Transporta un sakaru institūts

Evelīna Budiloviča

Lēmumu atbalsta struktūra pilsētas pārsēšanas mezgla pārveidošanai, kuras pamatā ir ilgtspējīgas mobilitātes principi. Rīgas pilsētas piemērā

Promocijas darbs

izvirzīts inženierzinātņu doktora zinātniskā grāda iegūšanai

Inženierzinātnes un tehnoloģijas: būvniecības un transporta inženierzinātnes nozares telemātikas un loģistikas apakšnozarē

Zinātniskais vadītājs
Dr.sc.ing., profesore
Irina Jackiva
Zinātniskais konsultants
Dr. Giannis Adamos

RĪGA – 2019

TRANSPORTA UN SAKARU INSTITŪTS

TRANSPORT AND TELECOMMUNICATION INSTITUTE

Evelīna Budiloviča

Decision Support Framework for the Urban Transport Interchange Transformation Based on the Principles of Sustainable Mobility. Case Study of Riga City

DOCTORAL THESIS

to obtain the scientific degree Doctor of Science in Engineering

Scientific area: "Civil Engineering and Transport"
Scientific subarea: “Telematics and Logistics”

Scientific supervisor:
Dr.sc.ing., professor
Irina Yatskiv (Jackiva)
Scientific consultant:
Dr. Giannis Adamos

RIGA – 2019

UDK 656.072:519.22

Transporta un sakaru institūts

E.Budiloviča

Lēmumu atbalsta struktūra pilsētas pārsēšanas mezgla pārveidošanai, kuras pamatā ir ilgtspējīgas mobilitātes principi. Rīgas pilsētas piemērā, 2019

ANOTĀCIJA

Evelīnas Budilovičas disertācija "Lēmumu atbalsta struktūra pilsētas pārsēšanas mezgla pārveidošanai, kuras pamatā ir ilgtspējīgas mobilitātes principi. Rīgas pilsētas piemērā". Zinātniskais vadītājs ir Dr.sc.ing., profesore Irina Yatskiv un zinātniskais konsultants ir Dr. Giannis Adamos (University of Thessaly, Grieķija).

Darbs ir veltīts Rīgas pilsētas transporta sistēmas ilgtspējīgas attīstības problēmai. Disertācija ietver detalizētu pilsētas transporta sistēmas analīzi, kā arī situācijas izpēti jauna infrastruktūras objekta (pārsēšanās mezgla) izveidē, un kā tas ietekmē pilsētas transporta sistēmu. Tika veikta pārsēšanās mezgla kā galvenā multimodālās pilsētas transporta sistēmas objekta nodrošināto pakalpojumu analīze.

Tika izstrādāta lēmumu pieņemšanas atbalsta struktūra pilsētas sabiedriskā transporta sistēmas (PSTS) ilgtspējīgai plānošanai un termināļu pieejamībai, kas ietver ilgtspējīgas attīstības mērķus.

Struktūra tad tiek izmantota, lai aplūkotu, kā Rīgas pašvaldība varētu virzīt pilsētas transporta sistēmu uz ilgtspējīgumu un multimodalitāti, lai plānotu lēmumus par pasažieru tīklu Rīgas pilsētā projekta Rail Baltica ietvaros – Rīgas centrālo multimodālo sabiedriskā transporta mezglu. Dažādiem rīkiem un vienotai pieejai, tika izmantoti Rīgas starptautiskās autoostas (RSAO)/pārsēšanās mezgla dati. Tika veiktas dažādu veidu aptaujas, sastādīts lēmumu pieņemšanas koks par kvalitātes rādītājiem, veikta salīdzinošā analīze starp Eiropas autoostām un tika izstrādāti 4 praktiskie piemēri ar mērķi uzlabot pasažieru apkalpošanas kvalitāti.

Disertācijā sniegtā analīze ir noderīga kā teorētiskai, tā praktiskai izmantošanai pilsētas administrācijai un lēmējpersonām.

ANNOTATION

The thesis of Evelīna Budiloviča "Decision Support Framework for the Urban Transport Interchange Transformation Based on the Principles of Sustainable Mobility. Case Study of Riga City". The scientific supervisor is Dr.sc.ing., professor Irina Yatskiv and scientific consultant is Dr. Giannis Adamos (University of Thessaly, Greece).

The work is devoted to a problem of Riga urban transport system sustainable development. The thesis consists of a detailed analysis of the transport system of the city, as well as an investigation of the situation in the development of a new infrastructure facility (interchange) and how this affects the transport system of the city. The analysis of the services provided by the interchange, as the main object of the multimodal urban transport system, was conducted.

The decision support framework for urban public transport system (UPTS) sustainable planning and interchange accessibility that incorporates the objectives of sustainable development was developed.

The framework is then used to consider how the Riga municipality might move the city's transportation system towards sustainability and multimodality – to planning decisions for passenger network in Riga City in the frame of Rail Baltica project – Riga central multimodal public transportation hub. For different tools and common approach, data of Riga international coach terminal (RICT) were used. Different types of surveys were conducted, a decision tree on quality indicators was compiled, a comparative analysis between the leading European coach stations was done, and 4 cases were developed to improve the quality of passenger service.

The analysis provided in the thesis is useful for both theoretical and practical use by city authorities and decision-makers.

ABBREVIATIONS

Abbreviations	Definitions
ATD	State Ltd. Road transport administration
BS	Baltic States
CC	Closeness Centrality measure
EC	European Commission
EU	European Union
GHT	Greenhouse Gases
IR	Interconnectivity Ratio measure
LDZ	JSC “Latvijas dzelzceļš.”
O-D	Origin-Destination matrix in transportation
PV	JSC “Pasažieru vilciens”
P&R	Park & Ride
PORT	Riga Passenger Terminal Ltd.
PPP	Public-Private Partnership
PT	Public Transport
PTS	Public Transport System
RCRS	Riga Central Railway Station
RD PAD	Riga city Development Department
RICT	Riga International Coach Terminal
RIX	Riga International Airport
RLC	The main regional cities of Latvia
RMS	PS “Rīgas mikroautobusu satiksme”
RPTH	Riga Central Multimodal Public Transportation Hub
RS	RP SIA “Rīgas satiksme.”
RTS	Riga Transport System
RTSM	The Riga City Transport Simulation Model
RVC AZ	Historic Centre of Riga and its protection zone
SD	Sustainable Development
SDG	Sustainable Development Goals
SUD	Sustainable Urban Development
STI	Sustainable Transport Indicator
STS	Sustainable Transportation System
SUT	Sustainable Urban Transport
SUTS	Sustainable Urban Transport System
SWOT	Strengths, Weaknesses, Opportunities, Threats analysis
TAZ	Transport Analysis Zones
TS	Transport System
TSI	Transport and Telecommunication Institute
TSM	Transport Simulation Model
UN	United Nations
UTS	Urban Transport System

CONTENT

LIST OF FIGURES

LISTS OF TABLES

INTRODUCTION

The relevance of the problem and the motivation of the research

Traffic congestion is a significant problem of public transport systems in many countries (Huang, 2009; Min,2011; Sivilevičius, 2011; Vlahogianni, 2005). Increasing urbanisation over the years has resulted in the development of vast areas as urban extensions. Many roads have incrementally led to catering to the increased traffic demand (Goerigk, 2013). The cities have been developed in a disintegrated urban form spreading along significant traffic corridors (CES, 2006). Congestion on arterial roads is due to haphazard development, narrow streets, congested junctions, unorganised parking and others, a situation that creates hindrance to the smooth flow of traffic (CES, 2006). Most of the major corridors and bridges are no longer able to cope even with the present traffic demand.

Each year the number of the planet's inhabitants increases. By 2050, 70% of the total population will live in cities. Now, in Latvia (2019), 68.3% of the population lives in urban areas. This growing mobility demand congests the road network, causing long delays, excess fuel consumption, increased pollutants' emissions (i.e. carbon dioxide), and road safety level deterioration. Therefore, we need to think about the sustainable planning and development of cities. Development and planning are the main components of city life. The population ageing continues to grow: at that moment in Latvia, 22.2% of the country's inhabitants are in the "retirement age". The world tendency is that it will grow up.

To ensure urban life is necessary to use and apply the principles of sustainable planning. The 'sustainability' concept appeared for the first time in 1987 in the famous Brundtland Report (also entitled 'Our Common Future') produced by several countries for the United Nations (UN) (Brundtland, 1987). In 1798, Thomas Malthus published 'An Essay on the Principle of Population', in which he set out his famous 'theory of population'. This theory states that the population tends to grow quicker than resources (Brundtland, 1987). The term 'sustainable development' was initially mentioned in an official document in 1969. The law that constituted the National Environmental Policy Act (NEPA, 1969) defined sustainable development as: 'economic development that may have benefits for current and future generations without harming the planet's resources or biological organisms' (Sustainability for all, 2018). The sustainable development is a harmonious interconnection of all city systems, such as economy, environment and transport, in which the city residents feel comfortable, safe and convenient to live or move in the urban area.

The main idea of sustainable development is the vision to meet *'the needs of today's citizens without compromising the ability of future generations to meet their own needs'* (UNWC, 1987). Following this definition, attention is paid to the concept of fairness between current and future generations, where sustainability is looked at from a threefold perspective: economic, social, and environmental.

Development of the sustainable urban transport system is one of the keystones of the city sustainable planning. Two of 17 Sustainable Development Goals (SDGs) included in the Agenda 2030, are directly related to the main principles of transport system development:

- ***to develop qualitative, reliable, sustainable, and resilient infrastructure***;
- ***for access to safe, affordable, accessible, and sustainable transport systems for all***.

The implementation of these principles is the big challenge for East European countries and especially now that the number of public transport (PT) users decrease. As for Riga city, in the period between the years 2014 and 2018 (estimated data), the average decrease in the number of passengers has reached -1.3% per year (RD PAD, 2019).

How to do PT more attractive for users? How to implement these principles of SDG that concerns the transport system? How to do it on the first stage of transport infrastructure project development? These and other similar questions became the motivation for this research.

On the other side, various authorities in different institutional settings are usually responsible for transport infrastructure and spatial development. In infrastructure planning, government agencies usually are responsible for only a specific infrastructure mode, such as road, water, rail and develop often projects with limited scope. They focus on solving a particular problem and applying a minimalistic approach oriented on formal requirements for public consultation. Spatial planning authorities often pay too little attention to the accessibility effects of their plans.

This PhD thesis is devoted to the multi-modal transportation planning in Riga city. The main research question is: ***How should multi-modal transportation planning incorporate an evaluation of factors affecting accessibility and how are they currently considered in planning?***

The initial contribution of this research is the theoretical development of a decision-support framework that identifies the tools and approaches that decision-makers should use to create policies and programs to move society towards sustainability. These tools and approaches are either articulated or developed by the author throughout the thesis. Specific ideas explored include a transportation system towards sustainability and gaps identified between theory and practice. The approach is embodied in the proposed sustainable transportation decision-support framework that can be used for transportation planning and decision-making processes in the city.

The framework is then used to consider how the Riga municipality might move the city's transportation system towards sustainability and particularly – to planning decisions for passenger network in Riga City in the framework of Rail Baltica project – Riga central multimodal public transportation hub. The decision-making process should involve integrated institutions, networks, stations, user information, and fare payment systems and consider all significant impacts.

Multi-modal transport planning should be done by integrated institutions responsible for networks, stations, user information and fare payment systems. Such an organization or authority has to consider all significant factors, including long-term, indirect and non-market impacts, such as changes in equity and land use. Urban transport interchanges play an important role in transport systems. They are one of the main measures aimed at increasing the use of public transport and stimulating the modal redistribution (Lopes-Lambas, 2010). Urban transport interchanges are crucial in urban transport networks, as they allow the integrated use of various modes of transport in the public transport chain.

The object, subject, goal, and objectives of the research

The research *Object* is the public transport system planning process in the stage of strategic transport project implementation.

The research *Subject* is the transport interchange accessibility analysis in the context of sustainable mobility.

The research goal is to identify the gaps between theory and practice that exist in moving the urban public transport system towards sustainable development and to propose a decision support framework, considering the current transportation planning and decision-making processes in Riga city.

The following tasks are considered for implementation:

1. to review the modern approach to public transport system planning in multimodality provision;
2. to identify problems that exist in the sustainable development of Riga urban public transport system (UPTS);
3. to fulfil the holistic analysis of role and quality of service transport interchanges in the Riga Public Transport System (using RICT as a case study);
4. to analyse accessibility measures in the context of multimodality approach;
5. to develop a decision-support framework of transport interchange accessibility analysis that incorporates the objectives of sustainable development in transport system planning. The framework partly implied Riga TS analysis;
6. to assess the stakeholder’s role in urban transportation and develop comprehensive recommendations for them to promote a sustainable transportation system (STS).

The methodology and methods of research

The first stage of research is based on analysis of the scientific literature, White papers, European Union (EU) Commission's reports, transport planning guidelines and Internet sources. On this basis and taking into account the author experience and the working place in the Development department of Riga Council, the *research hypothesis* was formulated as follows:

a decision-support framework can identify the approaches and tools that decision-makers should use for creating policy and programs that move urban transport city towards sustainability.

The research methodology includes five main blocks and describes what will be done (see

Figure 0.1):

1. For understanding current trends and state-of-the-art the review of theoretical aspects of the sustainable transport system development and interchange as a significant object of this system will be done and included:
   1.1. sustainable development concept;
   1.2. urban transport systems (UTS);
   1.3. sustainable urban mobility planning;
   1.4. the role of interchange in the urban transport system.
2. For identifying problems that exist in the sustainable development of Riga urban public transport system the next items were analysed:
   2.1. Riga urban transport system: development, regulations, current situation analysis, SWOT analysis, recommendations for represented transport modes;
   2.2. Riga transport simulation model as a decision-making tool: current state and usability problems;
   2.3. Riga transport system analysis and should be spotlighted the main problems;
   2.4. Riga's interchanges, choosing the main factor for measuring impact: description, the new hub development, the process of impact analysis.
3. After highlighted main problematic indicator – accessibility – state-of-the-art of accessibility as a sustainable transport indicator was conducted: definition, public transport accessibility, different levels and measures. The set of accessibility indicators that connected with multimodality and possible impacts of the strategic project (Multimodal Hub) should be suggested.
4. The practical part consists of suggested approach application for Riga city and one of the interchanges (RICT):
   4.1. The evaluation of Riga transport system accessibility

4.2. RICT case study:

- stakeholder definition;
- accessibility indicator assessment: long-distance intermodal traffic, calculation of the interconnectivity ratio and closeness centrality;
- traveller satisfaction analysis: satisfaction survey (indicative characteristics, absolute and relative frequency of traveller satisfaction, correlation and regression analysis, evaluation criteria and indicators);
- quality indicator benchmarking: decision tree (list of attributes, indicator evaluation); GAP analysis between stakeholders (stakeholders satisfaction survey, comparison of travellers and stakeholders' criteria);
- meta-analysis: interchange comparison, meta-analysis between interchanges
- analysis of services provided in Riga interchanges: the survey of the information services providing in the Riga interchanges; ticketing services; services provided for people with disabilities; indoor-outdoor services; intelligent system services; strengths and weakness of studied interchanges

5. On the basis of it, the decision support framework for transport interchange accessibility analysis that incorporates the objectives of sustainable development in public transport system planning should be developed.

The PhD thesis consists of an introduction, five chapters, conclusion and appendix. The literature review results generated a considerable amount of information included in the ***first chapter*** and described the sustainable urban mobility principles, such as the sustainable development concept, sustainable transport system, sustainable urban mobility planning principles and the role of interchange in the urban transport system.

The ***second chapter*** analysed the Riga urban public transport system in the context of sustainable development, defining gaps between theory and practice, discussed the strategic plans and planning document. The existing decision-making approach presented (transport simulation model at the macro level). The SWOT analysis of the urban transport system prepared in this chapter. The recommendations for the development of the Riga transport system transport modes are prepared.

The ***third chapter*** provides an overview of the accessibility definition, as the most significant indicator for Riga public transport system, and it is implemented in the urban transport system. Also, accessibility measures are reviewed and analysed.

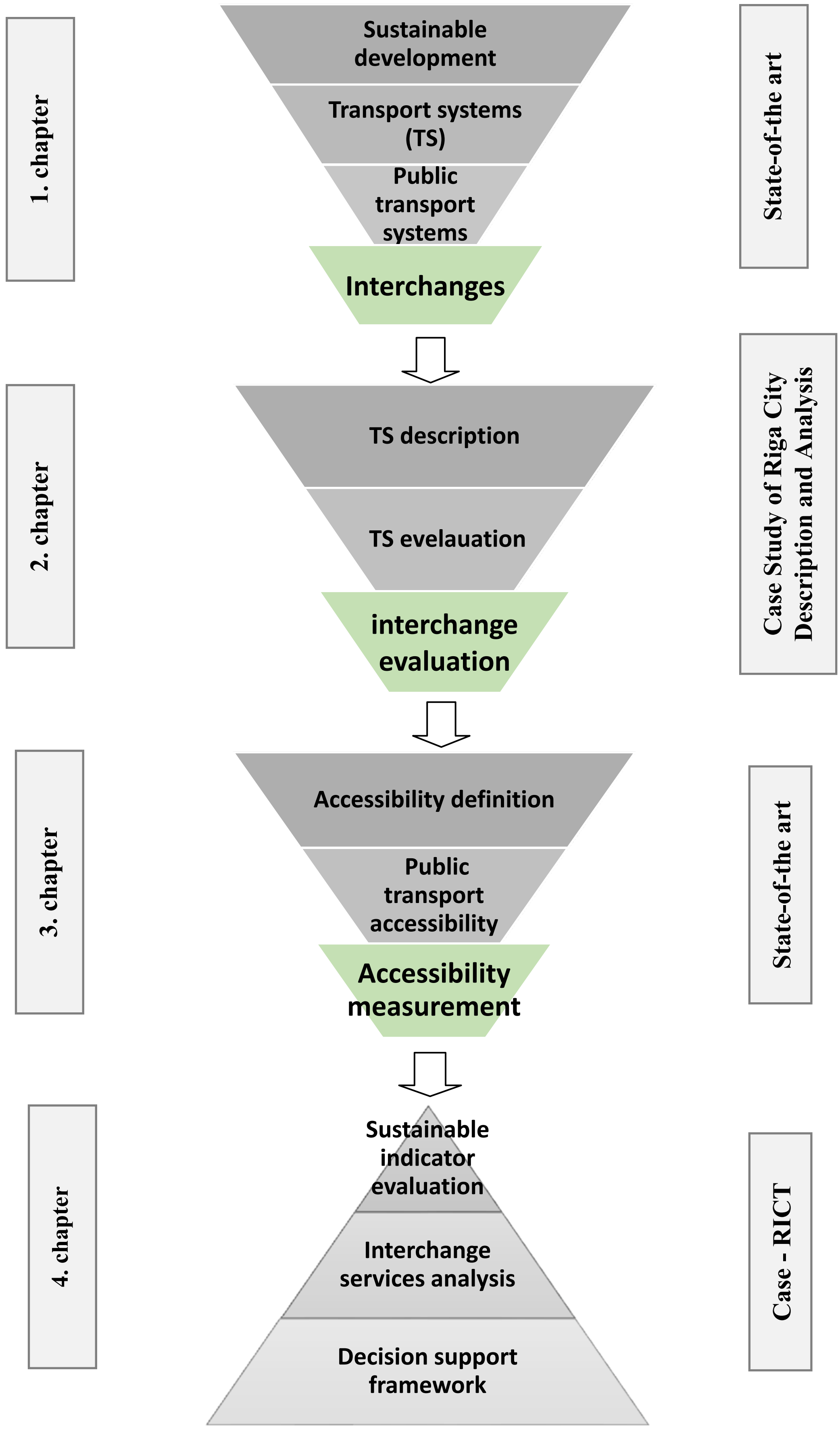


Figure 0.1. The thesis structure

The Riga transport system analysis and evaluation are presented in the ***fourth chapter***. The meta-analysis of the best European best practices is proved, the decision tree approach created, the traveller satisfaction survey and its analysis conducted. The data collection approach to this study is described as well, whereby; the topic is analysed in the actual context of the project involving users, researchers (designers), and stakeholders as focus groups. Four surveys methods have been conducted with focus groups and are presented here. The fourth chapter presents the synthesis of findings from the analysis is made based on the approach used. ***The fifth chapter*** presents the framework of the decision process and its analysis. The conclusion is made where the limitations of the study are also addressed, and some recommendations on further analysis are proposed.

The following theories and methods have been used in work: the system approach, the methods of statistical analysis, simulation modelling, decision tree approach, methods of service quality analysis, surveys and Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis.

The computer-based support for necessary investigations was as follows: the spreadsheet application software MS Excel, the simulation package EMME used to calculate the accessibility measure; Weka J48 – Waikato Environment for knowledge analysis that was used for the decision-tree approach application; the software Statistica 7 was taken for data analysis; for indicator calculation was written the script in programming language Python.

The author organised and prepared the following surveys for data collecting and analysis during the thesis preparation:

1) The survey of the leading sustainable development indicator definition for the Riga city, 2016 (RDPAD, TSI, independent experts);
2) The survey of the traveller satisfaction, 2017 (RICT);
3) The survey of practitioners from authorities, 2017 (RDPAD, RICT, SIA NORDIKA, State Ltd. „Road Transport Administration”);
4) The survey of the service providing stakeholders opinion, 2018 (RICT);
5) The survey of the information services providing in the Riga interchanges, 2018.

