event may feel less important, or be perceived as an unjustifiable cost, a luxury for later, or an unnecessary distraction from more urgent priorities. Do not succumb to this way of thinking, it is a false economy. The rapid restoration of infrastructure systems, if undertaken without consideration of resilience, will result in opportunities to enhance resilience being missed. The result will be a systemically vulnerable Ukraine enabled by low resilience infrastructure systems. The premature end-of-life /decommissioning that the war is likely to have imposed on many Ukrainian infrastructure assets, coupled with the aid and support that Ukraine is likely to receive from a grateful western world, and the commitment and energy of a population passionate about rebuilding their beloved Ukraine, will, once the conflict has been resolved, come together to create a rare window of opportunity to improve the infrastructure system as a whole, not merely the specific aspect being restored. Thus, ensuring Ukraine is served and enabled by resilient infrastructure systems fit for the 21st century (Figure 11).

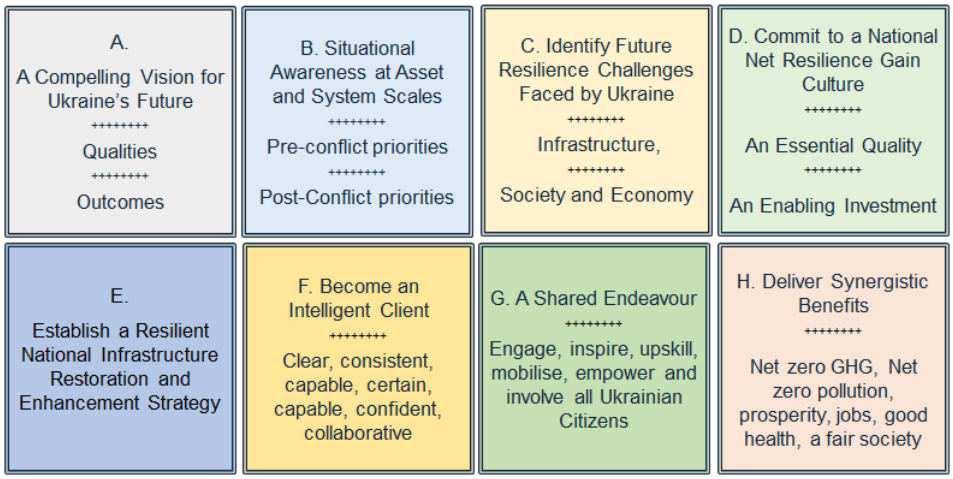


Figure 11. Seizing the systemic opportunity – 8 essential actions for resilient reconstruction and restoration

Title: Strengths and vulnerabilities of the functioning of the infrastructure of the Ivano-Frankivsk region in the conditions of martial law in Ukraine
Speaker: Roman Slyvka, Iryna Zakutynska
Time: 12:45-12:52

Summary: The main targets of Russia's missile attacks within Ivano-Frankivsk region were energy facilities and military facilities, however, the strikes were only partially successful (Figure 12). There were few rocket strikes compared to other neighbouring regions, in particular the Lviv region. The impacts did not cause critical damage to the energy infrastructure; it was restored and continues to function properly. The thermal power plants in the cities of Burshtyn and Kalush are functioning well and are united with a joint EU energetic system. The location of the region in the rear of military operations made it an important center for the movement of people, the transit of Western aid, the relocation of industry and the service sector from the East of Ukraine. With the participation of European partners, it is planned to develop railway tracks with a European track standard, which will become a trigger for the future socio-economic development of the region. The availability of a new European-standard railway will significantly improve transport logistics for industrial producers in Ivano-Frankivsk with a focus on the markets of Romania, Poland and Moldova and other markets of the Black Sea and Baltic regions.

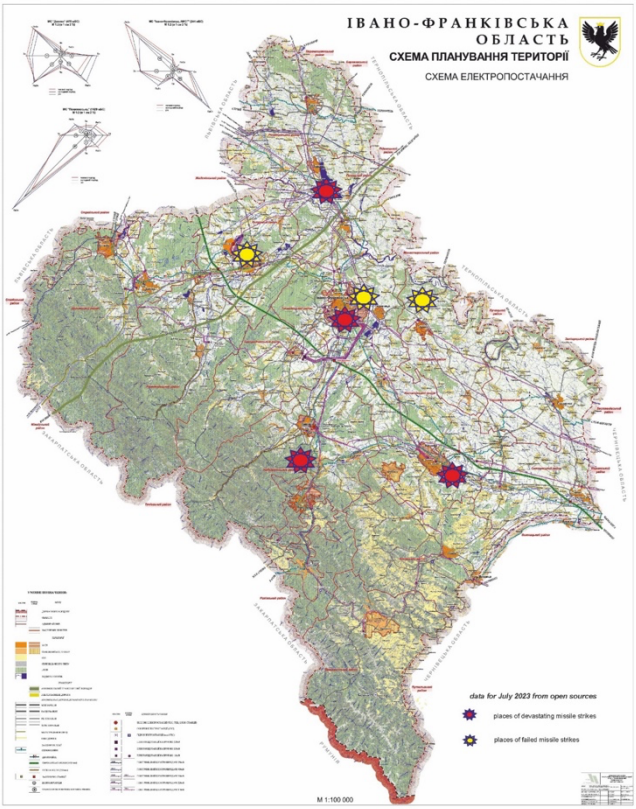


Figure 12. Locations of missile strikes in the Ivano-Frankivsk region from February 2022 to July 2023.

Title: Impact of transport infrastructure on tourism development in Lviv region
Speaker: Mariya Lushchyk
Time: 12:52-12:55

Summary: Transportation is a significant driver of progress and has also become a key factor in the growth of tourism. The impact of transport infrastructure on tourism development is multifaceted. Firstly, tourism cannot be considered independently of its connection with the transport system. Secondly, the development of tourism necessitates the creation of transport infrastructure that enables the free movement of tourist flows. Lastly, it is undeniable that the tourism industry has suffered unprecedented losses in the context of war. However, it cannot be claimed that tourism is stagnation in Ukraine. While the country has lost foreign tourists, this situation has presented an unprecedented opportunity for tour operators and others in the tourism sector to focus on domestic tourism. Additionally, following the victory, Ukraine has the potential to become a new centre of tourist interest, with the Lviv region serving as a gateway for foreign tourists and a transport and tourism hub. The development of Lviv's international transport capabilities is a key priority in strengthening the city's position as a vital communication hub between Ukraine and the European Union. To achieve this, the following initiatives should be implemented: continuation of the European railway line to Lviv, construction of a road with entrances from Kyiv and Poland with modern logistics and transfer complexes, and formation of a powerful hub of international communications around the airport.

Session 5

Title: Practical use of geologistics in the transport industry of the Western region of Ukraine: Lviv - key transport hub
Speaker: Olha Mamchur
Time: 14:30-14:50

Summary: Lviv's position as a key transportation hub Lviv is an important transportation hub for Ukraine and Eastern Europe, located on the Ukrainian-Polish border; it is 520 km from the Baltic Sea, as well as from Black Sea. The city of Lviv serves as a metropolis: a large number of economic, social, financial, cultural, educational and scientific institutions are concentrated here. Lviv is a significant center of railway lines connecting Ukraine with Europe. Lviv railway station is the second busiest in Ukraine, serving 9 million passengers. Danylo Halytskyi Lviv International Airport is the second largest in the country in 2021 (1.834 million pass per year; it is planned to complete the reconstruction of Terminal 1; airfield complex, construction of a cargo terminal etc). Main challenge in Lviv motor-transport hub development is lack of a northern bypass route and multi-level transport interchanges in the city. The development of transport (roads, railways, and an air hub) and logistics infrastructure, as well as the harmonisation of international transport corridors, will realise Ukraine advantageous position and become a regional transit hub (Figure 13). Reconstruction and development of the critical infrastructure of the Lviv transport hub will have a positive effect on the continental economy and society.

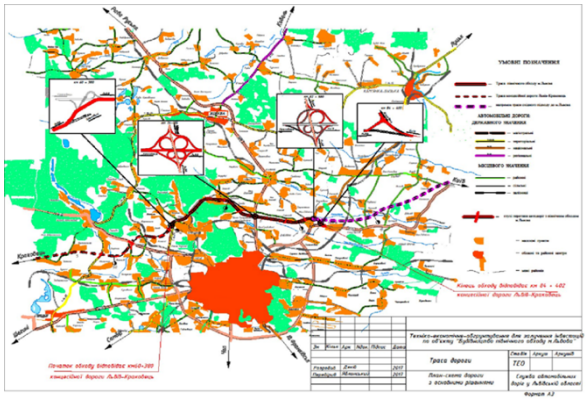


Figure 13. Northern bypass route in Lviv, Ukravtodor (Project), 2020.

Title: Geologistics in the transport industry of the Western region of Ukraine: practical usage and problem of infrastructure reconstruction
Speaker: Yuriy Borsuk
Time: 14:50-15:10

Summary: In this study, we used the project of connecting a central (regional, voivodstvo) city with the peripheral points of the specified territories in two administrative units of neighbouring countries. In order to obtain numerical indicators, we measured the distances between 74 hromada centres and the oblast city (Lviv Oblast) and 147 local council or gmina centres and the voivodstvo city (Podkarpatske Voivodstvo). A total of 221 settlements were analysed, and the curvature of road and railway lines and vehicle speeds towards the major city were determined. One of the necessary integration measures could be the appointment of international trains to the European Union, especially in the absence of air connections. The most logical way would be to reopen the defunct border crossings from the Western region to Poland, Slovakia, Hungary, Romania, or Moldova. We will look at direct connections between cities in the Western region of Ukraine and other oblasts as of 1 March 2023. The city of Lviv has the highest level of connectivity with the Lviv Oblast and the city of Kyiv, and the lowest – with Volyn, Zaporizhzhya, Kirovohrad, Mykolaiv, Odesa, Poltava, Sumy, Rivne, Kharkiv, Kherson, Chernivtsi, and Chernihiv Oblasts (Figure 14).