The surveys were conducted on condition of confidentiality such that responses could not be linked back to individual respondents.

Limitations of the research

1. One of the inherent limitations of the research was defining what it means for an Urban Public Transport System to be successful at carrying out state-wide multimodal planning.
2. Aspects of transport planning were considered in terms of multimodality and did not take into

account the aspect of environment and society issues.

3. Some conclusions are only suitable for Riga and depend on the characteristics (e.g., population, density, agglomeration area) of the city.

Theses for defence

1. When developing passenger hubs, the gap between the two analysis should be taken into account, i.e. in terms of the access to and from the interchange, or the attractiveness of the internal and external area.
2. The methodology of interchange evaluation requires complex analysis of stakeholders survey, intermodal long-distance trip analysis, traveller satisfaction analysis, GAP analysis between travellers and practitioners, meta-analysis between five EU interchanges, analysis of the information services implementation in the interchanges.
3. For implementing measures to improve multimodal passenger interchange service in the real city, a special methodological guide should be developed.
4. Analysis of transport interchanges accessibility that incorporates the objectives of sustainable development in transport system planning can be performed using the proposed framework.
5. The decision-making process for the development of Riga Central Multimodal Public Transportation Hub project should be based on the methodology of before-and-after analysis of the transport system accessibility.
6. The holistic approach to the assessment of the urban transport system functioning and the evaluation of the expected outcome of new infrastructures and services should be based on the accessibility indicators, simulation model, and simulation experiments to estimate the proposed solutions in the aspect of sustainability issues.
7. The local situation regarding the organisation of transport in the Riga City is moving to the soft modes of integration, and functional integration appears to be essential in order for transport policies to play a role in the interchange “time penalty” reduction.

Scientific novelty

1. Identified problems that exist in moving the urban public transport system towards sustainable development in Riga city.
2. Decision support framework of transport interchange accessibility analysis that incorporates the sustainable development objectives was proposed. The studding of transport hubs and interchanges in terms of accessibility, until now, have not engaged in Riga and Latvia.
3. Holistic analysis of the role in transport system accessibility and quality service of transport interchanges s in the Riga Public Transport System (RICT case study).
4. Set of tools developed for analysing the feasibility and a methodological guide for measures implementing towards multimodal passenger interchange service improvement.

5. The approach based on a decision tree to understand the users' perspectives and predict the most significant factors contributing to their satisfaction and act accordingly to accommodate their needs

Practical importance and applying

The proposed methodology can facilitate decision-makers:

1. Considering that the implementing of the standard guidelines and, plans (for instance SUMP) in transport planning, it is necessary to carefully evaluate and make a preliminary analysis of the most important from the sustainable development point of view, the indicators for the city in terms of sustainable development.
2. In terms of multimodality, special importance is attached to the services provided by the terminal (interchange), and from this point of view, the conclusions made by the author are significant for designers involved in the passenger interchange planning.
3. The developed framework can serve as a guideline for a decision-maker and be used for an urban transport system planning. The conclusions and recommendations developed for the city of Riga and RICT are useful and implemented in practice. The letters from the RICT (Appendix 6) are attached.
4. Based on the decision tree approach on travellers satisfaction questionnaire data, decision-makers can address the critical quality indicators that are linked with the highest overall evaluation of the station. Decision-makers may then be able to follow the "tree rules" in order to increase the performance of their stations with the minimum number of interventions (as only the most critical quality indicators may be affected and not all).
5. The thesis analysed the real object RICT. All conducted analysis that was done during this research can be implemented in another interchange and city. The developed framework can be used as a methodology for interchange analysis before and after reconstruction.

The work approbation

The main results of the research were presented at the following conferences and workshops:

1. The 3rd Conference on Sustainable Urban Mobility (3rd CSUM), 26-27 May 2016, Volos, Greece.
2. The 16th Conference on Reliability and Statistics in Transportation and Communication (RelStat'2016), 19-22 October 2016, Riga, Latvia.
3. The 10th International Scientific Conference Transbaltica 2017: Transportation Science and Technology, 4-5 May 2017, Vilnius, Lithuania.
4. The 10th International Logistics Doctoral Student Workshop. Fraunhofer IFF, 20-22 June 2017, Magdeburg, Germany.

5. The 17th International Multidisciplinary Conference Reliability and Statistics in Transportation and Communication (RelStat-2017), 18-21 October 2017, Riga, Latvia.
6. The 4th Conference on Sustainable Urban Mobility (4th CSUM), 26–27 May 2018, Skiathos, Greece.
7. European Transport Conference (ETC), 10-12 October 2018, Dublin, Ireland.
8. The 18th International Multidisciplinary Conference Reliability and Statistics in Transportation and Communication (RelStat-2018), 17-20 October 2018, Riga, Latvia.
9. The final conference of Alliance project, 17 October 2018, Riga, Latvia.
10. The 11th International Scientific Conference Transbaltica 2019: Transportation Science and Technology, 4-5 May 2019, Vilnius, Lithuania.
11. The part of the research collected material about the history of the public transport in Latvia and Riga was published in Latvia Republic National Encyclopedia in 2018.

The results of the research were published in the following journals and proceedings:

1. Yatskiv I., Budilovich E. (2017) A comprehensive analysis of the planned multimodal public transportation HUB. Transportation Research Procedia (ISSN: 2352-1465), Vol. 24, pp. 50-57 (2017) DOI: 10.1016/j.trpro.2017.05.067 (Scopus)
2. Yatskiv I. and Budilovich E. (2017). Evaluating Riga Transport System Accessibility. Procedia Engineering (ISSN: 1877-7058), Vol. 178, pp. 480–490 (2017) DOI: 10.1016/j.proeng.2017.01.091 (Scopus)
3. Yatskiv I., Budilovich E., Gromule V. (2017) Accessibility to Riga Public Transport Services for Transit Passengers. Procedia Engineering (ISSN:1877-7058), Vol.187, pp.82-88 DOI: 10.1016/j.proeng.2017.04.353. (Scopus)
4. Tsami M., Budilovich (Budiloviča) E., Magginas V., Adamos G., Yatskiv (Jackiva) I. (2018) Assessing the Design and Operation of Riga's International Coach Terminal. In: Kabashkin I., Yatskiv I., Prentkovskis O. (eds) Reliability and Statistics in Transportation and Communication. RelStat 2017. Lecture Notes in Networks and Systems, vol.36. Springer, pp. 497-506 (Web of Science)
5. Tsami M., Adamos G, Nathanail Ef., Budilovich (Budiloviča) E., Yatskiv (Jackiva) I., Magginas V. (2018) A decision tree approach for achieving high customer satisfaction at urban interchanges. Transport and Telecommunication, 2018, Vol.19 (3), pp.194-202 (Scopus)
6. Budilovich (Budiloviča) E., Magginas V., Adamos G., Yatskiv (Jackiva) I., Tsami M. (2019) Investigating the Accessibility Level in Riga's International Coach Terminal: A Comparative Analysis with European Interchanges. In: Nathanail E., Karakikes I. (eds) Data Analytics: Paving the Way to Sustainable Urban Mobility. CSUM 2018. Advances in Intelligent Systems and Computing, vol 879. Springer, Cham. pp 839-846

7. Budilovich (Budiloviča) E., Nacionālā enciklopēdija. Tautsaimniecība/Transports/ Pilsētas transports. Latvija. Rīga, Latvijas Nacionālā bibliotēka, 2018. 601-604lpp

8. Magginas V., Nathanail Ef., Adamos G., Tsami M., Yatskiv (Jackiva) I., Budilovich (Budiloviča) E. (2018) Environmental Friendly Transport Interchanges: Active Travel Accessibility and Policy. In: Kabashkin I., Yatskiv I., Prentkovskis O. (eds) Reliability and Statistics in Transportation and Communication. RelStat 2018. Lecture Notes in Networks and Systems, vol.68. Springer, 572-581 (Web of Science, Scopus)

9. Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., Blodniece, E., Nathanail Ef., Adamos G. (2018) A Cross-Case Analysis of Riga Interchanges' Information Services and Technologies. In: Kabashkin I., Yatskiv I., Prentkovskis O. (eds) Reliability and Statistics in Transportation and Communication. RelStat 2018. Lecture Notes in Networks and Systems, vol.68. Springer, 582-592

10. Yatskiv (Jackiva) I., Budilovich (Budiloviča) E. (2019) Decision-support Framework for the Urban Public Transport System Sustainable Planning: Riga Case Study. The 11th International Scientific Conference Transbaltica 2019: Transportation Science and Technology, 4-5 May 2019, Vilnius, Lithuania, Springer (In print)

1. SUSTAINABLE URBAN MOBILITY

1.1. Sustainable development concept

The significant problem for urban areas is that more and more people live in cities. According to the latest statistics, approximately 70% of the European Union citizens live in urban areas, 40% of which live in large urban areas of over 200.000 inhabitants. By 2050, it is estimated that about two-thirds of the world's population will be living in an urban area (European Commission, 2007). This growing mobility demand congests the road network, causing long delays, excess fuel consumption, increased pollutants' emissions (i.e. carbon dioxide), and road safety level deterioration. The United Nations Conference on Sustainable Development – or Rio+20 – took place in Rio de Janeiro, Brazil on 20-22 June 2012. It resulted in a focused political outcome document – 2030 Agenda for Sustainable Development (Agenda 2030), which contains clear and practical measures for implementing sustainable development. The Agenda 2030, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. This document defines the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries (United Nations, 2015). SDGs comprise the following social issues: education, health, gender equality, environment, peace and other fields of life. To achieve the research goal is necessary to analyse the urban transport system in the city development context. Moreover, two of the SDGs provided by Agenda 2030 are related to transport:

(9.1) to develop **qualitative, reliable, sustainable, and resilient infrastructure**, and focus on affordable and equitable access for all groups of population;

(11.2) **for access to safe, affordable, accessible, and sustainable transport systems for all**, with particular attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons.

Before the transport system analysis, it is necessary to understand sustainable development. Sustainable urban development (SUD) and its management are crucial to the quality of the people life. As defined in Agenda 2030 (United Nations, 2015), it is strictly needed to work with authorities and communities to renew and plan cities, to think about human settlements in personal security, to stimulate innovation and employment. It is also recommended to decrease the negative impacts of urban activities, reduce and recycle waste and provide more efficient use of water and energy (United Nations, 2015).

Some definition of sustainability and sustainable development is compiled in Table 1.1. It can be concluded that sustainability refers to holistic system analysis, it is a harmony extended into the future with resource expanding and the quality of life improving.

Table 1.1. Definition of sustainability

Definition	Sources
Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs."	(WCED, 1987)
"Sustainability is equity and harmony extended into the future, a careful journey without an endpoint, a continuous striving for the harmonious co-evolution of environmental, economic and socio-cultural goals."	(Mega V., Pedersen J., 1998)
"The common aim [of sustainable development] must be to expand resources and improve the quality of life for as many people as heedless population growth forces upon the Earth and do it with minimal prosthetic dependence."	(Wilson, 1998)
"…sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation."	(TRB, 1997)
"the capacity for continuance into the long-term future. Anything that can go on being done on an indefinite basis is sustainable. Anything that cannot go on being done indefinitely is unsustainable."	(Center for Sustainability, 2004)
Sustainability is a principle that is central to the SUMP concept that central goal is improving the accessibility of urban areas and providing high-quality and sustainable mobility and transport to, through and within the urban area…"	(ELTIS, 2016)

Sustainability can also be addressed at the spatial level. Rodrigue (2017) suggested two spatial levels of sustainability, such as:

1. Global – long-term stability of the earth's environment and availability of resources to support human activities.

2. Local – localised forms often related to urban areas in terms of jobs, housing and environmental pollution.

The first official reference of sustainable development in this context was in the Report for the World Commission on Environment and Development (UNWC) in 1987 where the term of sustainable development was introduced (UNWC, 1987). The UNWC proposed "three pillars" of sustainability such as social, economic and environmental (Figure 1.1).

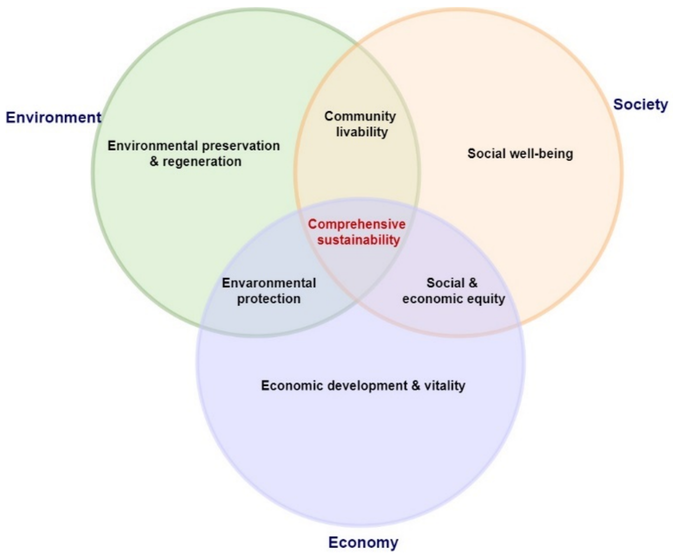


Figure 1.1. The concept of sustainability

The researches provide different descriptions of these pillars. Rodrigue (2017), as one of the authority researcher of transport planning field, proposes the following definition of pillars:

- Social equity places the priority on satisfying the diversified needs of the population, such as food, health and education being among the most basic. Maintaining human capital (knowledge, skills and capabilities) is mostly the responsibility of educational systems, but corporations also provide substantial training opportunities to their workforce.
- Economic efficiency is an issue that has received many emphases as it promotes improvements in the welfare of populations. Key concepts are related in achieving or sustaining economic growth, maximise profits, increase competitiveness and expand markets. Globalisation has given a new dimension to economic development by enabling an extended range for comparative advantages to be exploited.
- Environmental responsibility tries to respect the carrying capacity of environmental systems, to conserve and recycle resources and to reduce the generation of wastes. The environmental footprint of human activities has received much attention.

Sustainable development includes territorial zoning of urban areas, construction of infrastructure facilities, social well-being of residents, high-quality and reliable public transport, as well as deep and safe routes of freight traffic. The basis for the vital activity of the city is the transport or transport systems of the city.

1.2. Urban transport system

One of the main aspects of urban development is transport and the transport system (TS).

The traditional viewpoint of transport experts and policymakers, as noted by Goulias (2002) is that TS exist to provide for the safe and efficient movement of people and goods in an environmentally responsible manner. This definition encompasses not only the benefits to society from a well-designed TS but also the critical issues that we still have to address and resolve.

According to Casseta (2009), a transport system (TS) can be defined as the combination of elements and their interactions, which produce the demand for travel within a given area and the supply of transportation services to satisfy this demand. Moreover, Cassceta (2009) mentioned that the TS of a given area could also be seen as a sub-system of a more extensive territorial system with which it strongly interacts. Considering an urban system that consists of a set of households, workplaces, services, transportation facilities, government organisations, regulations, several subsystems can be identified, including the activity and TS, both relevant for system purposes (Figure 1.2).

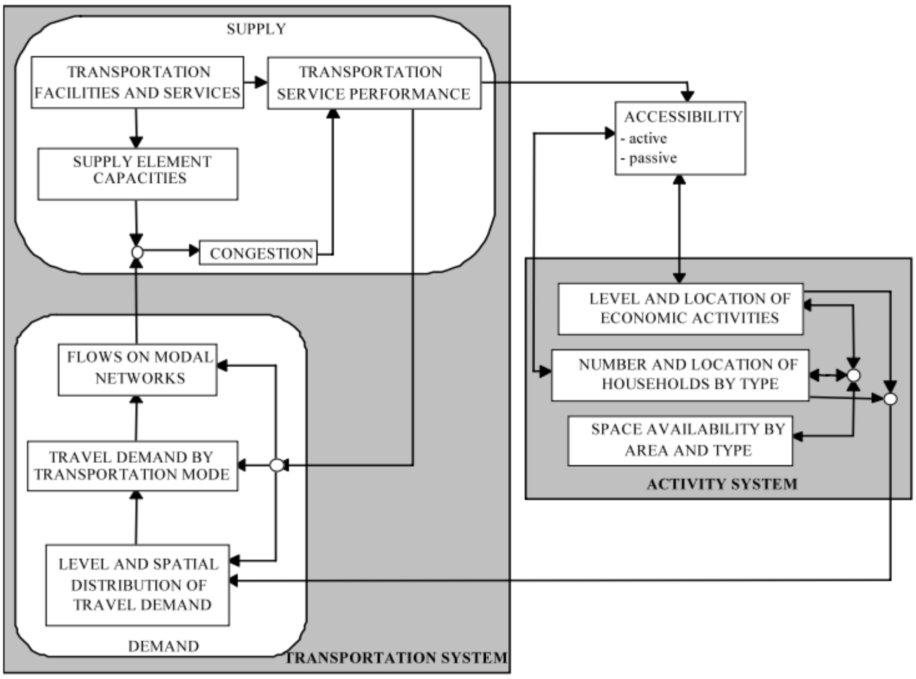


Figure 1.2. Relationships between the transportation system and the activity system (Cascetta, 2009)

The TS can be conceptualised as the set of relationships between nodes, networks and demand. All the components of a TS are designed to facilitate the movements of people, goods and information, either as separate or joint components.

The TS, according to Janic (2014), consists of infrastructure, transport modes/vehicles, supporting facilities and equipment, workforce and organisational forms of their use. The TS could include different forms/modes that can be categorised by groups: rail, road, water, air, and their combinations operating as intermodal or multimodal transport service networks (Figure 1.3).

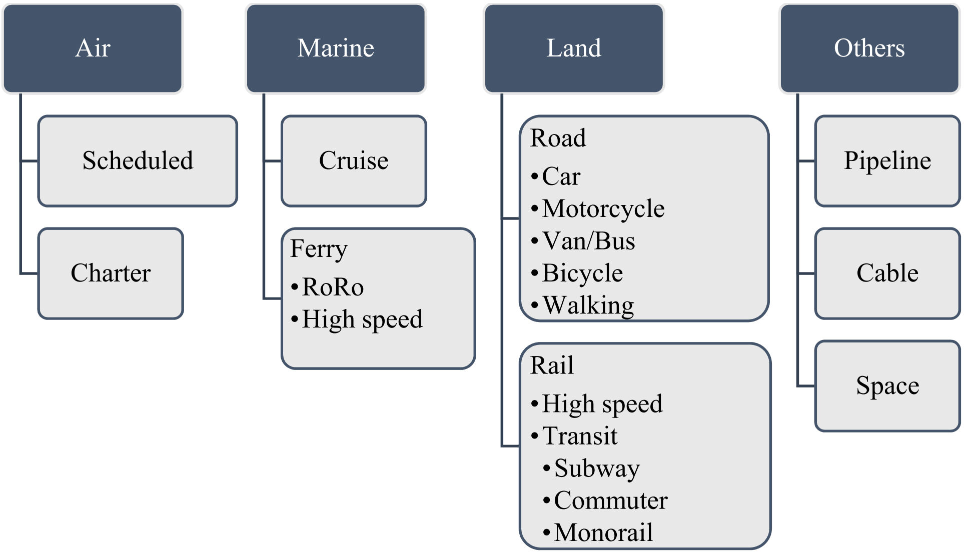


Figure 1.3. Diversity and characterisation of transportation modes (ALLIANCE project, 2018)

Rodrigue (2017) refers to transport as one of the essential human activities worldwide. He suggested that it is a component of the economy and plays a significant role in supporting spatial relations between locations. Transport creates valuable links between regions and economic activities between people and the rest of the world. It is composed of core components, which are the modes, infrastructures, networks and flows. Transport is a multidimensional activity whose importance is: historical, social, political, economic, environmental. Moreover, Rodrigue (2017) defines the transport system like the system that supports the complicated relationship between its core components: nodes, network and demands (Figure 1.4).

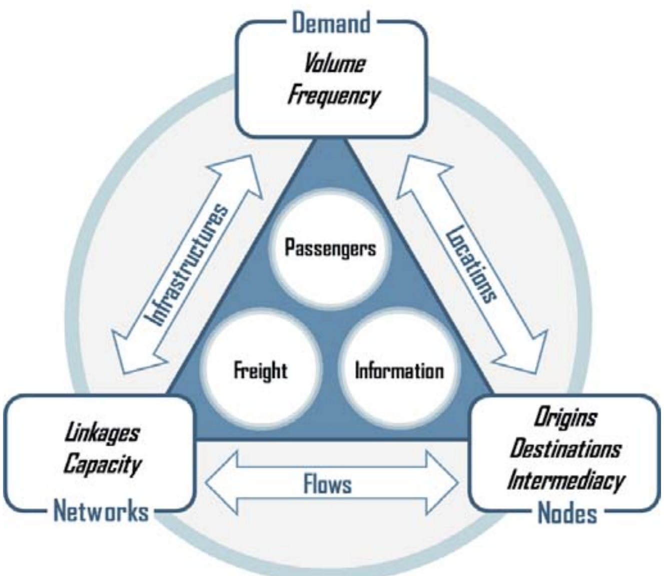


Figure 1.4. The transport system (Rodrigue, 2017)

Depending on the volumes and intensity of passengers and freight/goods demand, each mode has different self-contained components distinguished mainly according to the type of technologies, resources used, and concepts of providing transport services.

One of the main elements of the TS is the infrastructure – the physical components of the transport system that occupy a fixed position in space and create a transport network that includes connections (segments of roads and railways, pipelines, etc.) and nodes (intersections of segments of roads, terminals for various purposes, etc.).

Gorev (2010) suggested that for transport system development in any state, firstly is necessary to create an efficient and perfect system of passenger transport in the three main levels:

1) urban passenger transport with the primary purpose to provide the mobility of citizens by road travel of passengers within the territory of settlements;

2) regional passenger transport system with the primary purpose to speed the passenger movements within the region (agglomeration) mobility;

3) a system of external transport that provides links between the regions of the country, international and interregional mobility.

The scope of this PhD research is the urban transport system and primary goal to analyse - how the URTS provide access between residents and traveller.

The United Nations Economic Commission (2015) defines that the UTS should lead to enhanced mobility and generate more significant equity between citizen groups.

As defined in the Eltis platform – Portal (2003) – the urban transport takes place within the borders of a city or a conurbation and in all belt around it with travel distances of up to 20km. Usual travel distance by PT between 5 and 8 km and a travel time of up to 0.5h (larger values may be valid for big metropolises and conurbations).

All components of the UTS need to interact with each other. It is strongly recommended to coordinate the collaboration between them on the one hand. Rodrigue (2017) concludes that urban productivity highly depends on the efficiency of its transport system to move labour, consumers and freight between multiple origins and destinations. He categorises urban transportation by three boards of the collective (public transport), private and freight transportation (Rodrigue, 2017).

The classification of the urban transport system, presented in Figure 1.5, defines that the UTS consist of passenger transport, freight transport and special transport. The research limitations define to analyse public transport influence into UTS.

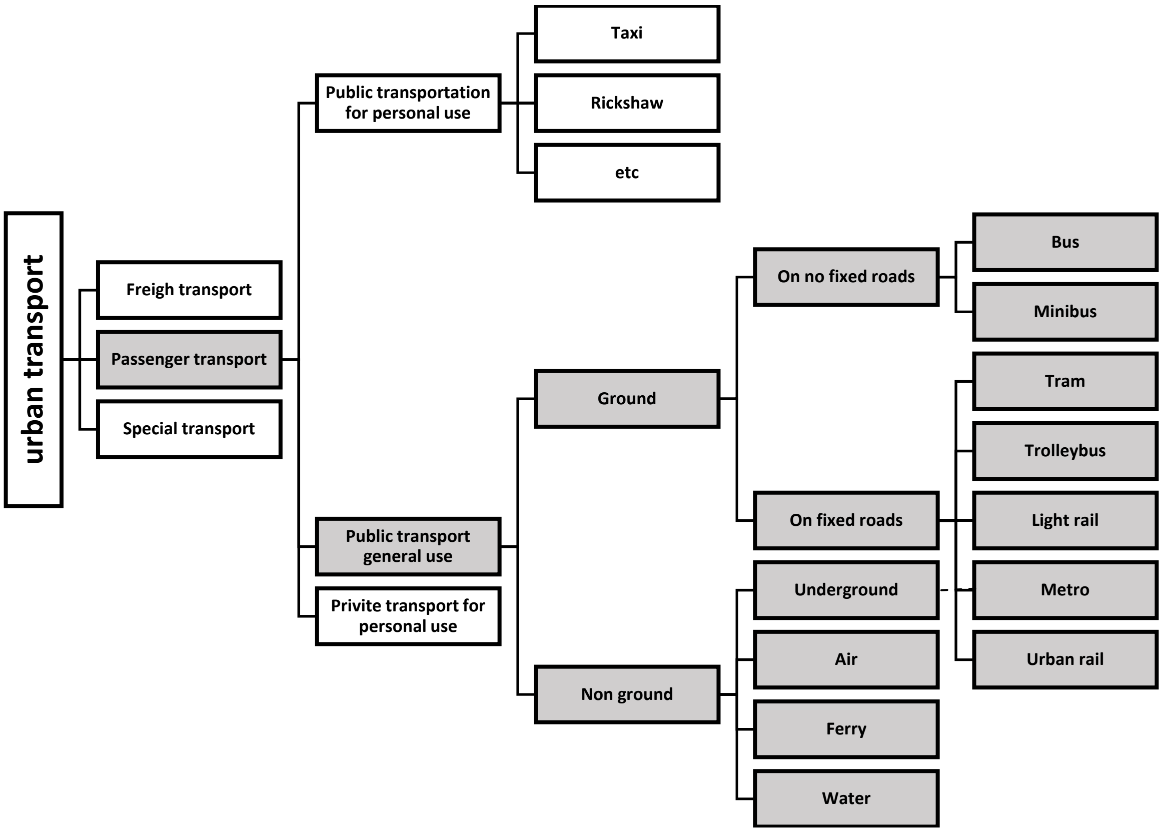


Figure 1.5. Urban transport classification (Pticina, 2015)

Passenger transportation or public transport takes the central part of the transport system. It includes public transport for personal use, public transport general use and private transport for personal use. Regarding the thesis “the public transport general use” will be analysed.

Public transport (PT) (also known as public transportation, public transit, or mass transit) is the transportation of the group of passengers their incidental baggage over long or short distances, within or between urban areas, usually, managed on a schedule, operated on established routes, and that charge a posted fee for each trip (Collins English Dictionary; English Oxford Living Dictionaries; Schofer Joseph, 2018). These services are providing travellers with updated information about routes, departure times, possible disturbances, and connecting services. Urban transport is often referred to as PT – a set of services that provide for the transport of passengers in or between cities at a fixed cost. Cities usually have their integrated transport systems; often, UPT is also provided in the suburban area.

PT is an essential component of the state infrastructure, and the development of many other industries and territories depends on it. It is also one of the elements of social security in a country, region or local levels. The PT includes city buses, trolleybuses, trams (or light rail), passenger trains, rapid transit (metro/subway/underground, etc.) and ferries. PT services between cities provided by airlines, coaches, and intercity rail.

The main tasks of PT as a component of public infrastructure are to meet the current demand for transport, to provide access to populated areas and the opportunities for mobility within it. According to Rodrigue (2017), the PT provides publicly accessible mobility over specific parts of a city.

Most PT systems use the fixed routes with the set of stops with a prearranged timetable, with the most frequent services running to a headway. However, most PT trips include other modes of travel, such as passengers walking or catching bus services to access train stations (McLeod Sam, 2017). Share taxis offer on-demand services in many parts of the world, which may compete with fixed public transport lines, or compliment them, by bringing passengers to interchanges (publictransportaion.org, 2018).

Additionally, the primary system can be supplemented by auxiliary ones that use the rolling stock of small capacity, the so-called Paratransit. Various kinds of calling technologies and flexible routes use for this service's implementation, which allows providing transport services for various specific objects and people groups (Vlasov D.N., 2017). Paratransit sometimes uses in areas with low demand and for people who need a door-to-door service (publictransportaion.org, 2018).

PT plays an essential role in the European Union (EU) because approximately 60 billion public transport passenger journeys per year are carried out with local and regional buses, suburban rail transport, metros, trams, and waterborne transport services. The economic value of PT services in Europe is estimated to range around 150–200 billion € per year, with growing relevance (ALLIANCE project, 2018).

1.3. Sustainable transport system

The sustainable transportation system (STS) development starts with the public space organisation. The primary objective is to reduce the demand for transportation according to the number of trips and the length of travel distance. The United Nations Economic and Social Commission organisation (ESCAP) of urban space helps to minimise the distances that people are travelling to obtain goods and services (ESCAP, 2012). The STS requires the provision of a different, integrated and balanced public transportation services. The different groups of passengers have different transportation needs depending on the distances they need to travel, their trip purpose, income, age, gender and physical ability (ESCAP, 2012).

The STS should ensure the efficient use of scarce resources. It is achieved by promoting fuel-efficient and green vehicles, car sharing, and encouraging the use of non-motorized transportation. By promoting public transportation and non-motorized transportation, the transportation system is made more efficient for both the providers and the users. As fewer people use personal vehicles, the lower is the level of traffic congestion and demand for new roadways (ESCAP, 2012).

The significant benefits of the STS are to optimise the use of scarce resources, reducing traffic congestion and air pollution. Everyone needs to have access to affordable transportation for improving health, to get an education and social empowerment. It is a mode that everyone can get to work at a place of people choices. The STS may also work as a catalyst in the development process. As ESCAP (2012) defined, a city with the STS can easily attract new businesses and other activities.

The STS theme is central in many projects that are carried out within the framework of the European and other international scientific programs: BEST – Benchmarking European Sustainable Transport (2000-2003), STELLA – Sustainable Transport in Europe, and Links and Liaisons with America (2001-2005), TRUST – Trade Union Vision on Sustainable Transport Project (2006-2008), ECR Sustainable Transport Project (2008), SEGMENT – SEGmented Marketing for Energy-efficient Transport (2010-2013), ENDURANCE European network (2015), SUMBA – sustainable urban mobility and commuting in Baltic cities (2017) and others.

The theme of STS is also researched in the scientific field. Researchers, such as Jeon and Amekudzi (2005), Boschmanna and Kwana (2008), Enoch (2012), Maya (2013), Lama and Sumaleea (2013), Gössling (2014), Lia et al. (2014) and others, work in the theoretical studies in the area of Sustainable transport and transportation development.

Sustainable transportation can be defined, as Rodrigue (2017) suggested, as the capacity to support the mobility needs of people, freight and information in a manner that is the least damageable to the environment (Figure 1.6).

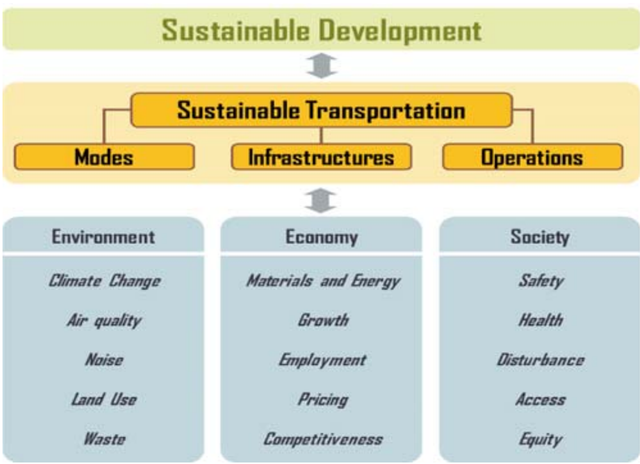


Figure 1.6. Sustainable transportation (Rodrigue, 2017)

Some of the more useful definitions of STS are compiled in Table 1.2. They all refer that sustainable transport should be environmentally friendly, affordable, and safe and consider the needs of the population, the direct users of transport. The development of the STS should be considered in the long run as well.

Table 1.2. Definition of the sustainable transportation system

Definition	**Sources**
…is Transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes	(OECD, 1998)
The goal - is to ensure that environmental, social and economic considerations are factored into decisions affecting transportation activity	Moving on sustainable transportation (MOST, 1999)
… is one in which fuel consumption, vehicle emissions, safety, congestion, and social and economic access are of such levels that they can be sustained into the indefinite future without causing tremendous or irreparable harm to future generations of people throughout the world	(Richardson, 1999)
… is one that is accessible, safe, environmentally-friendly, and affordable	European conference of ministries of transport (ECMT, 2004)
Allows the primary access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health and promotes equity within and between successive generations. Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development. Limits emissions and waste within the planet's ability to absorb them uses renewable resources at or below their rates of generation and uses non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise.	European Union Council of ministries of transport (CST, 2005)

A sustainable urban transport system (SUTS) requires the strengthening of various features of the system, including accessibility and mobility, reliability and efficiency, as well as safety and security, social equity, convenience and comfort. It should be people- and environmental-friendly. The SUTS is more attractive for commuters and more economically viable for operators if they offer the option to travel from one point of the city to another. The structure of SUTS represented in Figure 1.7, where all areas that it encompasses are shown.

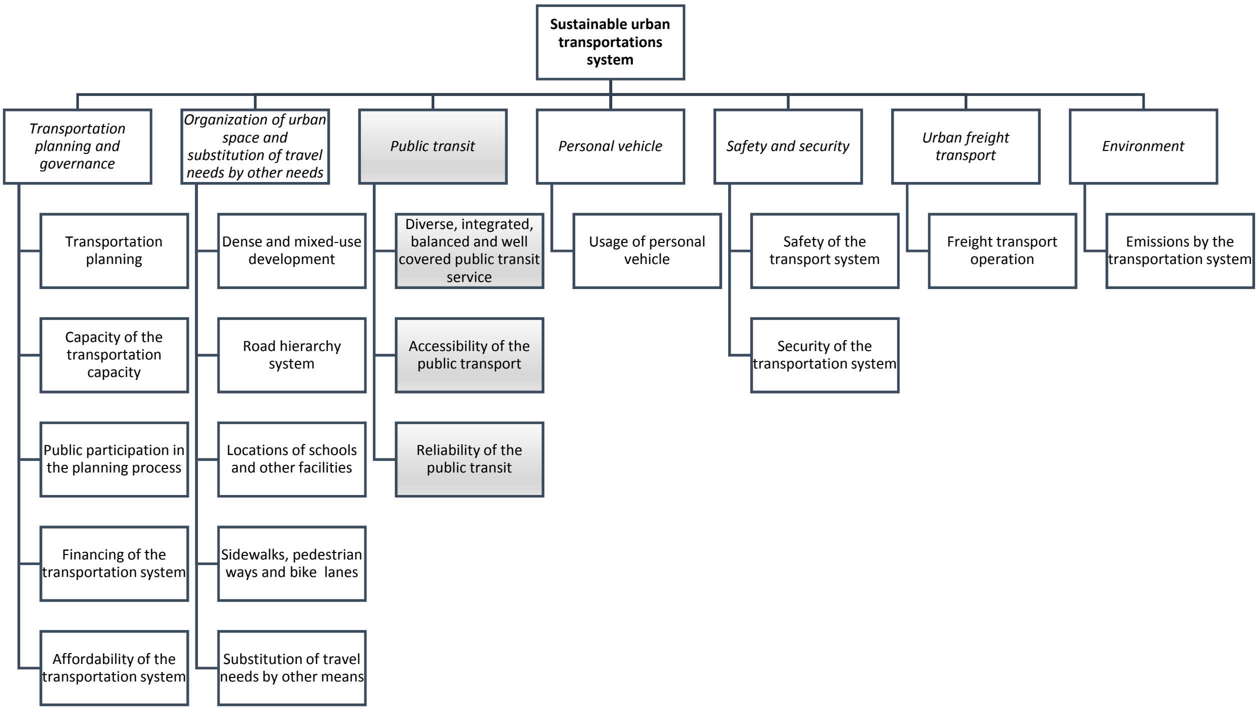


Figure 1.7. Areas and Subareas of Sustainable Urban Transportation System (UN ESCAP, 2012)

The United Nations Economic and Social Commission (UN ESCAP, 2012) defines the objectives and measures for STS that are represented in Table 1.3.

Table 1.3. STS objectives and measures (UN ESCAP, 2012)

STS the primary objectives	**STS measures**
Reduce the travel demand, mainly by motorised modes by reducing the number of trips and trip lengths	The organisation of urban space – land use planning and finding a better solution to meet the needs through action in other areas
Greater use of genuinely sustainable modes (i.e. walking and other non-motorized transport)	Making services and opportunities accessible by walking and non-motorized transport
Efficient use of existing systems and reducing the use of all resources – natural, physical and financial	Development of a balanced, integrated transport system that ensures efficient travel using multiple modes

Increasing energy efficiency and emission standards of motorised vehicles	Technological standards (vehicle, fuel, emission etc.) Improvement in the efficiency of urban freight logistics through the organisation of freight distribution and delivery facilities and services

For STS analysis, it is important to define and evaluate the respective indicators. Sdoukopoulos et al. in (2019) calculate and consolidate the sustainable transport indicators (in total 47) considered in Table 1.4..

The indicators are divided into three sustainability pillars as represented in Figure 1.1. 63.8% of all indicators are related to one of the three pillars. The environment is represented by 15 indicators, Society – by 8 and Economy – by 7. However, nine indicators included in all three spheres such as Urban planning and land-uses, Integrated planning, Non-motorised modes, Mobility, Public transport, Infrastructure, Multimodality, Transport external costs and Parking – moreover, Liveable public space & amenities and Fragmentation involved in Society and Environment. Society and Economic bring together such indicators as Demographics and socio-economic characteristics, Affordability, Commuting, Traffic congestion. Also, Economy and Environment combined the New smart&green technologies and Vehicles fleet. The authors suggested that environment includes a slightly higher number of indicators as a society and far more significant when it is compared to the economy. Table 1.4. results represent that, by experts' suggestion and ten indicators ranking scores, the problems are in all sectors: Environment, Society and Economics. The ranking of indicators for Riga city was not analysed in this research; it could be the next step of the sustainability

United Nations economic commission for Europe (UNECE) in (2015) defined that public transport is a central component of SUTS (Figure 1.8). The Urban public transport system (UPTS) should lead to enhanced mobility and generate more significant equity between citizen groups. To achieve all these aspects, various challenges must be solved, and one of the most important is the ability to measure all these features of the system. The primary goals of the SUPT are to provide:

- diverse, integrated, balanced and well covered public transit services;
- accessibility of public transport;
- reliability of public transport.

Table 1.4. The sustainable transport indicator (Sdoukopoulos et al., 2019)

	Sustainable transportation			
	Indicators	**Environment**	**Society**	**Economic**
1.	Health impacts		x	
2.	Cultural aspects		x	
3.	Trips to/from school		x	
4.	Accessibility		x	
5.	Safety		x	
6.	Security		x	
7.	Active citizens		x	
8.	Social equity		x	
9.	Economic productivity			x
10.	Contribution to economy and development			x
11.	Freight transport			x
12.	Transport efficiency			x
13.	Public expenditures, investments and subsidies in transport system			x
14.	Institutional aspects			x
15.	Transport cost and prices			x
16.	Air pollutant emissions	x		
17.	Air quality	x		
18.	Water Run-off	x		
19.	Energy efficiency	x		
20.	GHG emissions	x		
21.	Fossil fuel energy consumption	x		
22.	Impacts to sites of historical and architectural importance	x		
23.	Renewable and alternative fuels	x		
24.	Impacts on habitats	x		
25.	Waste	x		
26.	Traffic noise	x		
27.	Resource use	x		
28.	Land consumption	x		
29.	Recycling	x		
30.	Hazardous materials and environmental damages	x		
31.	Liveable public space and amenities	x	x	
32.	Fragmentation	x	x	
33.	New, smart and green technologies	x		x
34.	Vehicles fleet	x		x
35.	Traffic congestion		x	x
36.	Commuting		x	x
37.	Affordability		x	x
38.	Demographic and socio-economic characteristics		x	x
39.	Non-motorised modes	x	x	x
40.	Urban planning and land-use	x	x	x
41.	Integrated planning	x	x	x
42.	Mobility	x	x	x
43.	Public transport	x	x	x
44.	Infrastructure	x	x	x
45.	Parking	x	x	x
46.	Multimodality	x	x	x
47.	Transport external costs	x	x	x

As presented in Figure 1.8, the SUTS consists of the Input, Infrastructure and services, and Output parts. The Infrastructure includes the PT as a consolidation of the tram, buses, metro with the interconnection with cycling and taxi.

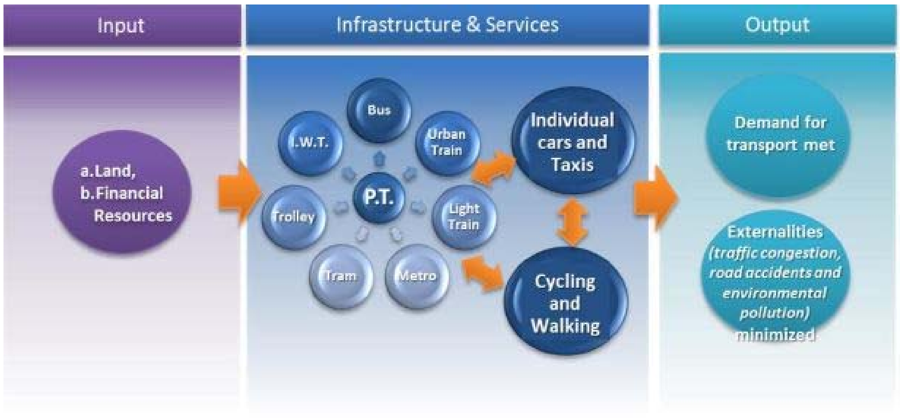


Figure 1.8. Sustainable urban transport system (UNECE, 2015)

The UPTS is more attractive for commuters and more economically viable for operators if they offer the option to travel from one point of the city to another.

Verseckiene et al. (2015) suggested that sustainable development of PT requires a complex assessment of various factors and frequently, improvement of one factor may cause the deterioration of the other. On the other hand, improvement of one factor may cause the improvement of all the system. Also, she suggested that the solution for making PT sustainable should be a fully balanced system of measures.