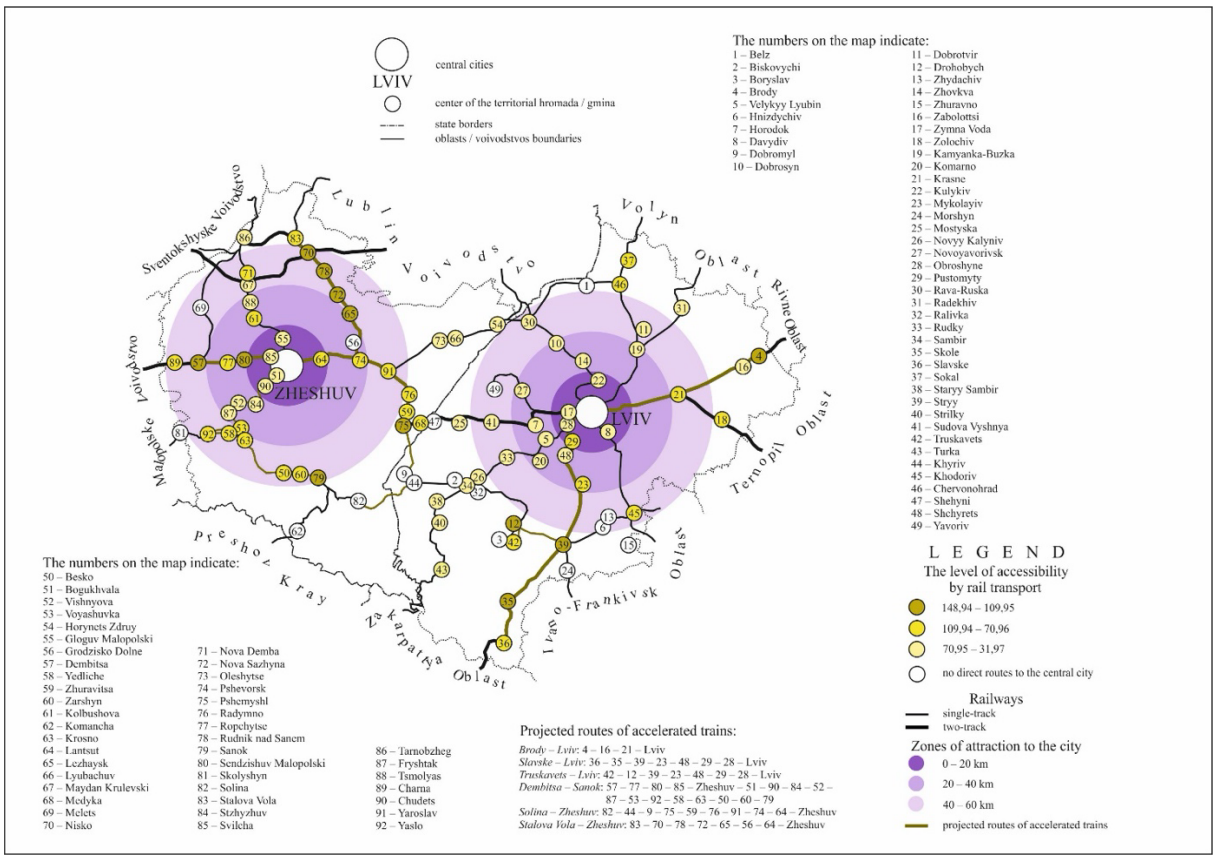


Figure 14. Railways accessibility of Lviv Oblast (Ukraine) and Podkarpatske Voivodstvo (Poland).

Session 6

Title: Socio-economic prerequisites for the functioning of suburban railway transport: Settlement system and IDP
Speaker: Iryna Hudzelyak
Time: 15:10-15:30

Summary: Lviv oblast is notable among other oblasts of Ukraine for its dense network of settlements. There are 44 cities, 34 urban-type settlements, and 1850 villages (the largest number of villages among the regions). There are four areas of high urban concentration in the settlement system. Lviv agglomeration has 1,12 million inhabitants. This is 45% of the region's population. The city of Lviv is home to almost 71% of the agglomeration's total population. Within Lviv, there is a high population density in new neighbourhoods located on the outskirts. Russia's full-scale military invasion in Ukraine has triggered the largest wave of forced migration in Europe since World War II. In September 2022, 4.2 million people were officially granted asylum in Europe. Lviv, as the largest transport hub in the western region, received transit refugees who sought shelter. In the first six days of the war alone, nearly 300,000 people left through nine checkpoints on the Ukrainian-Polish border in Lviv Oblast. In May 2023, almost 244 thousand IDPs were officially registered in Lviv oblast, including 150 thousand in Lviv. This amounted to 7% of the total number in Ukraine (5 million people). The migration load of the permanent population of the Lviv oblast is 9.5%, and in the city of Lviv it is 14.5% (Figure 15).