The integration of land-use planning and transport planning is as the keystone of a sustainable transport planning (Banister, 2008; Cervero, 2009; Van Wee, 2013). As Litman (2014) mentioned, transport planners have started to apply Level-of-Service ratings to walking, cycling and public transit, and to consider demand management strategies as alternatives to roadway capacity expansion.

Including the transport sustainability issues in the planning process seems to be the mandatory requirement for strategic transport planning (Te Brömmelstroet M., Bertolini L., 2009). Various authorities in different institutional settings are usually responsible for transport infrastructure and spatial development. In infrastructure planning, government agencies usually are responsible for only a specific infrastructure mode, such as road, water, rail and develop often projects with limited scope. They focus on solving a particular problem and applying a minimalistic approach oriented on formal requirements for public consultation. Spatial planning authorities often pay too little attention to the accessibility effects of their plans.

Kenworthy (2006) discussed planning, and decision making for sustainable cities and set out ten critical responses to the challenge of changing the nature of urban development to a more ecological, sustainable model, which suggests that sustainable urban form and transport are at the core of developing an eco-city. The author suggested that the main one from ten key dimensions of four critical “Sustainable Urban Form and Transport” factors is “decision-making process which should be sustainability-based, integrating social, economic, environmental and cultural considerations as well as compact, transit-oriented urban form principles”.

1.4. Sustainable urban mobility planning

Sustainable urban transport system planning is a matter of concern to city officials, institutions and researchers. Also, as noted in Valdes & Monzon (2016) among the various communications and initiatives launched by the European Commission (EC), it is particularly worth highlighting the Thematic Strategy on the Urban Environment adapted in 2006 (EC, 2005). Strategy strongly recommends the development and implementation of Sustainable Urban Transport Plans (SUTP) for cities of over 100,000 inhabitants. The EC (European Commission, 2007) defines a SUTP as a combination of urban mobility management measures that cover all modes and forms of transport in a relevant geographical area.

A mobility plan is a way to reach a more energetically efficient and less pollutant transport system by implementing integrated measures (WHO, 2011). The aim is to promote the use of different modes of transport is trying to avoid the increase of traffic in urban areas. The area of matter in a mobility plan is more significant than in an ordinary traffic plan. It affects all the mobility within all its aspects, and one of the main aims is to make the citizens conscious about the necessity of more rational use of the transport system (Mattsson, 2006). The cooperation with the citizens is essential in order to make the plan work and obtain the effects wanted.

However, for sustainable development, the sustainable urban mobility plan (SUMP) is needed. The definition of the SUMP comes from European Commission (2013) and sounds as *“A Sustainable Urban Mobility Plan has as its central goal improving the accessibility of urban areas and providing high-quality and sustainable mobility and transport to, through and within the urban area. It regards the needs of the 'functioning city' and its hinterland rather than a municipal administrative region.”* This plan integrates the ideas and activities from SUTP.

Figure 1.9. Sustainable urban mobility plan (ELTIS, 2016)

The SUMP structure consists of the 11 main themes and is presented in Figure 1.9. The glossary of the platform ELTIS (2016) gives the following definition of the SUMP – a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. It is built on existing planning practices and takes due consideration of integration, participation, and evaluation principles. A common challenge for planners in local administrations is to convince decision-makers of the added value of a Sustainable Urban Mobility Plan. The ten main arguments for SUMP preparing are follows (ELTIS, 2016): (1) Improving the quality of life; (2) Saving costs - creating economic benefits; (3) Contributing to better health and environment; (4) Making mobility seamless and improving access; (5) Making more effective use of limited resources; (6) Winning public support; (7) Preparing better plans; (8) Fulfilling legal obligations effectively; (9) Using synergies, increasing relevance; (10) Moving towards a new mobility culture.

Sustainable urban development includes the sustainable development of the transport system. Therefore, mobility is an integral part of the development of the entire city.

The platform ELTIS (2016) defines mobility as the potential for movement and the ability to get from one place to another using one or more modes of transport to meet daily needs. Mobility focuses on the satisfaction of needs, while transport (including vehicles, infrastructure and traffic rules) is the instrument which is required for the concrete realisation of mobility. Mobility is a direct result of social activities such as living, working, relaxing and production, trade and consumption (for goods). Due to the spatial separation of activities, the demand for transport services arises. The type of transport services chosen to meet this need for mobility is the result of a political process. In the context of SUMP, the term mobility can be interpreted as the ideal scenario wherein all citizens have environmentally sound, convenient, fast, comfortable and affordable modes of transport, helping to improve accessibility across the functioning area of a city.

One of the sustainable transportation goals that are defined by the European Union is to increase the citizen's mobility regarding multimodality. Multimodality is the possibility for the passenger during one trip to use more than one transport modes, for example, car-PT, bike-PT-walking etc.

Multimodality is an essential term in the SUMP context as it represents a modern intelligent approach to mobility, contrasting with the use of private motor vehicles for the majority of trips.

Multimodality, according to (Handy, 2002) refers to the selection of alternative transport modes for different trips over a specified period (e.g. a day or week). Multimodality (and also intermodality) requires the integration of infrastructure and transport services across modes in both passenger and freight transport.

The SUMP should foster multimodality by creating highly accessible, convenient, safe and fast connections for sustainable modes of transport.

Litman (2014) suggested that multimodal transportation planning is complicated because modes differ in various ways, including their availability, speed, density, costs, limitations, and most appropriate uses. He provides the following recommendations for multimodal transportation planning:

- Multimodal transportation planning should have integrated institutions, networks, stations, user information, and fare payment systems.
- Consider a variety of transportation improvement options, including improvements to various modes, and mobility management strategies such as pricing reforms and smart growth land-use policies. Take into consideration various combinations of these options, such as public transport improvements plus supportive mobility management strategies.
- Consider all significant impacts (including long-term, indirect and non-market impacts) such as equity and land-use changes should at least include: congestion, roadway costs; parking costs; consumer costs; traffic accidents; quality of access for non-drivers; energy consumption pollution emission; equity impacts; physical fitness and health; land use development impacts; community; liveability.
- Impacts that cannot be quantified and monetised (measured in monetary values) should be

described.

- Multi-modal comparisons should be comprehensive and marginal and take account of factors such as transit system economies of scale and scope.
- Special consideration should be given to transport system connectivity, particularly connections between modes, such as the quality of pedestrian and cycling access to transit stops and stations.
- Special consideration should be given to the quality of mobility options available to people who are physically or economically disadvantaged, taking into account universal design (the ability of transport systems to accommodate people with special needs such as wheelchair users and people with wheeled luggage) and affordability.
- Indicate impacts concerning strategic objectives, such as long-range land use and economic development.
- Use comprehensive transportation models that consider multiple modes, generated traffic impacts (the additional vehicle traffic caused by the expansion of congested roadways), and the effects of various mobility management strategies such as price changes, public transit service quality improvements and land-use changes.
- People involved in transportation decision-making (public officials, planning professionals and community members) should live without using a personal automobile for at least two typical weeks each year that involve normal travel activities (commuting, shopping, social events, etc.) to experience the non-automobile transportation system (Litman, 2014).

The critical bone of multimodality is the interchange, and multimodal transport helps to provide the carriage of passengers or freight, or both, using two or more modes of transport.

On the other hand, multimodal transportation is a kind of integrated operation process, it is a combination of modern organisation modes and a single transportation mode, and it has essential improving transportation service quality by researching the decision of multimodal transportation scheme in the process of transportation.

Multimodal transportation uses the optimal efficiency as a goal and is defined as the complete transportation process, using at least two modes of transport to create connection and transport together and, of course, a critical role played by transport interchanges (hubs).

1.5. The role of interchange in the urban transport system

Urban transport interchanges play a crucial role in urban transport networks since they allow different modes to be used in an integrated manner within the public transport chain. In this context, identifying and monitoring users' requirements is of particular importance to achieving the most appropriate policy measures for public transport interchanges, because they are particularly affected by the quality of service (City-HUB Project, 2015).

The UTS consists of two types of interchanges: freight and passenger. They have a different kind of services and functions. The subject of research is the analysis of the PT interchange.

Let us define the term "interchange". Some researchers use the term node, hub, transport point and others. What is the difference between node, interchange and the transportation hub? Javier Aldecoa suggested that "*many people misuse the definition of an interchange. I always define in the same way, but some people prefer to refer to a single transport node as an interchange (maybe they do not have good examples)*". Pitsiava-Latinopoulou et al. (2012) define that the interchange is to ensure integrated and efficient transport of passengers between different transportation modes and between several routes. Union guidelines for the development of the trans-European transport network (Regulation 1315/2013) defines the interchange as an urban node, which is an urban area where the transport infrastructure of the trans-European transport network, such as ports including passenger terminals, airports, railway stations, logistic platforms and freight terminals located in and around an urban area. Interchange is connected with other parts of that infrastructure and with the infrastructure for regional and local traffic.

City-HUB (2015) noted – that the interchange plays a primary role in the city as a node where some transport activities are concentrated: transfers between different transport modes or different services of the same mode of transport.

Rodrigue (2017) defines that the node – "*is the value of the network is proportional to the square of connected nodes*." Aldecoa gives (ALLIANCE project, 2018) the following definition: an interchange is a place where you can transfer from one transport mode to another one with certain conditions of accessibility, safety, information, transfer and quality. The other definitions say that a transport hub (also transport interchange) is a place where passengers and cargo are exchanged between vehicles or between transport modes with a minimum of transfer time, which include train stations, rapid transit stations, bus stops, tram stops, airports and ferry slips (Wikipedia, 2018). MoTiv project (2018) used the term that the interchange is a transfer between trip legs takes place at transfer locations, which can consist of any interchanges: bus stops, bus and train stations, car- or bike-share parking, hubs, airports and others: transfer locations and interchanges used as synonyms. Interconnectivity refers to the ease of connecting between transport modes at transfer locations, which enables multimodal travel.

After the terminology analysis, the following definitions were suggested to use:

- node – access point in the network;
- interchange – the place where the passenger can transfer between deferent transport modes

(more than two) with services;

- hub – the interchange between different transport modes with services and in the different regional level (local transportation, regional transportation and international). This term is usually used for large airport, railway and maritime port classification.

The NODES project's (2016) overall objective was to build a toolbox to help cities in the design and operation of upgraded/new urban interchanges, as a way to provide more significant support, services and satisfaction to the travellers, users, interchange operators, and to social and economic actors that depend on the efficiency of interchange operations. A set of criteria and performance indicators of interchange were developed in this project. The general objectives based on the triangle of stakeholders' goals (financial, environmental and social) are the following:

1. Financial: to enhance accessibility and integration; intermodality and liveability;
2. Environmental: to increase safety and security conditions; economic viability and costs efficiency; environmental and energy efficiency;
3. Social: to stimulate the local economy.

The general objectives can be translated in needs of the interchange stakeholders, suggested Hoeverna et al. (2014), more specific individual customers of the public transport, the citizens that benefit from a well-functioning PT and its interchanges. A common platform for the integration of different interests should be to make the multimodal transportation more attractive, in the requirement of the planning process to optimise the transfer and waiting time.

Pitsiava-Latinopoulou et al. (2012) suggested that urban transport interchange should:

1. provide a reliable and adequate level of the direct services offered, such as information and ticketing;
2. develop adequate facilities serving the transfer in service areas and waiting areas/platforms, through offering amenities, Internet access, comfort, and others;
3. provide adequate access to the site for all users (especially the disabled);
4. afford assistance to travellers with navigating aids, so that they can find their way from where they are to where they wish to go, both within the interchange, as well as to and from the local vicinity (way-finding);
5. offer smooth and seamless navigation and movement of users, also improving their understanding, enjoyment and experience (legibility);
6. allow users to move around the interchange under several alternatives, providing at the same time clear connections to existing routes, facilities and services (permeability).

The sustainability aspects of transport interchanges usually focus on environmentally friendly services and infrastructure. Sintropher (2012) includes sustainability among the three main criteria for evaluating urban interchanges. Apart from sustainability, integration and technical design are the main components to be analysed. Edwards (2011) considers transport interchange design as an urban realm component. According to his view, social sustainability is related to sustainable modes of transport. It is generally accepted that an appropriate interchange design has to consider all modes of transport, especially soft modes (i.e. cycling and walking) (Taylor and Mahmassani, 1996, Tsami et al. 2013a and 2013b).

Three elements which defined during the City-HUB project (2015), are used for investigation how the urban interchanges linked to urban and spatial planning:

1. governance, which incorporates the identification of the stakeholders (decision-makers and providers) and users (travellers and visitors), and the definition of their roles, needs and methods for developing a cooperative scheme for coherent decision making;
2. services, which are related to the physical design, the transportation modes, the information provision at the interchange, as well as to the visitors' facilitation while staying at the interchange;
3. user needs and expectations in the interchange design and operation. These needs and expectations are usually addressed through the survey assessing users' perception of service quality.

Nathanail et al. (2017) contribute to the definition of these three elements of seamless urban interchanges (Figure 1.10). As the upper layers of a pyramid, the base of which is the urban and spatial planning, which provides and foundation and strong support to the development and operation of these facilities.

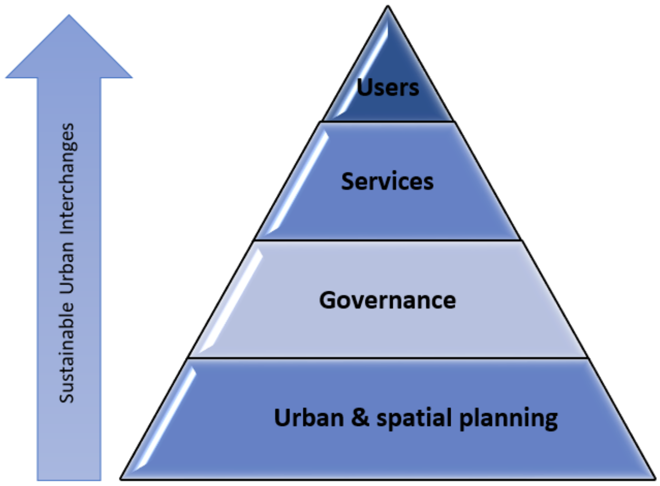


Figure 1.10. The pyramid of urban interchange elements (Nathanail et al., 2017)

The scheme of the involved stakeholders in the urban transport system decision-making process is represented in

Figure 1.11. Passengers who are the primary users of the service and operators who provide these services; as well as those who make decisions create laws and regulations for the use of public transport.

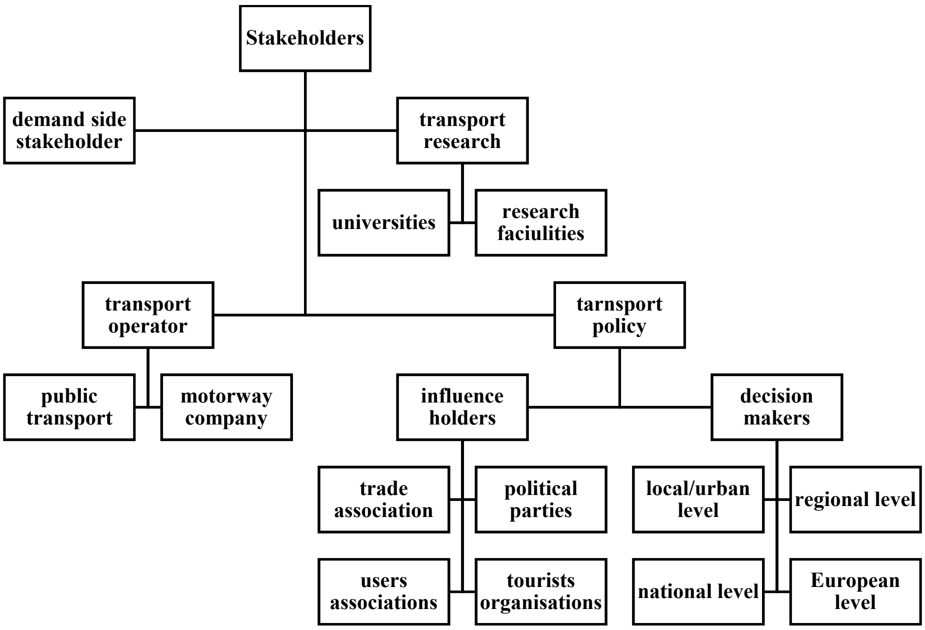


Figure 1.11. Urban transport system stakeholders (City-HUB Project, 2015)

Integrated land use and infrastructure planning are a very challenging task. Land use-transport integration is a long-standing mantra for planning policies and proven to be difficult in practice. Figure 1.12 represents and explains the interchange functionality.

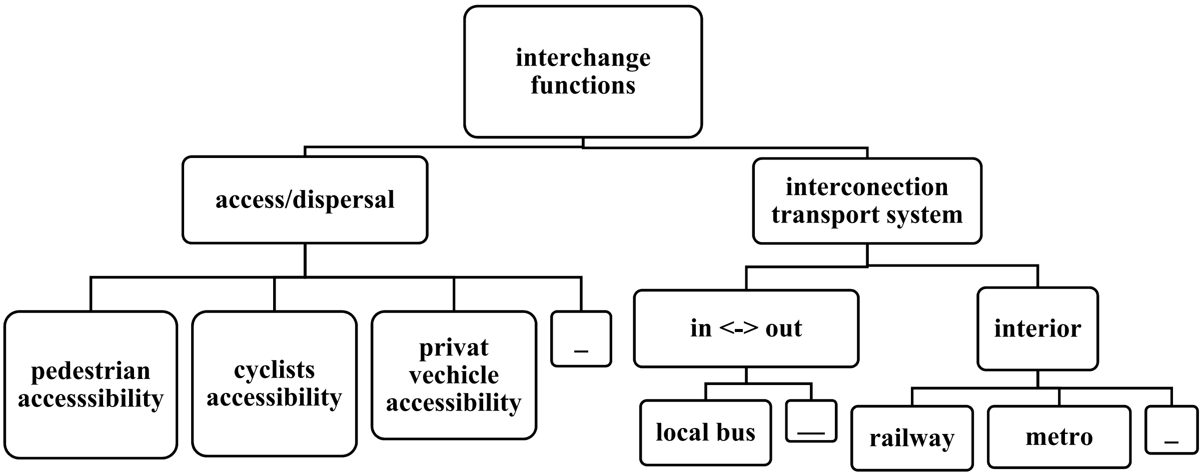


Figure 1.12. Interchange functions and urban environment (Lamiquiz Patxi et al., 2014)

Table 1.5 compile the six goals of the interchanges as an urban space with type describing by Lamiquiz Patxi et al. (2014).

Table 1.5. Interchange as an urban space (Lamiquiz Patxi et al. (2014))

Goals	Tips
1. Multiple uses, both regarding activities and flows	Locate stations as closes as possible to existing/new urban facilities and attractions
2. Plentiful opportunities for the interaction between the life inside and outside buildings	Ex: the opening of a direct entrance to the significant attraction, the connection between stations and public squares or waterfronts…
3. High visibility and presence of people at all times	Consider the station and its surroundings as one single public space (visual + physical connections, but also regarding details and materials)
4. Enough legible points of access to an exchange between different foci of activity	Ex: Bring the metro entrance as close as possible to the main local existing activity centre (even when it means extra-tunnelling). Consider the inside of the interchange as a public space in its own right.
5. In internal structure favouring the overlap of mobility flows in space and time	Provide many opportunities for the overlap of mobility flows: more targeted flows, accessing the metro system below ground or the urban facilities above ground + more casual flows, including passers-by
6. Links with the wider surroundings	Connect pedestrian/cycling channels in the station with pedestrian/cycling channels in the neighbourhood

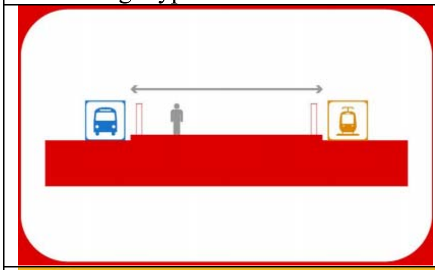
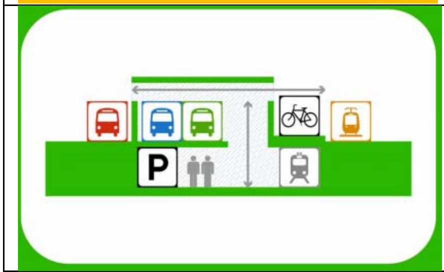
The interest in the transport interchanges environment built consists of three main concepts:

1. as an influence area, place of the origin/destination (land use);
2. as a set of channels for access and dispersal (networks);
3. as the space of the direct interface, the immediate surrounding space between the interchange and its urban environment where in-out inter-connections take place (space).

Adamos et al. (ALLIANCE project, 2018) explain that transport interchanges play a crucial role in urban development, facilitating links between different modes, routes and destinations. He characterises the interchange by its position in the transport network: the surrounding urban environment; the integration of different modes; the legislative framework that is in force. Also, the authors mentioned the primary functions of interchange such as coordination and management; accessibility to all; quality to the traveller; safety. Moreover, provide the idea that for interchange design, the transport system needs to be: seamless, smart, clean, safe and accessible for all users.

There is not the only definition of transport interchanges in literature, the author has reviewed them and suggests the typology and the characteristics that were advised and discussed with the plenary speaker in Summer School in the frame of ALLIANCE project J. Aldecoa in Table 1.6. (ALLIANCE project, 2018).

Table 1.6. Classification: Interchange typologies (ALLIANCE project, 2018)

Interchange type	Urban topology	Description
	Connecting point	The node of the public transport network which is subject to analysis and monitoring due to its considerable demand between different transport lines
	Intermodal area	The area at a suitable connection point between different public transport network modes urban and metropolitan, urbanised to improve modal interchange efficiently in safety and accessibility
	Interchange	Building located on a strategic "connection point" between different public transport networks of modes; both urban and metropolitan as well as long distance. It needs to improve modal interchange efficiently in safety accessibility and quality.
	Large-size Interchange	Public transport interchanges with a demand superior to 150.000 passengers/day
	Long-distance Interchange	Group of buildings necessary to allow the operation of the different transport modes which converge in a long-distance station (airport, train or bus station)

The typology depends on presented modes in the transporting area. It is also important to take into account the spatial levels of the interchange typology.

For sustainable urban interchange development, the indicators need to be considered and implemented (Table 1.7).

Table 1.7. Sustainable interchange indicators characteristics and its description (ALLIANCE project, 2018)

Interchange indicators	Characteristics	Description
Users & location indicators	User needs	• Citizens using the interchange need a secure and safe environment • The interchanges design need to be completely accessible and without transfer assistance • The interchange has to be clean, well-maintained, protected against weather, with architectural quality and attractive • Short transfers, legibility, the permeability of spaces, enabling way-finding and navigation need to be organised • Information simple and help network legibility in different accessible formats • Intermodal operations flexible, Smart and with ticketing integration • Adapting management and business models to each interchange is necessary
	Urban network	The planning and development of urban public transport network need to be considered
	Catchment area	The interchange does not only serve the urban network, but it also serves an area where people come or go on foot or use other modes to get to and from the station It is also important to sign the interchange as a “transfer point.”
	Development area	Within the catchment area, it should be attractive for businesses, offices, and households to locate themselves near the interchange
	Interchange area	It becomes necessary to define the area of influence that could facilitate the transfers between all modes of transportation
	Interchange building	The interchange building has to be a meeting point for the district area
	Modes and operators	We have to take into account all the different transport modes to include all of them in the same infrastructure with the same quality and image
Demand indicators	Total transportation and modes demand	Demand is the primary indicator of a transport facility’s performance and usefulness and, therefore, justifies the public economic investment
	Potential users	When people’s mobility rights are considered, an important indicator may be the population covered by the transport facility. This population value can be calculated by metric reach (population within the immediate urban surroundings of the transport facility)…
	Covered population	… or by travel time reach (population within the metropolitan hinterland of the transport facility)
Network indicators	Closeness: average travel time	Closeness centrality measures how neighbouring a node is to all the other nodes along the shortest paths using travel time. It described the ease of movement along with the public transport network and synthesised, regarding speed and service frequency. It is calculated as the average necessary time to reach any other node
	Betweenness: number of times integrating optimal routes	Betweenness centrality (through-movement potential): is another network measure that identifies the transport nodes that will be traversed the most by journeys between different pairs of nodes after all potential journey combinations are considered. It captures the geographical distribution of public transport flows between each pair of nodes across the network

	Straightness: average necessary transfers	Straightness centrality (or 'degree centrality', as described in Curtis (2010), describes the directness of journeys along with the public transport network, focusing on the number of transfers. It is a topological network indicator, measuring the average minimum number of transfers between the interchange and any other node
Mobility integration indicators	Accessibility by Private Vehicle	defined as the inverse of the mode distance from the interchange to all other nodes. Cost=time, assuming the mode speed of each road
	Accessibility by Public Transport	defined as the inverse of the mode distance to all other stations. Cost=time
	quality-pedestrian or cycle networks	Integrated with the interchange location; near, but not directly related; not even near
Urban integration indicators	Axial Local Integration	It is crucial for an interchange to be integrated into the urban environment. Some configurational analyses help to find optimal places both at a city and local scales. They relate to the natural pedestrian flows in the city, citizens ability to remember locations and finding its way easily and naturally
	Visual Integration (Isovists) at a close-up level	According to Space Syntax terminology, Interchanges must be located in areas of high integration values ("integration core"), both global and local. Global integration relates to the need of all citizens to know where primary transport nodes are located within a general structure of the city

As mentioned in (UITP, 2009), the interchange needs to bring the added value. Around the stations or nodes, it is interesting to develop offices, retail stores and hotels. A dense, compact, mixed-use, pedestrian-oriented development with the right street and sidewalk connectivity will increase the likelihood of attracting public transport passengers (UITP, 2009). This activity helps people to be able to get to all important destinations either on public transport or by walking and cycling. The NODES project results (Project NODES, 2016) revealed that regional growth strategies must ensure that significant new trip generators (employment, schools and universities, and shopping centres) located near public transport.

Regarding the link between multimodal interchanges and their impacts on land use, Benister & Berechman (2001) proposed that it cannot be direct if there is not a robust integrated development plan associated to the policymakers' involvement. Some cities have the right business model based on public-private partnership (PPP) for developing their transport interchange, for instance, in Cervero & Murakami (2009) there is an example in Hong Kong – to use the selling of land properties to develop the intermodal transit hub.

Researchers now could try to analyse the integrated land-use plans offering new urban facilities and their related value due to the evolution of the transport city-hub Heddebaute & Palmer (2014). There are some research projects during the last years: City-HUB (2015), NODES (2016), CLOSER (2016) (2010) and others, where their spotlight was passenger interchange, city-hub or terminal. As a result, the typologies and guidance, set on best practices were developed and disseminated. City-HUB (2015) aims to make urban interchanges more accessible to all users. The approach is integrated, covering the different aspects of an urban interchange to increase the use of public transport, improve efficiency and propose a new business model.

The interchange should provide intermodality principles (Figure 1.13). Intermodality is the relationship between the all transport mode. It includes the PT, regional and international transport. Rodrigue (2017) defines the intermodality as "*The movements of passengers or freight from an origin to a destination relying on several modes of transportation. Each carrier is issuing its ticket (passengers) or contract (freight).*"

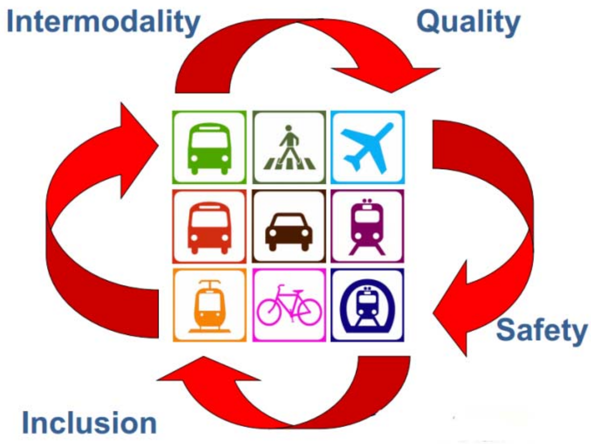


Figure 1.13. Add-on intermodality principle (ALLIANCE project, 2018)

1.6. The public transport quality

The materials of this paragraph presented in European Transport Conference 2018 (10 - 12 October 2018. Dublin Castle, Dublin, Ireland).

Public transport plays a crucial role in intracity trips providing daily services to residents. Well-designed and operated interchanges can improve the quality of public transport services and support seamless door-to-door travelling (City-HUB project, 2013). Nowadays, an interchange is more than just a simple node in a network; it has many elements. In this context, identifying and monitoring users' requirements is significant to achieve the most appropriate policy measures for urban transport interchanges, because they are particularly affected by the provided quality of service. Quality of service is of increasing importance to all businesses, including passenger transportation organisations, and influences customers' satisfaction, passengers' demand, investment decisions and revenues.

Availability of services and provision of adequate capacity are at the forefront of convenience, particularly in large, dense urban areas. High-level measures can include frequency, operating hours, network structure, reliability (ensuring that passengers arrive at their destination on time) and comfort (including crowding).

Developed standards EN13816 (2002) and EN15140 (2006) have defined services, which should be investigated when analysing an interchange. It was developed based on the results of the QUATTRO project (2017), which reflected in the public transport quality matrix (Table 1.8).

According to EN 13816 (2002), the quality of PT system services is a set of quality criteria and appropriate measures for which the service provider (entity claiming compliance) is responsible. The PT quality matrix suggests a general structure for analysing the functional status and technical condition in urban public transport. According to the matrix, the public transport system (PTS) service quality represented by eight components: availability, accessibility, information, time, customer care, comfort, security and the environment. Each component is a set of indicators is describing PTS service quality. The interchange provides comfortable and safe conditions for passengers to stay both inside and outside the facility.

Table 1.8. The public transport quality matrix (QUATTRO, 2017)

Components of PTS quality	**Characteristics of PTS quality components**
1. Availability	– Network – Timetable
2. Accessibility	– External interface – Internal interface – Ticketing
3. Information	– General information – Travel information – normal conditions – Travel information – abnormal conditions
4. Time	– Journey time – Punctuality and reliability
5. Customer care	– Commitment – Customer interface – Staff – Physical assistance – Ticketing options
6. Comfort	– Ambient conditions – Facilities – Ergonomics – Ride comfort
7. Security	– Safety from crime – Safety from accident – Perception of security
8. Environment	– Pollution – Natural resources – Infrastructure

Passenger satisfaction is associated with the perceived discrepancy between actual and ideal levels of service. Therefore, both perceptions and expectations of service are being considered regardless of the management method. Information and fare interfaces are related to the level of service, which represents the quality and cost that are delivered to customers. Also, including concepts such as relations with customers, comfort, cost, flexibility, frequency of services, information delivered, reliability of service, safety and security issues, integration of services and integration of fares/tickets, as well as time use and efficiency in the operations (Monzon, 2016).

1.7. Conclusions

1. The transport system is the most important component of a city, which provides the possibility of relocation of inhabitants and equal rights. Therefore, the development of transport systems is unthinkable without considering its development in the concept of sustainable development.
2. Particular attention should be paid to public transport, which should lead the most important component of TS. Public transport should be comfortable, safe and punctual. The development and promotion of the use of public transport contribute to reducing traffic and improving the environment in the city. The public transport attractiveness can be improving by consideration of all the serving quality aspects.
3. Multimodality and the development of multimodal transportation are a trend in the EU. In order to ensure multimodality, it is necessary to develop interchanges and HUBs.
4. The sustainable urban transport system needs to be evaluated before new development of the infrastructure object and after, for analysis and comparing the leading indicators that need to be defined.
5. The general objectives defined by Hoeverna (2014) can be translated in needs of the interchange stakeholders, more specific individual customers of the public transport, the citizens that benefit from a well-functioning PT and its interchanges. A common platform for the integration of different interests should be to make the multimodal transportation more attractive, in the requirement of the planning process to optimise the transfer and waiting time.
6. Well-designed and operated interchange should improve the quality of transport services and support seamless door-to-door travelling. Moreover, the interchange should be more than the simple node at the network.

2. RIGA URBAN TRANSPORT SYSTEM IN CONTEXT OF SUSTAINABLE DEVELOPMENT

2.1. Public transport development in Latvia and Riga

The body of this paragraph is published in Latvia's National Encyclopaedia (Budiloviča, 2018).

One of the most important social services in Latvia is public transport. The first PT mode a horse omnibus began to run in 1852. The first Latvian self-propelled locomotive was tested on the Hagen manor in Jelgava highway in 1871. In Liepaja, 1885, the first electric tram in the Baltic States started to carry passengers. The electric tram movement in Riga started in 1901, and in 1907 the first public taxi started to work.

In Latvia, the importance of PT is functional, but its potential is not sufficiently exploited and has been decreased in 2008.

The greatest popularity of the PT sector was reached in the 20th century between the 1970s and the 1980s, but since 1990, it began to decline sharply. As a result, passenger transportation by PT in 1993 was five times higher than in 2014.

In the national strategic planning documents, PT has been recognised as an essential part of the country's development and the goals and objectives to be achieved in this sector have been set. In Latvia's Sustainable Development Strategy "Latvia 2030" (LR Saeima, 2010), transport infrastructure and PT are defined as an essential component of spatial development.

One of the main state tasks is to develop rail transport, while at the same time facilitating its connection with other modes of transport, including private ones (by introducing car parks and bicycle huts at transport nodes, bus transport coordinated with rail transport, including in urban traffic and others).

Generally, trams, trolleybuses, buses and suburban trains are used as PT in cities. Public transport outside the city is provided by intercity buses and trains. Sometimes water transport is used as PT.

Waterway services in Riga started in 1853. City passenger ships regularly operated on four lines. Over time, crossing the river was offered by both private entrepreneurs and the Riga City Council, but around 1990, along with the restoration of Latvia's independence, regular shipping along the river Daugava ended when this type of transport was probably lost, and ships owners started to offer tourist tours.

The trolleybus traffic has been organised in Riga since 1947. Since 2008 the trolleybus rolling stock has been gradually upgraded with trolleybuses equipped with diesel generators. Moreover, trolleybuses started to operate on routes where there was no overhead contact line in certain sections or to overcome obstacles (planned street repairs, mass events, icy contact lines, vehicle crashes, etc.). Since 2015, trolleybus traffic is provided by low floor vehicles.

Bus operation initially started in 1924. It is the most popular transport mode in Latvia.

Travelling by public transport is popular in Latvia. According to CSB data, 248.2 million journeys - about 130 times a year per capita was done in 2016. The data shows the increasing of inhabitant mobility.

2.2. Riga urban transport system

The priority of EU policy planning documents is to reduce Member States' greenhouse gases (GHG) emissions by 20% compared to 1990, and particularly in the transport sector, which accounts for 27% of the total emissions of Member States. In order to achieve total GHG emission reductions at Member State level, there is a need for improvements in the transport sector, for example, by more promoting cycling in daily habits National-level policy planning documents conclude that in the transport sector, road transport accounts for 91.3% of total transport GHG emissions, which is 23.9% of total GHG emissions. The priority is to reduce the use of private vehicle usage, primarily by improving the quality and accessibility of public transport, creating a suitable environment and infrastructure for pedestrians and cyclists. Therefore, action should be taken at the national level to promote the availability and development of cycling infrastructure. Regional and local government development documents foresee the development of bicycle routes' and the establishment of parking lots. A significant shortcoming that needs to be addressed is the absence of a regular cycling infrastructure development plan for the agglomerations of Riga and Pieriga, which could hinder the availability of increased mobility in these densely populated areas in the future. Therefore, there should be active at the regional level that promotes interconnection and increases the opportunities for the mobility of citizens.

The transport system planning and development principles conform to national and EU rules. Behind the national level, there are EU-level regulations and documents for the sustainable development of urban transport systems, which are summarised in Table 2.1.

To plan the transport system, the state government uses three spatial levels such as national, regional and local (Figure 2.1). The national-level regulations provide documentation of three spatial scopes: long-term, medium-term and short-term. As for the city, the case study is Riga; there are several regulations and spatial planning documents: strategy, mobility plan, master plan and others that are compiled in Appendix (Appendix 7).

Table 2.1. EU regulations and documents of transport planning

Document title	Document description
White Paper (2001)	It is stated that the common transport policy had to be part of an overall strategy integrating sustainable development, including economic policy, land-use planning policy, social education policy, urban transport policy at local level - especially in large cities, budgetary and fiscal policy, competition policy and research policy.
Mid-term review of White Paper (2006)	The review argued for a comprehensive, holistic approach to transport policy, considering that mutually complementary action is needed at national, regional and local levels of governance including industry and society.
Green Paper (2007)	Introduced several topics addressed to stakeholders and citizens in order to indicate the most serious problems on urban mobility and possible solutions to these problems.
Action plan on urban mobility (2009)	Urbanisation and its impact on transport were identified as one of the key challenges in providing a more sustainable transportation system, through short and medium-term actions (from 2009 to 2012) that integrate urban mobility and promote partnerships at a local, regional and national level and enhance the involvement of EU stakeholders, citizens and industry.
White Paper (2011)	The paper contains objectives, actions and initiatives for the realisation of a more sustainable transport system till 2050 and indicates intermodal integration as one of the most important issues of future transport systems.
European Innovation Partnership for Smart Cities and Communities (2012)	Combining Information and Communication Technologies, energy and transport management, aims at coming up with innovating solutions that can address the major environmental, societal and health challenges that European cities face.
Urban mobility package (2013)	Introduction of the concept of “Sustainable Urban Mobility Plans” (SUMPs), as a result of the broad exchange of knowledge and experience between stakeholders and planning experts across the European Union.
Thematic research summary on passenger transport (2013)	This report foresees that intermodal mobility concepts should aim at increasing flexibility and efficiency through the combination of transport means and the concurrent assurance of reliability and comfort.

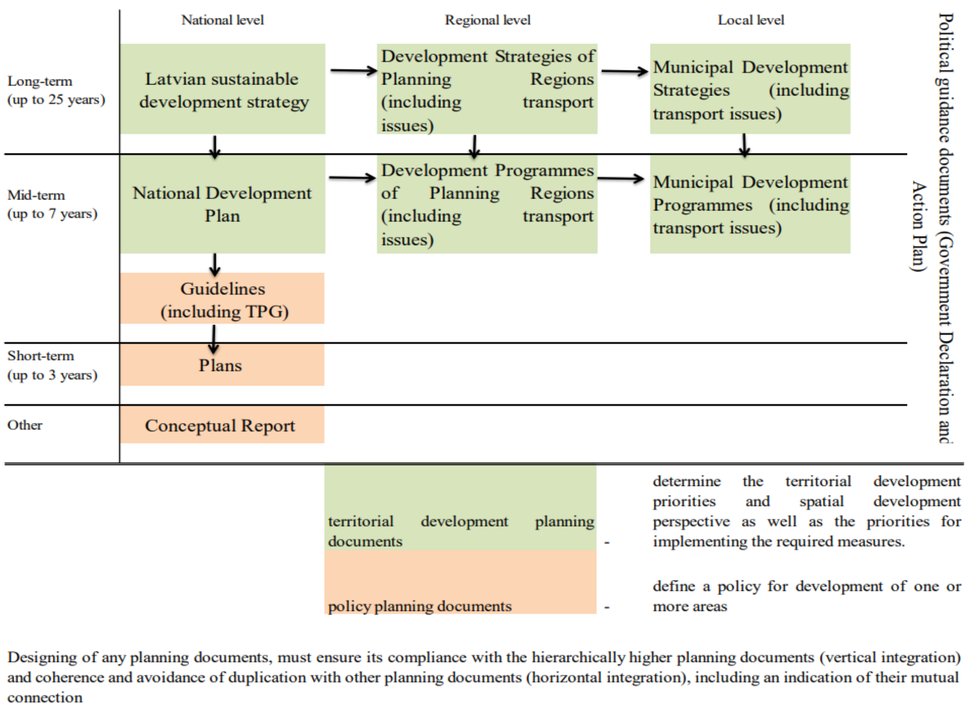


Figure 2.1. The hierarchy for transport planning documentation

As defined in Sustainable Development Strategy of Riga (SDSR) until 2030 (Strategy, 2014) one of the main purposes is to improve the UTS, and the vital public transport infrastructure element will be the Riga Central Railway Station (RCRS), which will provide multimodal functions. The station needs to be functionally and architectonically connected with the international bus station. The largest bicycle parking should be constructed in Riga with an opportunity to leave bicycles at a safe point for the night.

SDSR proposed the new transport structure, as shown in Figure 2.2 (Strategy 2030, 2014), which define the main points of the SUTS development, such as:

- the free central part of the city of transit transport, therefore simultaneously reduce the fragmented nature of the main roads in Riga;
- the necessity to complete the connection of Dienvidu tilts (Southern Bridge) and non-constructed parts of the Main Eastern road as soon as possible;
- the Riga International Airport, Riga Passenger Port, and the entrance of “RailBaltica” to the RCRS should be mentioned as the transport infrastructure objects of national importance;
- a logical connection of public rail transport should be constructed from the RCRS to Riga International Airport.

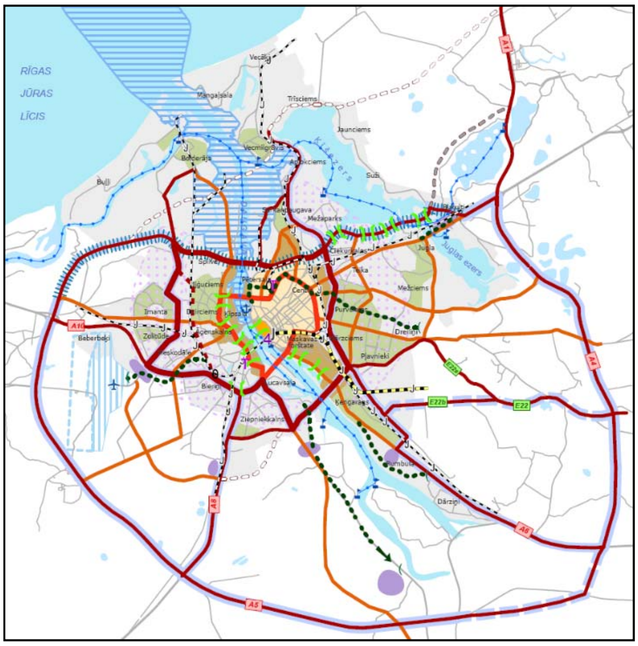


Figure 2.2. Perspective transport spatial structure of the city (Strategy 2030, 2014)

The priorities are formulated as follows (Strategy 2030, 2014): development of traffic infrastructure, reducing the traffic of car transport in the centre of the city and residential territories of localities when guiding the intense traffic to main city roads and motor roads and developing public transport traffic, cycling traffic, and walking; optimisation of transport flows to reduce pollution, etc.