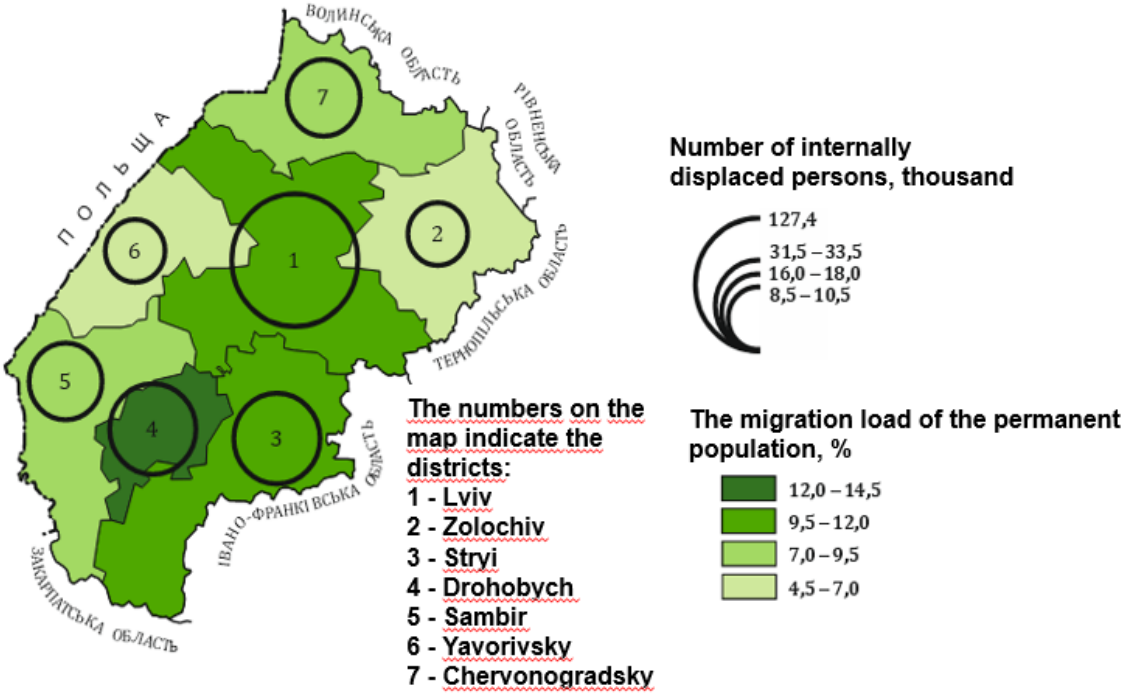


Figure 15. The number of internally displaced persons and the migration load of the permanent population in Lviv oblast, February 2023

Title: Socio-economic prerequisites for the functioning of suburban railway transport: Capacity of the territorial communities
Speaker: Iryna Vanda
Time: 15:30-15:50

Summary: In Ukraine, "capacity of the territorial community" is considered mainly in the context of "ability" (rather than "containing"), and characterized by: population, pupils of general secondary schools, area of the territory, tax capacity index of the local budget, share of local taxes and fees in the local budget revenues. The suburban communities of Lviv have a high capacity in terms of population

and pupils, reflecting the old settlement of the region, and a relatively better demographic situation compared to the national background; a typical feature is a small area of territory, with high population density and transport infrastructure development. Capacity and infrastructure provision of suburban communities are increased due to geographical factors: favourable location, effective use of the socio-economic and demographic potential of community centres, development of transport links. Suburban communities have a high realization of entrepreneurial potential (self-employment, microenterprises), development of small and medium-sized enterprises (often with foreign capital, in the context of reindustrialization of the region). Transport accessibility is an important factor in the localization of new production facilities (Figure 16).

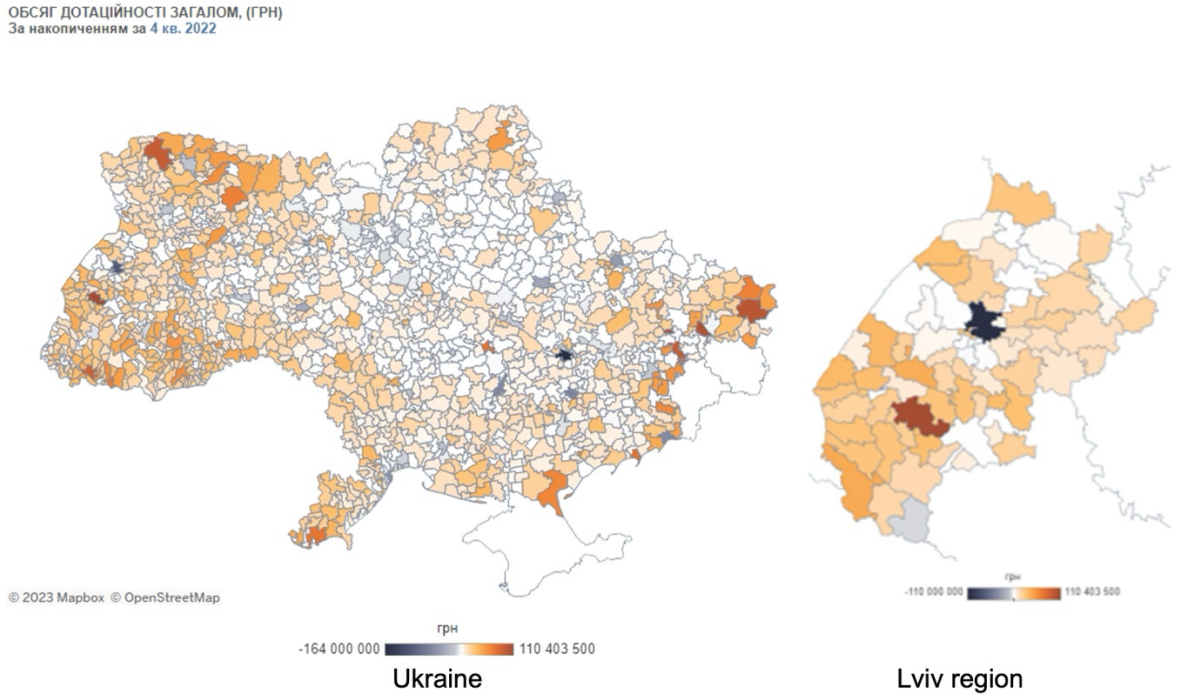


Figure 16. Value of dotation of budget fund of local communities in UAH (2022)

Title: Socio-economic prerequisites for the functioning of suburban railway transport: Challenges and perspectives of the functioning of suburban railway transport
Speaker: Yuriy Borsuk
Time: 15:50-16:10

Summary: The development of railway transport in the suburbs of Lviv at the present stage in the context of the war is impacted by the following factors: (1) Impoverishment of the population and more frequent use of public transport to get to villages and summer cottages, which are seen as an additional source of income for families in the face of high unemployment. (2) Accommodation of almost 400,000 internally displaced persons. A project of suburban transport using "shuttle trains" was presented. Some suburban directions have already been developed by the Lviv Oblast Council (Lviv–Sudova Vyshnya, Lviv–Novoyavorivsk, Lviv–Shchyrets, Lviv–Hlibovychi). Other suburban routes were developed to specific endpoints (Kamyanka-Buzka, Krasne, Mykolayiv-Dnistrovskyy, Rudky, Zhovkva). The problems of suburban railway communication in Lviv Oblast include the following: (1) Suburban trains run only to the final station of Lviv. (2) Suburban train routes are scheduled only during peak hours. From 10.00 to 17.00 there are 7 suburban trains. (3) Transfers within the Lviv hub have not been organised. (4) Certain stops with high passenger traffic have not been introduced. More specifically, Hnata Khotkevycha, Maloholoskivska, Shevchenka, Lyubinska, Knyahyni Olhy, Stryyska, Chervonoyi Kalyny (Figure 17).

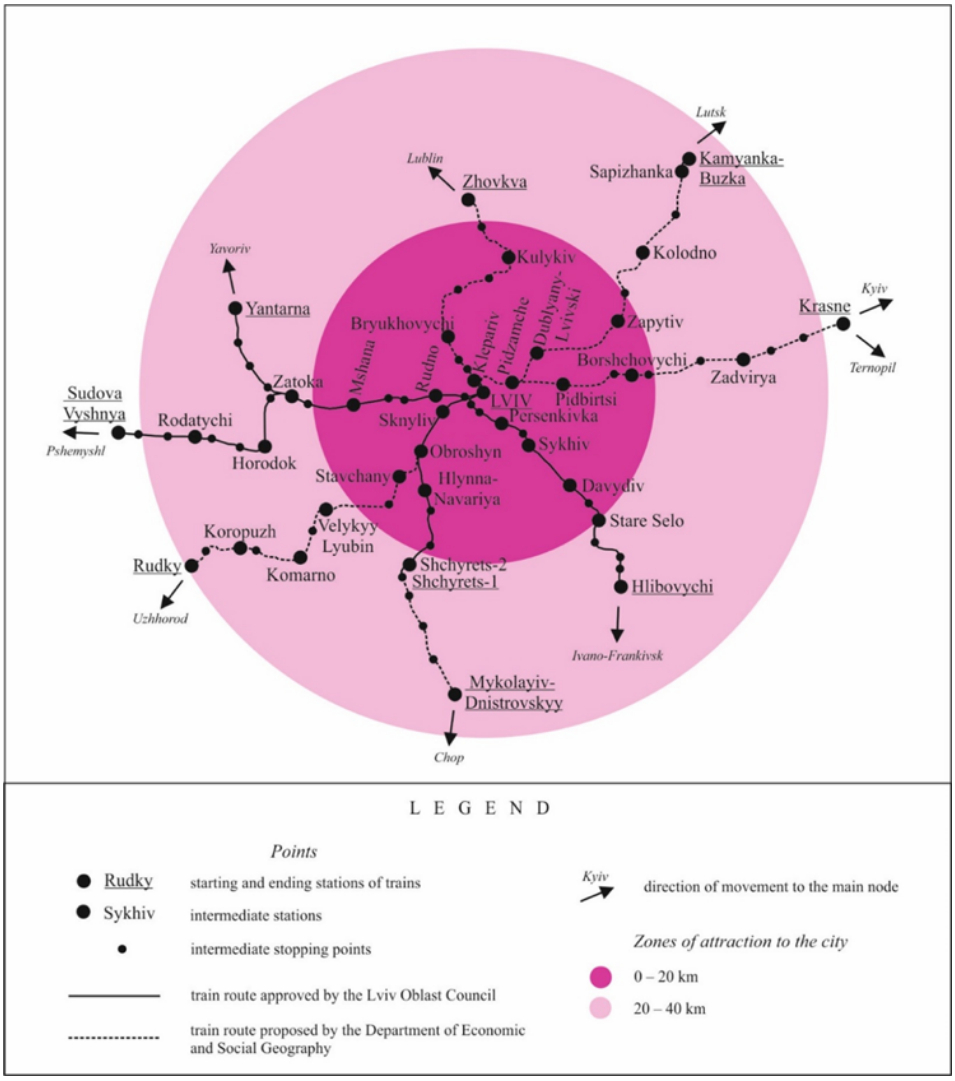


Figure 17. A project of suburban transportation using «shuttle trains».