Sustainable development of the urban transport system is aimed at improving all quality indicators, particularly one of the most essential – accessibility. The significant problems of PT accessibility in Riga are that it doesn't have a legal platform for the settlement and managing of passenger transportation between all the areas of Riga and its agglomeration. Also, there is no cooperation of SUTS between the authorities. As previously mentioned, there are some plans for improving UTS, but there is no integrated plan for their implementation. For example, for the implementation of the new HUB (RCRS redeveloping regarding Rail Baltica project) to the existing UTS, there is no comprehensive analysis of it. That is why it is necessary to analyse how the new HUB development will improve UTS by passenger railway, regional buses services and PT services integration. It should improve the passenger base for public PT and make transport investments more profitable.

The Riga municipally works to create the Riga development action program to reach all measures that the Strategy (Strategy 2030, 2014) proclaimed. The action plan will consist of three scenarios of urban infrastructure development:

1. A short-term action program to be implemented by 2025. Within this framework, the current situation is being studied, and a possible vision of a long-term action program is proposed.
2. A medium-term action program to be implemented by 2030;
3. A long-term action program to be implemented by 2050.

The developed scenarios define the necessary transport infrastructure development and determine the indicators for analysis and monitoring. The full view of the urban transport system will be represented in those documents.

The thesis case study is Riga city. The next paragraphs are devoted to explaining Riga's transport network and gave an overview of the current city situation.

Riga, as the capital of Latvia, is a central node of the country transport star-designed network with a total territory of 303,996 km^2 and a population of over 677294 registered residents on January 1, 2019. Riga is Latvia's socio-economic, business and cultural centre, where the most significant transport hub in the country has historically developed. Riga city and surrounding municipalities are the central regional metropolis, accounting for about 60% of the population of the country. The total length of Latvian roads is 20131 km. The national road network is classified into three categories: the major roads with a total length of 1672 km, the regional highway – 5388 km, the local roads – 13031 km (Latvijas autoceļi, 2019). Intracity trips service RS (bus, trams and trolleybus), RMS (minibus), PV (rail), TAXI, bicycles.

Spatially the structure of the population setting of Riga is explicitly concentrated and reflects the city's historical evolution. The spatial structure of the population setting of Riga is made of a core, suburb and periphery, as shown in Figure 2.3. A railway ring defines the border of the city core, and this part of the city mainly has a compact type of population setting. The suburb is characterised by a combination of micro-districts and mixed population setting. The periphery is distinguished by private houses and few-storey buildings with various recreational territories.

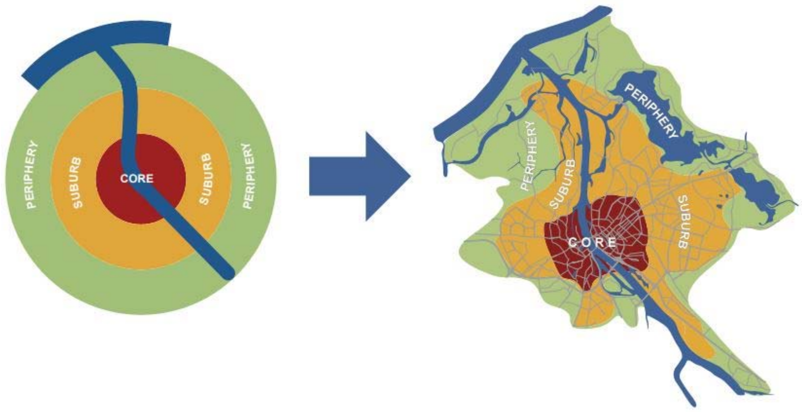


Figure 2.3. Spatial structure of the population setting of the city (Strategy 2030, 2014)

Riga agglomeration consists of the Riga city and Riga region (7297.6 km^2). Approximately 60% of Riga region residents every day go to work in Riga city. Riga region (Figure 2.4) residents have their places of work and the educational establishments of their children in Riga city, and the widely accessible public and social infrastructure of the Riga city dictates that the processes associated with recreation and entertainment take place specifically there. These factors create substantial preconditions for increased daily commuting flows. The further the commuters live, the less they use active travel, thus non-motorized modes. That is why it is necessary to analyse the Riga agglomeration transport system in total (Riga city + Riga agglomeration).

The total view of the Riga city and its agglomeration is presented in Figure 2.4, based on the division into municipalities with various degrees of integrity in the labour market of the Riga city (RD PAD, 2019):

- Municipalities with a very high degree of integrity in the labour market of Riga city;

- Municipalities with a medium or high degree of integrity in the labour market of Riga city.

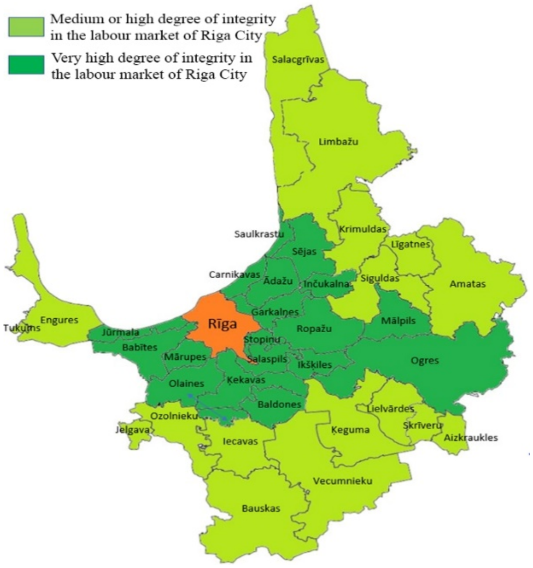


Figure 2.4. The agglomeration of the Riga City based on the integrity of the population of the municipality in the labour market of the Riga City (Source: RD PAD)

The number of inhabitants living in the Municipalities with a very high degree of integrity in the labour market of the Riga City and Municipalities with a medium or high degree of integrity in the labour market of the Riga City is the ¼ of all the Latvian population, see Table 2.2.

Table 2.2. Variation of population size between 2010 and 2018

Factor / year (thousands)	**2010**	**2012**	**2014**	**2016**	**2018**
Latvia	2 120.5	2 044.8	2 001.5	1 969.0	1 934.4
Riga	673.4	649.9	643.4	639.6	638.0
Municipalities with a very high degree of integrity in the labour market of the Riga City	251.9	251.7	251.0	252.3	256.4
Municipalities with a medium or high degree of integrity in the labour market of the Riga City	242.9	234.8	229.8	226.6	221.4

One more aspect of the commuting trip is the high level of the motorisation of the agglomeration inhabitant. The current situation of motorisation is represented in Figure 2.5. The conclusion is that the level of motorisation will continue to increase gradually, creating additional pressure on the transport infrastructure and necessitating appropriate measures to improve mobility.

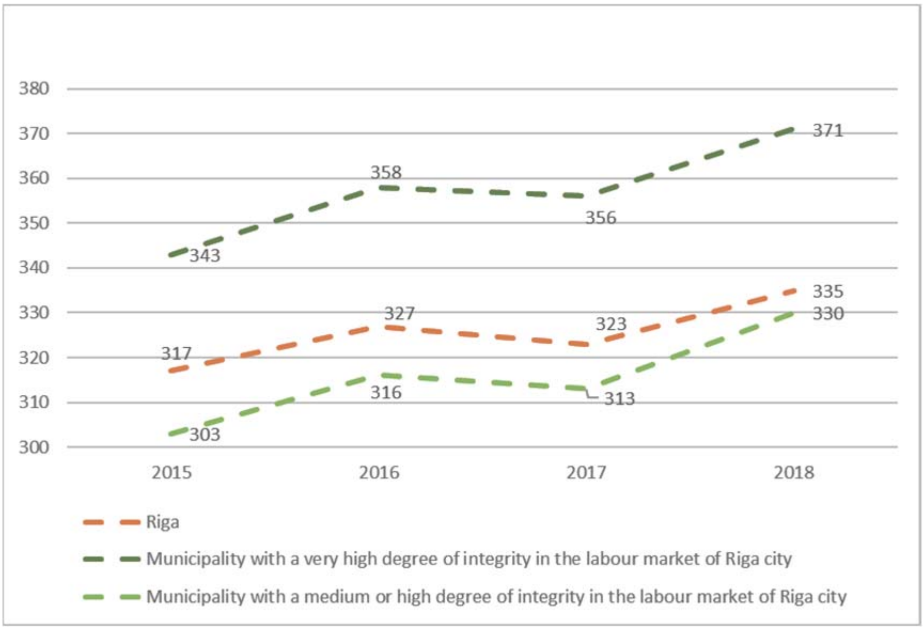


Figure 2.5. Level of motorisation (number of passenger vehicles per 1,000 inhabitants) in Riga and the agglomeration of Riga in the period between 2015 and 2018 (Source: RD PAD)

When assessing the overall situation of transport (cycling is not to be taken into account), the inhabitants for commuting to work use the following transport modes (RD PAD, 2019):

- Vehicles: 59 to 70%;
- Train: 16 to 21%;
- Regional bus carriers: 9 to 14%;
- Public transport: 5 to 6%.

The thesis object is Riga and Riga urban public transport system. In Riga, passengers are served by various modes of transport – mass transport (electrified – trams and trolleybuses; buses; rail; minibuses) and personal transport – taxis. The route network in the city consists of trams, trolleybuses and bus routes, which together make up 81 public transport routes with a total length of 1321 km. Eight thousand six hundred fifty-four journeys are provided on working days and 126 774 km for servicing. The most critical role in passenger transport in the city is electrified transport – 58.8% of all shipments. The Riga Urban Public Transport System (RUPTS) consists of 54 bus lines, nine tram lines, 19 trolleybus lines, 21 minibus lines, passenger railway with 22 stations, and 9-night buses. The structure of transport routes is mainly designed to connect the city centre with the surrounding neighbourhoods, as the most significant passenger demand is in the city centre.

The layout of the PT network is oriented to the centre. The bus route network is vast, it complements the electrified transport network and provides services in areas where there is no electrified transport, or its network is inadequately branched, as well as far from the areas in the centre. The structure of the bus network is radial. Of the 55 urban routes, more than 80% of the routes go to the centre. Other routes connect peripheral areas. A few years ago the diametrical routes are being developed, connecting two radial routes into one. The 21 routes cross the boundaries of the City of Riga, connecting it with the surrounding counties (Garkalne, Babīte, Marupe, Kekava, Stopinu and Salaspils). Inside the city centre, there are some overlaps between public transport modes. Outside the city centre, the network becomes less coherent, and there are missing links in the outer ring of the city on both sides of the Daugava River. The Daugava River is a bottleneck for the development of a complete, coherent public transport network.

According to world practice, minibuses (formerly route taxis) are a type of "public paratransit" and occupy a niche between private and PT. It represents a reasonable alternative for people who use personal cars. Unlike other modes of public transport, they do not have fixed stops. In Riga since 1992, minibuses are developing rapidly as a form of public transport. Minibuses have 20 routes and service 8% of urban public transport passengers

Figure 2.6. Riga PT routes and stops (Source: RD PAD)

The public transport network, which is very dense in the city centre has a thinning network towards the borders of the city (Figure 2.6). In general, the coverage of the PT network (walking distances to stop) can be evaluated as good or very good. Only 5-7% of inhabitants of Riga and 3-5% of employees need more than 5 min to reach the nearest PT stop (RD PAD, 2017).

Mass passenger transportation in the Riga City is carried out by local governments “Rīgas satiksme” (RS), the general partnership “Rīgas microautobusu satiksme” (RMS) and a subsidiary of JSC “Latvijas dzelzceļš” (LDZ) – JSC “Pasažieru vilciens” (PV). Taxis are carried out by private firms and individual operators.

RS public company provides transportation by trams, buses and trolleybuses. The company also provides other services: trips in the Retro tram in summer and bicycle parking (there are more than 30 bicycle parks for about 250 bicycles) (Rigas Satiksme, 2016). The leading indicators and its statistical information from 2015 until 2018 of the PTS are presented in Table 2.3.

Table 2.3. Leading availability indicators for PTS of the Riga City

Year	Indicator / Transport mode	Run (mileage) within the route network (kilometres for tram), in thousand km	Route length, in km	Number of routes	Number of vehicles servicing the route, maximum number of hours	The number of passengers carried, m.
2015	All	43 513	1191.6	81	574	146.8
	Bus	25 648	926.8	53	316	68.66
	Trolleybus	10 507	163.7	19	186	44.76
	Tram	7 357	101.1	9	72	33.4
2016	All	41 711	1216.4	83	580	143.4
	Bus	23 809	951.5	55	322	67.6
	Trolleybus	10 477	163.7	19	186	43.4
	Tram	7 425	101.1	9	72	32.3
2017	All	42 417	1236.2	84	587	142.7
	Bus	24 128	951.5	55	325	67.4
	Trolleybus	10 371	163.7	19	183	42.5
	Tram	7 918	120.9	10	79	32.7
2018	All	42 818	1199.0	81	574	139.9
	Bus	25 082	947.2	56	320	66.3
	Trolleybus	10 099	150.7	17	180	41.3
	Tram	7 637	101.1	8	74	32.3

Figure 2.7. Railway infrastructure in the Riga City (Source: RD PAD)

The railway covers all parts of the city and consists of a large number of passenger and cargo stations (Figure 2.7). Some suburban train lines connect Riga region and the Riga City (from Riga to Jurmala, Saulkrasti, Aizkraukle, Salaspils, Tukums, and Jelgava). About 3% of all public transport in Riga is carried out by rail. Continuing to address the issues of the development of Riga transport infrastructure, it is necessary to envisage the integration of the existing railway into the public transport network of the city. The railway infrastructure can provide fast and direct connections from the significant neighbourhoods to the city centre with a significant number of stops.

In 2017, PV carried 17.3 million passengers, which is by 1.5% higher than in 2016 and by 2.5%higher than in 2015. The year 2016 was the first year of an increase since 2007. The most substantial part of the increase in the passenger numbers is due to the implementation of the zonal tariff system, which has made it particularly attractive to travel between various localities on the outskirts of the Riga City, which are not interconnected by any public transport routes operated by RS (RD PAD, 2019).

The precision of train traffic reached 99.18% in 2017. Only 0.16% of the 84,252 services were not run.

According to the survey conducted by SKDS, Ltd. in the year 2017 to find out the levels of customer satisfaction among the clients of PV, 61% of the passengers use trains to get to work, but 20% use it to get to their educational establishments. The survey results clearly show that PV plays a significant role in commuting needs in the agglomeration of Riga City. It has been found out in the customer satisfaction survey that 57% of the passengers mention that the costs of the trip are not high – this is an argument in favour of choosing a train ride. (RD PAD, 2019)

Every year public transport services are used by a large number of residents. The new ticketing validation system was introduced in 2009. The passenger number has increased until 2014, but from 2015 has decreased after the ticket price was doubled. (Figure 2.8)

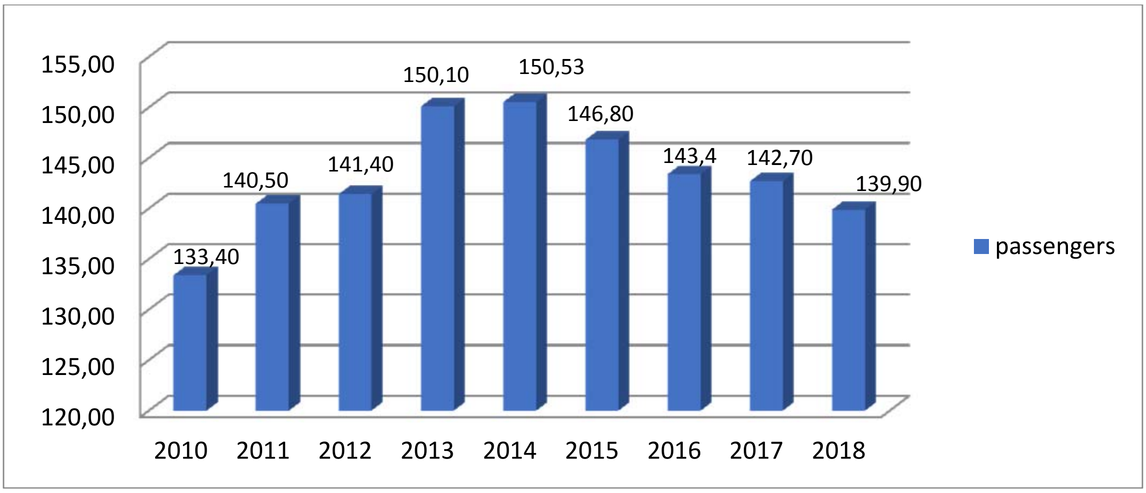


Figure 2.8. Number of carried passengers (Source: RS)

One of the main approaches to assess the quality and convenience of urban transport is to evaluate travellers' satisfaction. In the spring of 2018, the Riga municipality conducted an annual survey about the residents' satisfaction of local authorities work, and also included questions about mobility. The results of the survey showed that 86% of residents are satisfied with the availability of PT services and that 47.1% use PT for daily trips, 31.7% use cars and 8% prefer bicycle.

The Riga city bus and trolleybus routes for passenger transportation are provided by rolling stock (95% with the low floor) since 2016. Tram rolling stock renewal is not fast. The city tram route network was run by 26 low-floor trams. RS continues to work on the implementation of energy-efficient off-the-shelf transport technology solutions in the existing transport infrastructure in Riga, with the target from 2020 onwards.

Resource-efficient planning of public transport network development in the future means creating a route/route that would allow passengers to move more quickly between neighbourhoods, providing easy transfer, without spending time in the city centre and reaching the destination faster than at present.

The next part of this paragraph was published in Magginas et al. (2018) *and the material was prepared by the thesis author.*

The Riga transport system is represented by all transport modes (private cars, walking, cycling, cargo, public transport). The Riga City development strategy (2014) provides urban transport hierarchical principles: pedestrian-cyclist-public transport-private transport-freight transport (Figure 2.9) and the city tries to implement them.

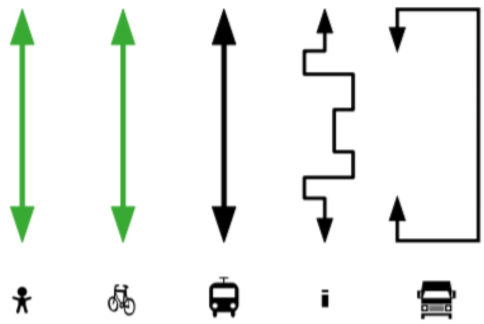


Figure 2.9. Mobility principles in the core of the city (RD PAD, 2014)

One group of the main transport system users is cyclists. The availability of cycling, as well as walking and using the PT, provides people with the opportunity to be environmentally friendly and healthy. (Velokoncepcija, 2015). As defined in the Cyclist development plan (2018), up to 52.1% of Riga inhabitants cycle periodically and only 9.9% use bicycles for their daily commuting. The main reason for this is the poor connectivity between the bicycle and the Riga public transport system, as well as the bad connectivity between different transport modes. Along with the increased number of traffic accidents involving cyclists, specific land use planning issues that pose restrictions in the interventions that can be implemented (mainly those of a hard nature, such as infrastructure development or expansion) cycling remains a less attractive option for commuting.

It comes at odds with the fact that the majority of the city's population live within cycling distance of the city centre (89%), which is the sufficient distance of cycling. Specifically, 42% of citizens live within 5 km (20 min) of the city centre, which has a particularly competitive ride distance indicating great cycling potential.

The “Rules of the Road” of the Republic of Latvia (Rules of the Roads N.571, 2015) foresee that cyclists need to use the road network or the infrastructure for bicycles, and only in the case that the conditions are dangerous for their life, they can also use the sidewalk.

The public transport provider of Riga RS allows carrying bicycles free of charge in public transport (trams, trolleybuses, buses) by the rules of procedure. Regarding trains, the conditions for the carriage of bicycles stipulate that a luggage ticket must be purchased, if there are no bicycle holders in the wagon. Railway wagons that are fitted with bike holders are marked with a label at the doors (PV, 2018). Regional buses are not fitted with bike holders to facilitate bicycle carriage and improve mobility while providing easy transportation of bicycles. Since public transport is subsidised from the state budget, the ATD concludes contracts with carriers and set conditions for the provision of buses with bicycle holders, assessing the routes where this would be needed and where there is the highest demand for bicycle transportation (Cyclist infrastructure development plan, 2018).

Riga provides hard and soft policies for cyclists. Representative hard policies include government laws and regulations, such as the Rules of the road (Rules of the Roads N.571, 2015), the Road traffic law (Road traffic law, 2015), the Latvian administrative violations code (LR Administratīvais likums, 2010) and others.

In terms of soft policies, the Road Traffic Safety Authority organises informative events for children in schools. Also, pupils of the fifth class can obtain a cyclist license, after passing the corresponding safety exam. Inhabitants are regularly informed for such activities and initiatives through mass media and booklets.