Session 7 - External contributions and round table

Title: Human-geographic aspects of the formation of the East European gas hub
Speaker: Marianna Yaroshevych
Time: 16:10-16:13

Summary: The development of pipeline transportation infrastructure is mainly related to the gas and oil industries in the Western region of Ukraine. Ukraine has the largest network of underground storage facilities in Europe. Today, the total active capacity of Ukraine's underground gas storage facilities (UGSFs) is over 30 billion cubic meters. This is almost a third of the EU's UGS facilities. The largest gas storages are located in the UGS facilities at the intersection of key gas pipelines that connecting the gas transportation systems of Ukraine, Belarus, Poland, Slovakia. Their share in the total volume of all UGS facilities in the country is about 80%. The core of the promising Eastern European gas hub should be the region's largest gas storage facility, Bilche-Volytsko-Uherske (Lviv region), with a capacity of 17,050 million cubic meters, which can be created in the near future (Figure 18).

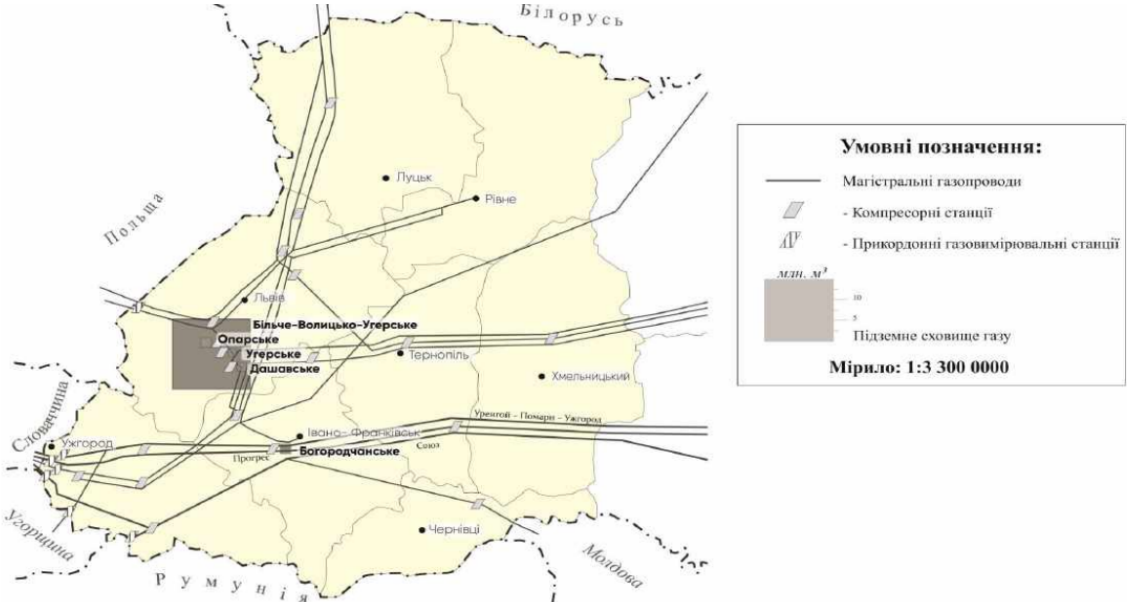


Figure 18. Gas storage facilities of Western region of Ukraine

Title: Energy safety of the city of Lviv: challenges and problem-solving
Speaker: Yuriy Polianskyy
Time: 16:13 – 16:16

Summary: Under the current conditions of martial law, the city's energy balance system requires resilience. The consequences of the disruption of the city's energy infrastructure have led to the idea that urban DHCs need to implement measures that will ensure modern practices in the context of the use of alternative energy sources, which in turn will reduce dependence on fossil fuels (especially gas) and also allow for the digitalisation of data that is currently in written form. It was these conditions that led the city to participate in one of the European Commission's Life SupportDHC project. The overall objective of the SUPPORT DHC project is to support a fast implementation of low-grade renewable energy (RE) and waste heat (WH) for district heating and cooling (DHC) in Europe. This is achieved by supporting DHC operators in drawing-up transformation plans leading to efficient DHC systems as defined in the Energy Efficiency Directive revision and in particular concrete investment plans for a fast implementation of packages of low-grade RE and WH measures. In six European countries (AT, DE, IT, LT, PL, UA), the SUPPORT DHC project in cooperation with involved DHC operators demonstrates such processes and leads to investments on the ground for a variety of EU-wide DHC system cases. In the context of the city of Lviv, an assessment and data collection will be carried out, which will later be transformed into a transformation plan that will provide an understanding of the future functioning of the city's energy supply system, and an investment plan that will allow analysis of the possibility of attracting foreign investment into the system.

Figure 19. Current SupportDHC project logo (EC Life program).

Title: Financial infrastructure of Western region of Ukraine in the conditions of martial law in state
Speaker: Zlata Login
Time: 16:16-16:19

Summary: The financial infrastructure of the Western region of Ukraine is characterized by a sufficient level of development. The western region of Ukraine covers about 25% of the area and population of Ukraine. During the martial law, all sectors of the state's economy undergo transformational processes due to the fact that it became necessary to concentrate all forces on the defence sector. In the Western Ukrainian market, as well as in the Ukrainian market as a whole, the most popular is the introduction of innovations in the banking sector. Compared to 2021, by the end of 2022, the Western region of Ukraine saw a reduction in bank branches by 11%. Branches were closed due to the outflow of both customers and employees from abroad. The most noticeable were the closures in the cities that are the financial centers of the region (for example, Lviv). However, if in cities the vast majority of closed branches have another branch nearby, then in towns and villages "banking deserts" have formed. Existing departments began to perform more functions. The components of the financial infrastructure belong to those that are critically important for the functioning of the economy and ensuring the livelihood of the population during the wartime period.

3 Outcome

John Lamb mentioned that there would be an expectation that engineers and transport planners would be going out to inspect damaged structures and bridges that are damaged after extensive destruction. But we wouldn't be able to get them there within the first 24 to 48 hours. And there's always too many bridges and not enough engineers. There's always too much work for bridge engineers. How do we find that sweet spot/balance between need and offer? There is remote sensing and there are military satellites that can be deployed and are being deployed in certain locations. A very base initial assessment and then watching the trend of failure over the subsequent or movements over the subsequent weeks, months in years, perhaps it's something that does need to include extensive and detailed analysis as to what we assess as a sector of geologists, bridge and structural engineers. It is easy to get this information and then most importantly to communicate that to the to the politicians

The workshop convened individuals ranging from scholars to policymakers, congregating to deliberate on Ukraine's crucial post-war recovery, with a particular emphasis on the Lviv region. This restorative journey demands resilience and sustainability, underscored by the potential offered by openly available data and the transformative capabilities of digitaliSation. Notably, the city of Lviv, situated in western Ukraine and intricately linked to the European Union via Poland, emerges as a focal point in this endeavour.

A central takeaway during the discussions is the inherently multidisciplinary nature of post-war recovery, necessitating collaborative efforts and alliances across diverse sectors. Insights gleaned from the operational frameworks of the UK infrastructure sector offer valuable parallels for Ukraine's endeavours in this domain. Lviv, recognised as a pivotal region, stands poised to serve as a benchmark and catalyst for Ukraine's broader recovery efforts. Thereby Lviv will have a vital role in the region's revitalisation. Urgent measures to improve Lviv's resilience are advocated, with the understanding that the area holds the potential to expedite the recovery not only of Ukraine but also its neighbouring EU counterparts.

Areas of future collaborative work were identified as a result of the Twinning between the University of Birmingham and Ivan Franko National University of Lviv. These include developing research proposals for future funding opportunities, see ScienceForUkraine https://scienceforukraine.eu/, and collaborating with colleagues from Ivan Franko National University of Lviv. Also, exchange of students and researchers between the two universities and seek appropriate funding for this, such as the Universities of Sanctuary https://universities.cityofsanctuary.org/.

Further insights shared during the discourse underscored the relevance of experiences drawn from the UK rail industry and aviation sector to inform Ukrainian authorities' decision-making processes. The need for a comprehensive dialogue involving stakeholders and proprietors, cognisant of the intricacies of cost and profitability dynamics within the railway sector, was emphasised. Recognising the multifaceted dimensions of railway operations, encompassing both passenger and freight considerations alongside broader imperatives such as decarbonisation, emerged as imperative.

Addressing the pressing challenge of infrastructure assessment and maintenance in post-conflict scenarios, participants highlighted the logistical constraints and resource shortages impeding timely response efforts. Strategies integrating remote sensing technologies and satellite deployments were deliberated as potential solutions to augment traditional assessment methodologies. However, a consensus emerged regarding the necessity of meticulous analysis by domain experts, including economists, engineers and politicians, to inform decision-making processes effectively. Ultimately, effective communication channels bridging technical insights with policymaking imperatives are of paramount for fostering sustainable and resilient infrastructure in Ukraine's evolving geopolitical landscapes.

Acknowledgements

The University of Birmingham (UoB), the Ivan Franko National University of Lviv (IFNUL) and bridgeUkraine.org would like to thank the following individuals and organisations.