The main Riga interchanges provide bicycle parking free of charge: Riga International Coach Terminal at the entrance and the car parking, Riga International Airport at the main airport area and the car parking, and Riga Central Railway Station at the entrance and the car parking of two nearby malls. On the other hand, such facilities are missing in the Riga Port Terminal.

Lastly, as part of this attempt, from 2016, the Riga Municipality Traffic Department includes cyclists in its traffic volume counting as a separate category.

2.3. Riga transport simulation model as a decision-making tool

The Riga city for transport system planning uses the transport simulation model (RTSM). RTSM is a macro-level model and developed in software EMME. It gives a possibility to provide a comprehensive multimodal transportation planning for urban, regional and national transportation forecasting (inro.ca). RTMS consists of the 3324 links; 180 zones; 11 modes; 10 transit vehicle types; 208 transit lines. The Input data are the following: Car counting data; Employment; Population; Car ownership; O-D matrix (2004); Network development scenario.

Traffic modelling tools help to:

- create and validate sustainable urban mobility plans (SUMPs);
- analyse strength-weaknesses-opportunity-threads (SWOT);
- prepare for the benchmark of the transport system;
- close the gaps of partially missing data about the situation on the roads;
- point out bottlenecks in the infrastructure or the supply of mobility options;
- detail ex-ante analysis for transport infrastructure object;
- present and explain the decisions and improve public engagement.

The validity of the model and the correctness of its use/support for decision making (DSS) depends mostly on the relevance of the data. The RTSM data availability and actuality that need to use for planning was analysed regarding the Cascetta (2009) defining TS scheme (Figure 1.2). The result of Riga TS data analysis is that TS modelling does not provide enough information and schematically presented in Figure 2.10:

- fragmented information (highlighted in orange colour): about the movement of demand, the distribution of jobs, the spatial distribution;
- unknown information (highlighted in red colour): information about housing (where they were going, how many people live, what type of transport used and why). The information about the demand for mobility does not exits;
- existing information (highlighted in green colour): data about the network, the cost of public transport, the cost of parking.

The RTSM was developed in 1996. RTSM was updated for the current development plan in 2004. RTSM was edited in 2007, 2008 and 2010 for the Riga North Corridor project. The RTSM version in software CUBE was prepared in 2011 for Riga and Pieriga Mobility plan. So, the current state of the Riga TSM is far from actual and not full for the correct decision-making process. For the measurement calculation and it result analysis, the current RTMS was used.

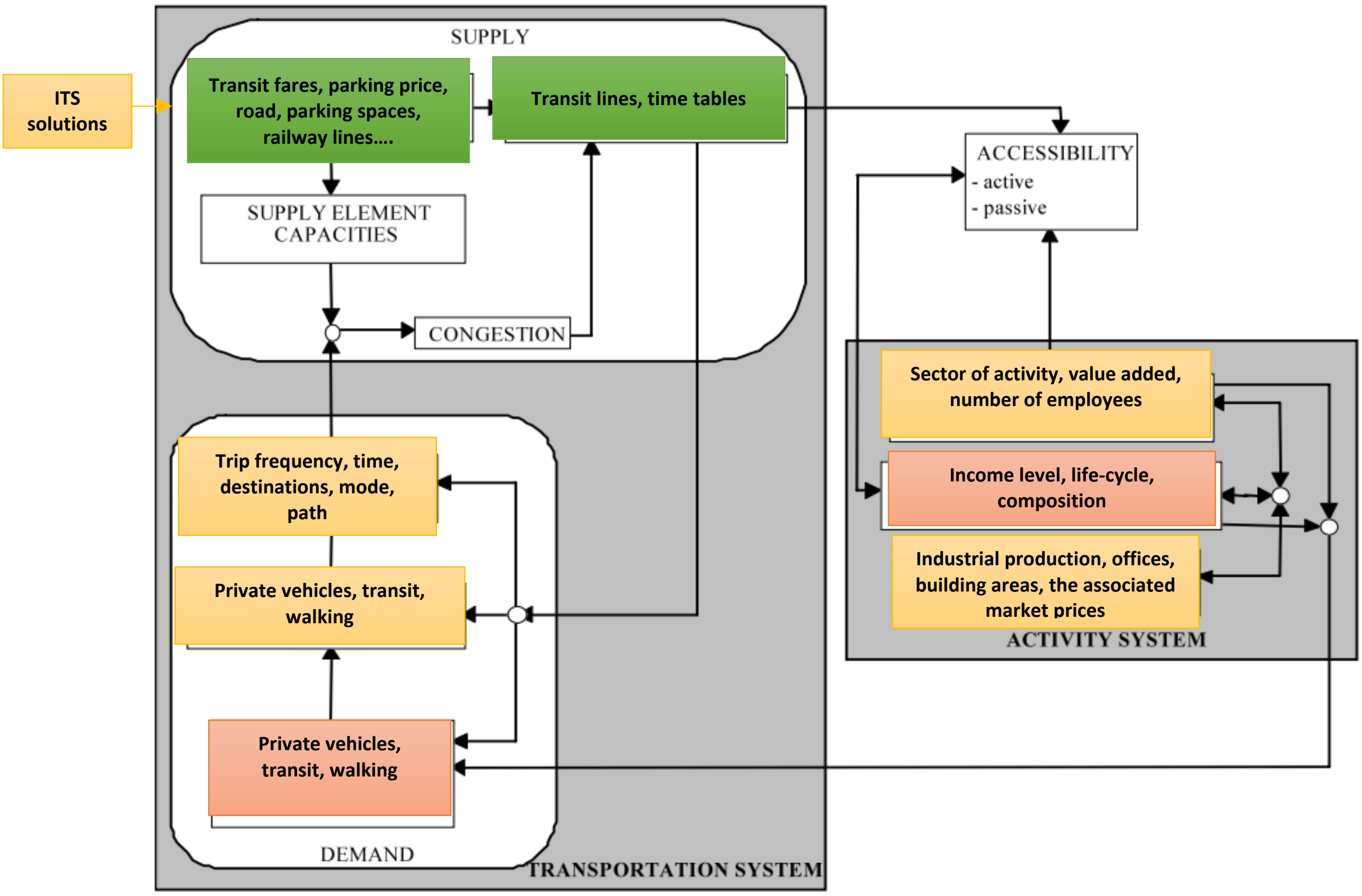


Figure 2.10. The Availability of Data for Transport System modelling edited by the author (Cascetta, 2009)

2.4. Riga transport system problem analysis

As it was mentioned above, there are several documents and plans of Riga transport system development at a different level of spatial planning.

The Riga and Pieriga mobility plan in 2011 (Mobility plan, 2011) formulated the main problems related to the traffic and transport infrastructure of the UTS of Riga agglomeration, such as:

1. lack of unified planning and management of public transport, road and rail networks;
2. lack of the bypass's capacity in the Riga City;
3. lack of bridges between the two sides of the Daugava river and a fragmented street network resulting in traffic flow congestion;
4. lack of pedestrian, cycle and segregated public transport facilities;
5. weaknesses in the organisational and legal framework regarding integrated transport systems and the promotion of sustainable mobility.

The Riga municipality started to develop the Riga Transport System Sustainable Mobility Action Plan in 2019, in which the central identified current situation and future development problems (RD PAD, 2019) are:

1. Lack of integrated PTS. Most of the transport in the Riga City is carried out by RS (including RMS), a smaller part is carried out by PV and intercity buses. There are no mutually coordinated timetables for the various PT type in the city. Single ticket mechanisms have not been introduced either to improve the travel habits of the inhabitants and their mobility.
2. The gradual decrease in PT travel speed. The increasing concentration of cars in the city centre due to the insufficient number of public transport lanes extends the duration of travel in the city and reduces the average travel speed. The reduction of the average travel speed is one of the preconditions for further reductions in the PT passenger flow. The time lost by passengers within a year due to these reasons exceeds 8 million hours.
3. The mutual linkage between the various locations of the city is organised by PT without travelling to the centre of Riga City.
4. The lacking linkage between the tram (defined as the priority of public transport in the long term) and many densely populated localities (Bolderāja/Daugavgrīva, Pļavnieki, Purvciems Ziepniekkalns, Zolitūde).
5. Insufficient PT infrastructure and number of routes for public transport to be able to support the introduction of the P&R system in the Riga City in the medium and long-term.
6. Not everywhere in the city the tram infrastructure (platforms, rails and power supply infrastructure) has been adapted to the use of low-floor trams.

As we see, most of the problems have not been solved since 2011 and are set as a task for 2019. The most critical is that there is no integration and legal framework regarding integrated transport systems and the promotion of sustainable mobility. However, the Riga development department has stepped up by participating in projects related to SUMPs.

Regarding the SUMBA (sustainable urban mobility and commuting in Baltic cities) Interreg project funded by European Union (www.sumba.eu), in which the thesis author participates as regional project coordinator, the expert and author analysed the strengths and weaknesses of the Riga transport system (Table 2.4). The presented SWOT analysis is a part of the SUMBA project reports regarding commuters mobility that will be announced at the end of the project in October of 2020.

Table 2.4. Riga transport system analysis of Strengths, Weaknesses, Opportunities, Threats

Weaknesses	Opportunities
The bridges Vansu and Akmens concentrate (through) traffic in and around the centre and the east bank, which leads to congestion, traffic unsafe, extra vehicle kilometres, barriers and substantial environmental impact. Transit traffic is using the roads in and around the Historical Centre of Riga since there is no by-pass like the planned Northern Transport Corridor available at present. Due to the economic situation, the budget for public transport outside Riga has decreased. As a result, many PT-lines in rural areas have been cancelled, or frequencies were lowered dramatically. The railway loop has led to a limited number of road crossings that appear as bottlenecks in peak periods. Reducing these bottlenecks will require considerable capital investments. The grid system in the central business district hurts liveability, and the one-way system has limited reach to control this. The UNESCO World Heritage listing limits possibilities for redesigning the traffic space. There is no strict road hierarchy reinforced by different designs, resulting in adverse effects on liveability and traffic safety. Also, the absence of lighting on several strategic locations is reducing traffic safety. The network of arterial streets is still incomplete and under development, and therefore failing to distract through traffic from the centre and residential areas. Most state road stretches in the Riga and agglomeration have some weak points regarding traffic safety, like access of properties via the highway, locations for U-turns and left-turns, zebra crossings, no median barrier, lack of lane is marking, etc. The same also refers to municipal roads. Apart from the central station area, there are no big transport hubs in the city and the outskirts. Also, rail and tram/bus/trolley are not interconnected, giving more pressure on the road system. Up till now, PT has no or hardly any priority at traffic lights. Only some tramlines have some priority measures at traffic lights. Also, since many routes are not diametrical, though passengers are forced to transfer, which worsens PT travel times and competitiveness. Infrastructure for pedestrian movements like road passing is limited and often lacking facilities for the disabled. The maintenance level of the road infrastructure is classified as weak. Due to specific investments in regular maintenance and reconstruction of roads in the past and next years, this percentage is decreasing. The road accessibility of the northwestern port region (Westbank Daugava) is limited; the access roads do not have a suitable design for the new envisaged developments.	The railway circle gives possibilities to make multimodal interchanges, and together with real-estate developments, the PT network can be strengthened, and the traffic can be better spread and disentangled. The marine passenger terminal and the railway station/bus station are close to the old town and the central business district and are capable of transferring many passengers without giving too much traffic impact problems in the area. The accessibility for pedestrians of both terminal and station, however, could be improved. Furthermore, the RICT is located in a narrow place, and walking distance towards the train station is too far for quick interchange. Improvement of these connections is possible and will provide better use of PT. New bridges can be combined with moving car traffic away from the existing bridges (Akmens in particular) and provide opportunities to reclaim the east bank as a valuable city promenade, and even to close the railway circle for interconnecting city sections, secondary centres next to arterial crossings and the marine passenger terminal. The grid system in the central business district can provide parallel safe and attractive cycle routes. The Daugava River is very suitable for water recreation as well as passenger and freight transport north-south and east-west. The further decentralisation of jobs and dwellers might reduce the strong orientation in the city centre, leading to more balanced traffic flow patterns. New infrastructure can be linked to new spatial developments to safeguard efficient use of the extra capacity. A more stringent car parking policy can lead to better traffic conditions throughout the city centre. The PT network can be enhanced, e.g. by better serving substantial origin-destination (O-D) patterns accompanied by promotion, leading to a modal shift away from the car. With a new railway bridge, together with the road infra linking with the port, freight traffic can be diverted from the centre. New infrastructure around Riga might strengthen the strategic position of Riga as the central transport hub/gateway city in the European region, leading to a higher budget for the road network. Investment in railways and surroundings can boost rail as a mode for the internal trip making, also reducing car trips. With the right investments in engineering, education and enforcement, traffic safety figures can further improve, as evidence from other European countries

Not all new development areas in the northwestern port region are connected to the rail network. The only route for rail cargo from the port region to the east bank goes via the city centre of Riga, resulting in hindrance and external safety issues. The old town has a street pattern and street dimensions that make it impossible for regular PT to operate services. The bridges over the Daugava river forms a barrier for PT, due to traffic congestion, network restrictions and extra vehicle kilometres. Only one bridge can be used by trams and one by train. Apart from the central station area, there are no big transport hubs in the city and the outskirts. There is no hierarchic line structure, consisting of fast lines serving main traffic flows and slower lines with more stops on minor traffic flows. Rail and tram/ bus/ trolleybus lines are not interconnected. Up till now, PT has no or limited priority at traffic lights, and the number of dedicated lanes is limited. Most routes are not diametrical, which forces passengers to transfer, and which worsens PT travel times and competitiveness. The road infrastructure is suffering from a maintenance backlog, which has a negative influence on comfort, travel speed and costs of repairs. The number of lines is high, with much parallelism, resulting in less efficient operations. The electric modes have not been developed with the growth of the city in the last decades. As a result of the ticketing system, the user is confronted with a less transparent network: especially transfer and choice opportunities are not yet encouraged by the fare system. The railway stations are poorly accessible and not integrated into the public transport system. The Railway rolling stock is outdated and unattractive.	suggests. With resources derived from economic prosperity, measures can be taken to improve the emissions of the vehicle stock. The adverse impact of the location of companies and services on the network and the surroundings can be reduced with the help of zoning policy, mobility management, and tax differentiation and alike. To combine road cross-river connections of the Northern Transport Corridor with a new rail connection in the Northern part of Riga. New infrastructure can be linked to new spatial developments to safeguard efficient use of the extra capacity. New road infrastructure can provide opportunities for more dedicated PT lanes, e.g. for restricting a bridge to PT modes only. The PT line network can be improved by introducing a hierarchic structure, more diametrical lines and interconnection with railways and between PT modes. With relatively small investments, the electric network can be extended to improve air quality and possibly travel speeds. A more stringent car parking policy can lead to better traffic conditions throughout the city centre. PT can be linked to the parking system. The PT network can be enhanced, e.g. by better serving important O-D patterns, accompanied by promotion, leading to a modal shift away from the car. The adverse impact of the location of companies and services on the road network and the surroundings can be reduced with the help of zoning policy, mobility management, and tax differentiation and alike. PT can play an import role in developing those policies, e.g. by providing an excellent alternative to the car. The connection of new spatial developments to train stations, improving the accessibility of the developments and the using of the passenger rail. Rail Baltica project can give new opportunities for optimisation and harmonisation of city PT system.
Strengths	**Threats**
The old city still has a street pattern and dimensions that reinforce the historical and cultural qualities. (Although this has by some sources been described as a weakness in the past). The Southern (Dienvidu) bridge leads to extra capacity for through and long-distance traffic that does not longer actively interfere with local traffic. The marine passenger terminal and the railway station/bus station are close to the old town and the CBD, and these sites are in principle capable of transferring many passengers without giving too much traffic impact problems in the area. Most arterials at the entrances of Riga have reserve capacity and albeit physical	The continuing rise in car ownership and car use might lead to highly oversaturated junctions, gridlocks (in the grid system of the central business district) and illegal parking, causing long delay, accessibility problems and inefficient capacity usage (e.g. the bridges). A lack of funds for public transport which already has led to a decrease in public transport services in the Riga region will lead to extra car usage from commuters who live in small towns, villages or rural areas. A location of a possible new bridge must be chosen carefully to be attractive to drivers to achieve the proposed/wanted change in traffic routes. If not chosen

barriers, do not have a substantial impact on liveability in the residential areas. Latvia has a good Public Transport historical tradition. As a result, the Riga region has train infrastructure with train stations and is served by transit buses which stop in several villages or small towns. Riga and agglomeration still have a well-developed PT network with high frequencies. In Riga, almost all inhabitants and employees live or work in a 5-minute walk of a PT stop. Inhabitants are used to travelling with PT and are well informed about the possibilities of PT. PT has good punctuality and an acceptable level of comfort. In recent years many investments in (new) rolling stock have been made. The integrated ticketing system has been deployed, leading to more PT integration. The large part of PT lines is electrical with trams and trolleybuses.	carefully there is a chance the real traffic jams in the City Centre will remain. The connection of the new bridge to the existing infrastructure might lead to new traffic jams at other locations. New bridges might excavate PT when the car mode becomes even more competitive, and PT's reaction to reduced demand is reducing frequencies. The promotion of bicycle use might lead to traffic unsafety if drivers are not yet used to bicycles, and the infrastructure does not protect the cyclist enough. The further decentralisation of jobs and dwellers will lead to more traffic flow in the outskirts, on relations not serviced by PT, leading to congestion and traffic unsafety. Also, commuting into the centre might rise, and the unbalance in PT volumes by direction might grow, which could reduce competitiveness. The development of new infrastructure will lead to a more significant maintenance program that will be challenged in situations of a shortage of resource. Completion of the outer ring might lead to new settlements far away from the city, causing more commuter traffic and vehicle kilometres. Lack of alternatives might lead to more dangerous cargo being transported via the city centre. Transit freight traffic will increase if the economy of Riga and Latvia is further developing. The transport of cargo by rail is losing competitiveness in comparison to transport by road, leading to an increase in road transport and decrease accessibility. The continuing rise in car ownership and car use might lead to a decrease of modal share and volume of PT, which decreases the possibilities for efficient and high-quality routes and lines structure. New bridges might excavate PT when the car mode becomes even more competitive, and PT's reaction to reduced demand is reducing frequencies. The further decentralisation of jobs and dwellers will lead to more traffic flow in the outskirts, on relations that cannot easily be serviced by PT. Also, commuting into the centre might increase the unbalance in PT volumes by direction. Completion of the outer ring might lead to new settlements far away from the city, causing more commuter traffic and vehicle kilometres and fewer opportunities for competitive PT. Urban sprawl around Riga along other corridors than the railway corridors, reducing the competitiveness of rail about car traffic. Rail Baltica project can give threats for current Riga PT system.

The resume of the problem is that the main aspect that needs to be solved is a transport infrastructure development or redevelopment, the second one, but also significant – the decision-making process organising in all level of the government and authorities.

2.5. Recommendation for Riga sustainable urban transport system implementation

Regarding the Riga transport system multimodality, all transport modes need to be analysed, such as water transport, freight transport, the railway and the public transport system (Table 2.5). The analysis of all transport modes helps to create a sustainable urban transport system in the city.

Table 2.5. Recommendation for Riga sustainable urban transport system implementation by transport modes

Transport mode	Activities to be carried out
Water transport	Evaluate the possible linkage of water transport with other PT types, creating transfer points to diversify modes of travel. Evaluate the seasonality of water transport activity (assessing the winter period). The effects of severe weather on transport (strong wind, flood, etc.) and their impact on the attractiveness of these modes of transport, including time gain/loss for passengers is to be evaluated. Evaluate the risks and economic effects of the introduction and maintenance of water transport in the short and long term. Estimate the number of passengers that would use it as a regular daily mode of travel. Evaluate places where it is possible to establish new piers (broken down by the necessary investments during the creation and construction of the infrastructure). Evaluate the piers which creation would be technically complex but necessary for the development of the Daugava crossing (ferries) for freight transport to/from the port. Evaluate the water transport as a way of reducing the transit of private and freight transport, which would remove the load from Daugava crossing in Riga. Estimate the division of responsibility of water aquaculture operators, technical servicing existence of an infrastructure or creation options. Water transport development solutions must consider the spatial plan of the territory planning of the territory of Riga spatial and waterfront and the planning of the Riga Historical Center and its protective zone.
Freight transport	To prepare proposals for the development of freight transport traffic. To prepare proposals for limiting freight traffic in the city centre, considering the current situation and the completion of the construction of various street infrastructure objects. To prepare alternative methods for internal city logistics to meet the needs of freight, business, and municipal services for freight. Prepare proposals to ensure the access of cargo vehicles to seaports, airport terminals, trade and logistics centres and other facilities, bypassing the city centre.
Intelligent transport systems	Prepare proposals for the development of ITS. Prepare proposals for mobile application. Prepare proposals for software development that will increase the efficiency of management of Riga and Riga suburbs transport systems. Prepare proposals for the establishment of a united centre of Riga public transport management and Riga suburbs traffic management. Prepare proposals for the implementation of the ITS or traffic flow regulation system at the intersections of Riga at the intersection to ensure the priority of the public transport movement. Offer guidelines for improving and upgrading ITS and requirements for its successful functioning.
Integration of passenger railway in the system of urban public transport	Carry out a (regional) analysis of existing passenger rail routes and assess their impact on urban transport. Consider the development of existing regional train opportunities that would improve the network of Riga and Riga suburbs routes, assuming, that a terminal station in Riga is allowed other than only Central Station.