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Supporting organisations
Birmingham Global, UK Brunel University London, UK
Workshop Chair, Co-chair, Speakers and Other Participants
Chair: **Stergios Aristoteles Mitoulis**, Associate Professor, University of Birmingham, UK [in person] **Co-chair:** **Olga Mamchur**, Associate Professor, Ivan Franko National University of Lviv, UA [in person] **Speakers** (in order of talk delivery): **Stergios Aristoteles Mitoulis**, Associate Professor, University of Birmingham, UK [in person] **Sotirios Argyroudis**, Associate Professor, Brunel University London, UK [online] **Oleh Veklyn**, Head of Department of Investment and Projects, Office of Investment and Projects, Lviv City Council, UA [online] **Dave Cousins**, Principal Engineer - Bridges (Monitoring and Load Testing), Accolade Measurement Ltd, UK [online] **Nadiia Kopiika**, BA/CARA Fellow, University of Birmingham, UK [in person] **Ivan Rudakevych,** Associate Professor, Department of Geography of Ukraine and tourism, Ternopil Volodymyr Hnaytiuk, National Pedagogical University, UA [online] **Iryna Hudzelyak,** Associate Professor, Head of Department of Economic and Social Geography, Ivan Franko National University of Lviv, UA [in person] **Liubov Kotyk,** Lecturer, Deputy Dean of the Faculty of Geography for educational and methodological work, Department of Economic and Social Geography, Ivan Franko National University of Lviv; UA [in person] **Iryna Vanda,** Lecturer, Department of Economic and Social Geography, Faculty of Geography, Ivan Franko National University of Lviv, UA [online] **Yuriy Borsuk,** PhD researcher at Ivan Franko National University of Lviv, Faculty of Geography, Lecturer, UA [online] **Tom Dolan,** UKCRIC Senior Research Fellow and C-DICE Postdoctoral Research Fellow, UCL, UK [online] **Roman Slyvka**, Associate Professor at Department of Geography and Nature science, Ivan Franko National University of Lviv, UA [online] **Iryna Zakutynska**, Associate Professor, Department of Geography and nature science, Ivan Franko National University of Lviv, UA [online] **Mariya Lushchyk**, Associate Professor at Department of Tourism, at V. Chornovil Institute for Sustainable Development, Lviv Polytechnic National University, UA [online] **Olga Mamchur**, Associate Professor, Ivan Franko National University of Lviv, UA [in person] Maryana Yaroshevych, Consultant, Ivan Franko National University of Lviv, UA [online] **Yuriy Polianskyy**, Project manager in Communal Institution “Institute of the City” (Lviv city Council), PhD student at Ivan Franko National University of Lviv, Supervisory Board member in Ukrainian Union of young geographers, UA [online]

Zlata Login, PhD researcher at Ivan Franko National University of Lviv, Faculty of Geography, UA [online]

Other participants

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Nigar Hashimzade, Professor, Brunel University London, UK [online]

Volodymyr Hrytsevych, Associate Professor, Ivan Franko National University of Lviv, UA [online]

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Myroslava Vlakh, Associate Professor, Ivan Franko National University of Lviv, UA [online]

Appendix A – The agenda of the workshop

No	Name of speaker	Duration	Specific topic	Times CET
-	all	15	Coffee	9:00-9:15
1	Stergios Aristoteles Mitoulis	20	Conflict-resilience framework for critical infrastructure peacebuilding	9:15-9:35
2	Sotirios Argyroudis	20	Trade-offs between resilience and sustainable solutions in infrastructure climate adaptation: the case of bridges in Ukraine	9:35-9:55
External contributions & Round table • **External contribution** - **Oleh Veklyn** - Lviv territorial community: place in Ukrainian wartime economy and goals of post-war reconstruction (10 mins) • **External contribution** - **Dave Cousins** - A quick overview of structural health monitoring and load testing for bridges and civil infrastructure (10 mins) • **External contribution** - **Nadiia Kopiika** – Bridges as the part of critical transport infrastructure in Ukraine. Monitoring and prolongation of service life (10 mins) • **External contribution - Ivan Rudakevych** – Transport infrastructure of the city of Ternopil: challenges of development - (5 mins) **Round table** - Resilience of critical infrastructure in post-conflict era 10:30-11:00				9:55-11:00
-	all	30	Coffee	11:00-11:30
3	Iryna Hudzelyak Liubov Kotyk Iryna Vanda	40	Human-geographical problems of development of the Lviv region: - Demographic-geographical (Iryna) (12mins) - Social and economical-geographic (Liubov) (12mins) - Decentralisation and local economic development (Iryna) (12mins)	11:30-12:10
4	Yuriy Borsuk	20	Economic efficiency of the use of railway passenger routes of the Western region of Ukraine	12:10-12:30
External contributions & Round table • **External contribution** – **Tom Dolan** – Resilient Infrastructure Systems: The foundations for a Safe, Secure, Sustainable, and Prosperous Future – (15 mins) • **External contribution** – **Roman Slyvka, Iryna Zakutynska** - Strengths and vulnerabilities of the functioning of the infrastructure of the Ivano-Frankivsk region in the conditions of martial law in Ukraine (7 mins) • **External contribution** – **Mariya Lushchyk** - Impact of transport infrastructure on tourism development in Lviv region (3 mins) **Round table** Human-geographical problems of development of the Lviv region underpinned by railway infrastructure 12:55 – 13:15				12:30-13:15
	all	45	Lunch	13:15-14:30
5	Olha Mamchur Yuriy Borsuk	40	Practical use of geologistics in the transport industry of the Western region of Ukraine - Lviv - key transport hub (Olga) (20 mins) - Geologistics in the transport industry of the Western region of Ukraine: practical usage and	14:30-15:10

			problem of infrastructure reconstruction (20 mins)	
6	Iryna Hudzelyak Iryna Vanda Yuriy Borsuk	60	Socio-economic prerequisites for the functioning of suburban railway transport: - Settlement system and IDP (Iryna H) (20 min) - Capacity of the territorial communities (Iryna V) (20 min) - Challenges and perspectives of the functioning of suburban railway transport (Yuriy) (20 min)	15:10-16:10
External contribution & Conclusion ● **External contribution – Marianna Yaroshevych** - Human-geographic aspects of the formation of the East European gas hub (3 mins) ● **External contribution – Yuriy Polianskyy** - Energy safety of the city of Lviv: challenges and problem-solving (3 mins) ● **External contribution – Zlata Login** - Financial infrastructure of Western region of Ukraine in the conditions of martial law in state (3 min) **Conclusion, discussion and future actions** (16:20-17:00)				16:10-17:00

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