	When regarding the development of the city's railways, it is necessary to consider the development plans for regional railway routes both in terms of the route and its intensity. To assess whether the location of existing railway stations and stop-points is justified and useful in perspective of the efficient integration of urban rail transport into the Riga and Riga suburbs public transport system. Evaluate and provide recommendations for improving the current situation. Improving the quality of accessibility of passenger rail infrastructure from various aspects: suitability for city rail routes (transfer distance, capacity, etc.); persons with disabilities; as a point of transfer to other types of public transport; for bicycle transport (spacious standing places or for carrying a bicycle in the train); availability of parking-lots or such development opportunities. Consider the various development opportunities of the city's railways, both in terms of time and in terms of funding. Urban railway development solutions should be based with the benefits to the passengers, the necessary changes in the part of the total Riga and Riga suburbs route network affected by each specific railway route and the cost/benefit calculation. Define what conditions the city rail route will be more attractive than other public transport routes or private transport. For example, the distance between stations, speed, or time-saving, distance from/to station, transit interval, ticket pricing policy, etc.
Public transport system	Identify problems in the existing public transport system in municipalities that could be included in the PTS. Develop at least three possible PTS strategies and examine the losses and benefits of the financial and socio-economic dimension. One of the strategies should be to evaluate the problems that may result from different responsibilities in the competences in Riga and outside it (including fiscal responsibility for the development and operation of public transport (from now on – PT) route network development and exploitation). Determine the sequence of priorities to carry out PTS (including purchase, renewal, and exploitation costs of rolling stock). To prepare proposals for changes in the regulatory enactments regulating public transport, defining the division of competences and financial structure (Riga City, State, Riga suburbs municipalities). To develop recommendations for mandatory regulations/requirements for local governments to improve access to public transport objects (especially railway stations), as well as recommendations/requirements for the creation or renewal of related infrastructure (pedestrian paths, bicycle paths, car and bicycle storage, lighting, etc., where relevant). Prepare proposals for improvement of the public transport network system. Prepare proposals for improvement of public transport ticketing system in Riga and Riga suburbs by developing detailed requirements and measures for their consolidation and better functioning. Analyse and integrate timetables and routes for all modes of transport in Riga and Riga suburbs. Offer guidelines for the modernisation of vehicles and rolling stock, with the opportunity of transporting bikes. To develop united criteria for quality requirements that would fit both the transport of bicycles and the transport of people with disabilities, etc. Develop a federal public transport stopping points equipment quality standard. The PTS needs to consider the solutions of the Rail Baltica project related to the development/rebuilding plans according to Riga Central Railway Station and RICT, and the Torņakalns Multimodal Center. Develop an existing PT Latency Map, a collection of problem streets and sections in which PT is experiencing delays in the movement. Several models are to be designed for morning and evening maximum hours. Delay is both an unplanned additional time spent by PT along the route and a planned additional time compared to the driving time when there are no delays in the relevant road section. To elaborate suggestions that the railway crossings are passing through the PT, optimise the operation, and the barrier would open immediately after the train's departure, or their closing times to be aligned with the PT timetables. Consider solutions that will liberate road sections of public transport in the city centre by limiting private and freight transport flows. Priority is solutions aimed at vehicles with increased emissions, while other vehicles reduce traffic in Riga's historic centre and its protection zone. When researching the tram system, determine the demand for extensions of existing tram lines and the creation of new lines. Reduce the rest of other vehicles in the city's central part streets, where the trolley and other vehicles are using rail tracks.

	Lifting the tram rails or physically demarcating from the rest of the other vehicles lane is especially important before crossings where other vehicles perform manoeuvres. Consider the opportunity of organising also another public transport movement in tram tracks.
P&R development	Consider the "Riga City Council's Parking Policy and Development Concept plan" elaborated in 2014. P&R system section development plan". To justify the placement of P&R foreseen in this plan, if necessary by making changes or improvement offers. Carry out an analysis of the performance indicators of the existing car park Ulbrokas street 13 (it is a single P&R), also from its fulfilment, location, price policy, synergies with public transport, etc. aspects. Research to find out the estimated number of private cars (per number of passengers) who would like to use P&R daily and be considered as the target audience. Categorise the P&R according to their target audience and their use (for internal use in Riga, guests of Riga suburbs, regular, occasional, etc.). Plan the position of the P&R as close as possible to existing or future urban rail transport (tram, rail), transfer points, multimodal or intermodal centres. Define the requirements for their reach and the duration of the transfer. The possibility to place the P&R outside the territory of Riga is also to be considered. Such solutions should be evaluated in cooperation with the respective municipality. Develop recommendations for P&R function provision necessary additional services and its desired size. The evaluation of private investment and state, municipal and private partnership (MPP) opportunities should be evaluated by creating P&R and allowing commercial activities in their immediate vicinity. Take an analysis of the experience of world cities in the field of promotion of the use of P&R. Based on the gained experience and other examples of good practice, offer parking-lot synergy solution with public transport (ticket system) and bicycle priority in the city. Offering P&R implementation solutions PT is to be provided with better speed to the city centre than by private transport. Determine the operating criteria required for the implementation of P&R. An ample, guarded bike parking space on the P&R is to be foreseen, where personal bikes can be arranged overnight. From P&R there must be provided with the cycling-friendly environment to the city centre. P&R facilities should have facilities for organising bicycle rental and service. Develop P&R plans for several development scenarios, which should also include financial and legal models.
Cycling	The construction of a network of bicycle tracks in the central part of the city and the provision of arterial connections with various localities of the city.

One more of the main aspects of what the decision-makers need to think is the ageing population. According to the World Population Prospects: the 2015 Revision (United Nations, 2015) population ageing – the increasing share of older persons in the population – is poised to become one of the most significant social transformations of the twenty-first century. During the next few decades, the share of the global population aged 60 or more is likely to rise to historically unprecedented levels. According to the latest estimates, by 2050 there will be two billion people aged over 60 (22% of the world population). In 2050, the world population is projected to be 3.6 times larger than it was in 1950. It is strongly recommended to think about this group of people, being users of the transport system in the future.

The second significant aspect is public engagement (PE). Cascetta et al. (2013) suggested that PE can be considered as the process of involving stakeholder concerns, needs and values in the transportation decision-making process. The overall goal of engagement is to achieve a transparent decision-making process with more significant input from stakeholders and their support of the decisions that are taken. The scheme of this aspect is presented in Figure 2.11.

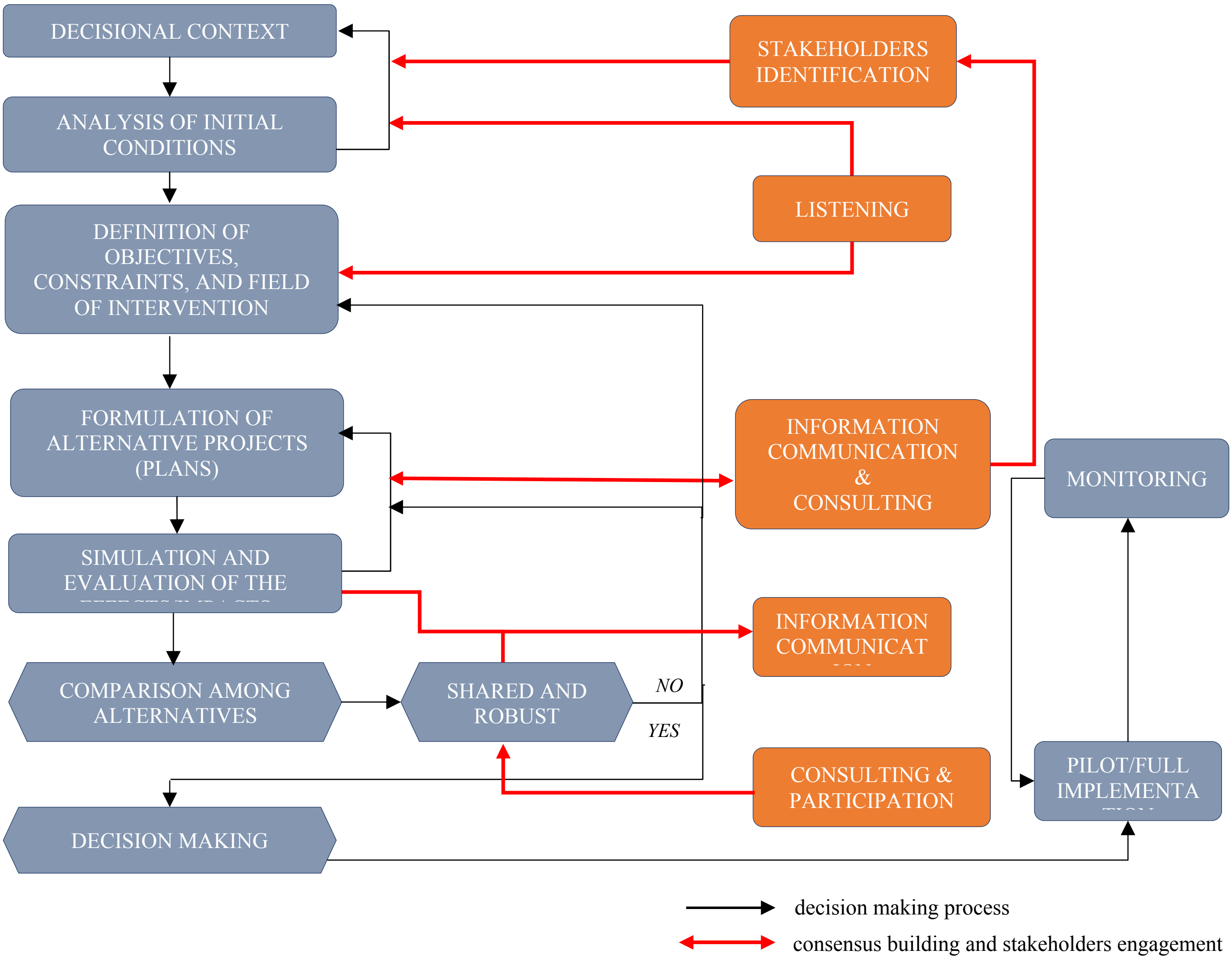


Figure 2.11. The framework of the overall bounded rationality transportation decision-making framework with PE and the roles of quantitative methods based on (Cascetta E., Pagliara F., 2013), updated by the author

2.6. The interchanges in Riga transport system – current state

The body of the paragraph is published in the author paper "A Cross-Case Analysis of Riga Interchanges" in collaboration with the authors: Yatskiv (Jackiva) I., Blodniece I., Nathanail Ef., Adamos G. (Yatskiv (Jackiva) I.,2019).

As mentioned above, the interchange is the principal object of the TS. Riga City is a case study of the thesis, and one of the thesis goals is the accessibility analysis of the city interchanges. There are four main transport hubs (interchange) in Riga. Three of them: Riga international coach terminal (RICT), the Riga Central Railway Station (RCRS) and the Riga passenger terminal Ltd. (PORT) are located in the old town, which is listed in UNESCO protected areas. The Riga international airport (RIX) is geographically located in another municipality, but still, it can be considered as a transportation hub of the city of Riga. RICT and RCRS provide regional, long-distance and international trips, during the PORT and RIX only international. A brief description of each interchange is provided below by Yatskiv (Jackiva) (2019):

1. RIX is the largest international aviation company in the Baltic area and the primary air traffic centre in this region offering regular passenger, cargo and postal delivery to the cities of Europe and the world. RIX renders both aviation and non-aviation services. It serves both national and international airlines becoming one of the few European airports that facilitate both full service and low-cost airlines.

2. RICT provides services for passengers and road passenger transportation companies that operate regional passenger inter-city, regional, local and international routes. Coach terminal location provides easy interfaces to other transport modes, located at the heart of the capital.

3. PORT to manage and develop the passenger port of Riga and its territories. Riga Passenger terminal serves cruise ships, ferries, superyachts, sailing yachts, navy vessels and other non-cargo ships.

4. RCRS is the central railway station in Riga that operates all passenger trains within Latvia. It is known as the main point of Riga due to its central location, and many public transport stops are located in this area. RCRS provides international, national and regional trips.

The description of the four main interchanges regarding passengers, area, working hours, governance and transport modes for the last mile is represented in Table 2.6.

Table 2.6. Riga City interchanges' description

Interchanges	**Year of creation**	**Passengers (2017)**	**Total area (m^2)**	**Working hours**	**Governance**	**Transport modes for the last mile**
RIX	1974	6 097 434	17 340	00:00-24:00	State	Car, taxi, bus, minibus, bike*
RICT	1964	1 661 529	13 000	00:00-24:00	Private	Car, taxi, tram, bus, minibus, bike*
PORT	1965	87 384	~1 000	09:00-18:00	Private	Car, taxi
RCRS	1861, redeveloped 1954	1 733 380	38 000	05:00-24:00	State	Car, taxi, bus, trolleybus, minibus, bike*

Regarding the ownership, two of interchanges RIX and RCRS are owned by the state, while, PORT and RICT can be characterised as private. After the passengers' flow comparison, it is assumed that RICT and RCRS serve approximately two million passengers per year. RCRS is the biggest one, and PORT is the smallest regarding territory coverage. RIX and RICT operate daily, while PORT works from 9 a.m. till 6 p.m. and RCRS from 5 a.m. till 12 a.m. Last-mile services provided from/to interchange are served by all transport modes in RIX, RICT and

RCRS. However, the accessibility of the PORT is classified as relatively weak, and the possibility to reach from/to this interchange is exclusively by individual transport (car) or taxi.

2.7. The strategic project of the new multimodal interchange and choosing the main factor for impact measure

The body of the paragraph is published in the author paper "Evaluating Riga Transport System Accessibility" in collaboration with the author Yatskiv (Jackiva) I. (Yatskiv (Jackiva) I., 2017b).

The main aim of the Riga urban transport system development is to create a more efficient, effective and inclusive urban transport system for travellers and citizens. Thus, at the stage of initial planning, it is necessary to analyse and evaluate the effects of the planned changes, allowing to improve our understanding of all elements of the new transport infrastructure projects. The new transport object provides a user-friendly clean, energy-efficient, safe, secure and intelligent systems for all users. The decision-making framework should include a holistic approach to analyse all aspects of sustainable transportation.

The authorities could move the UTS to sustainability and to study a particular aspect of decisions on the passenger planning network in the city of Riga in the frame of the Rail Baltica project – Riga Central Multimodal Public Transportation Hub.

The significance of the railway station is increased in the context of the most massive infrastructure project in the Baltic Sea Region - Rail Baltica. The goal of this project is to integrate the Baltic States in the European rail network. Latvia, as well as the other Baltic States, continues to use the rail width of 1520 mm, and one of the reasons why it is necessary to reconstruct is because most of the EU countries use the track width of 1435 mm (Railbaltica.info, 2014). Riga shall be the only Rail Baltica stop of passenger trains in Latvia, which will be conveniently linked with transport modes for the route change to Airport Riga. Riga Central Railway Station shall be reasonably linked with the international bus station; the most extensive bicycle parking lot shall be established here.

The Riga Municipality has the ambitious plan to reconstruct this node to Riga Central Multimodal Public Transportation Hub (RPTH) that will merge in a single infrastructure international and domestic passenger railway traffic, Latvian regional, local and Riga City public transportation traffic, as well as a personal transport access point and individual migration. RPTH integrates the European gauge railway line Rail Baltica and covers Riga Central Station area, related public transportation terminals (including RICT), stops, individual transport access, stoppage and parking sites, as well as infrastructure linked with the RPTH related to individual migration (Ministry of Transport LR, 2016). The decision is complicated because there are many stakeholders involved. The European Regulation No1315/2013 (Eur-lex.europa.eu, 2016) takes into account the fact that infrastructure projects need an involvement of public and private stakeholders to ensure the promotion of sustainable transport solutions, such as enhanced accessibility by public transport, telematics applications, intermodal terminals/multimodal transport chains, low-carbon and other innovative transport solutions and environmental improvements and the enhancement of cooperation between the different stakeholders.

According to the approach in passenger transport typology that was proposed by the CLOSER (CLOSER project, 2016) the RPTH could be classified as a national hub because it is a railway station, that is connected with other terminals at national or international levels. National authorities are interested in the terminal, however, under the umbrella of national policies and governmental companies or administrative bodies, most of the times own and operate the hubs, although private actors may also get involved. Rail Baltica is still at an early planning and design stage – holding companies are being established, final railway route is not decided upon, further planning and design stage works are expected to be procured in 2017. A broad level of political agreement has been reached, and the research process is still active for the planning of project implementation. That is why it is essential to plan and create a multimodal transport hub with only aim to improve the quality of Riga and country PT system. The quality of all aspects of integration should be viewed from this position, but the difficulty – a large number of stakeholders are involved: public (Ministry of Transport; Latvian Railway; Riga Central Station; International Airport; Riga City Development, Traffic Departments; Road Transport Administration) and private (RICT; Passenger carriers; Owners/managers of nearby infrastructure objects).

The list of significant changes of PTS in the project of RPRH includes the following:

- Network changes: street directions and new streets creation (Dzirnavu street connection with Krasta street; new street creation in Kļavu street, Turgeņeva street one lane for public transport).
- Junctions' reconstructions: traffic lights regulation for providing Level of Service in Marijas street–13. janvāra street–Satekles street; new signalling (including traffic lights and horizontal signalling) in 13. janvāra street; signalised junction coordinated with Trolleybus&Tram lines in Abrenes–Turgeņeva street.
- Trolleybus network: new schedule and new line (Turgeņeva street one-way street).
- Tram network: new schedule, a new line through Dzirnavu street, a new provision of an electrical system for Tramline, new Tram station and widening from Dzirnavu street to Turgeņeva street.
- City buses & minibuses network: new schedule, city Buses Depot (new Access from

Dzirnavu street from North & South City; safety turn proposed from Satekles street, Timoteja street).

- RICT configuration: the existing Terminal relocation to the new HUB; international coaches interchange dislocation in the 1st level under railway; access adapted to the new way disposed of in Elizabetes street etc.
- Private cars (kiss&ride/car parking): integrated option with Public Transport/Taxi Parking/Kiss& Ride; Taxi Parking disposed of in the North to provide a unified exit for passengers in the Hub Entrance.
- New pedestrian crossings without the tunnels will be created in the surrounding area.
- Bicycle network: a lot of new bicycle lanes will be created.

The new HUB development essentially changes the urban transport system. Yatskiv and Budilovich (2017a) discussed the Riga Central Multimodal Public Transportation Hub project and provided the procedure for the evaluation of sustainability measures of RTS before the new HUB development (Figure 2.12).

The procedure of impact analysis describes that the group of stakeholders should prepare a solution for the new project. To do this, it is necessary to know the important indicators of the significant sustainable transport system, which must be measured before and after the new infrastructure project implementation. These indicators will affect the stakeholders in the decision-making process. The main problem for solving these procedures steps is to define the system indicators that they need to analyse before and after the new project implementation.

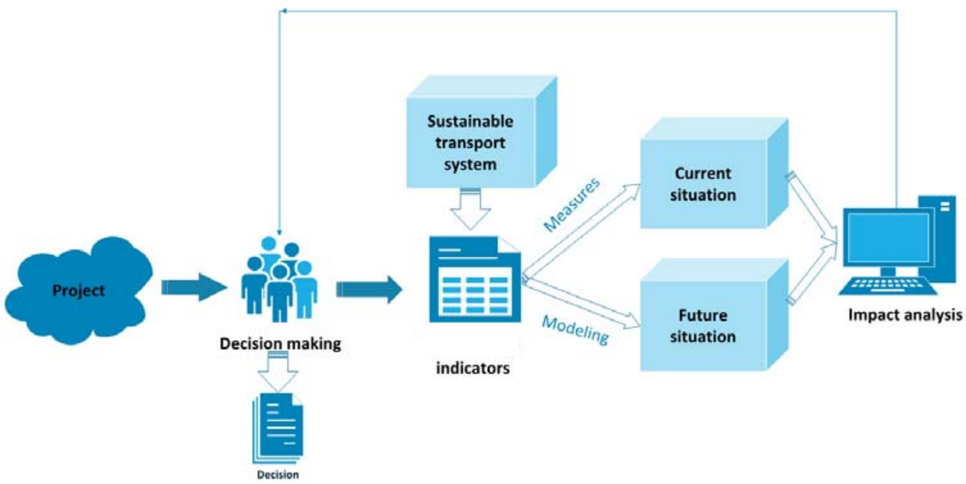


Figure 2.12. The procedure of impact analysis

It is necessary to create a comprehensive system of indicators and to evaluate which of them are defining sustainable urban development and how they refer to the transportation sector. Many scientists are working in this direction, and a different set of indicators is still under discussion (Buzasi et al. (2015); Alonso et al. (2015)). However, sustainable transportation indicators (STI) should be adapted to real conditions and state of the UTS, because each transport system has specific requirements, and the weights of STI in the analysis may be different.

The face to face questionnaire survey about the significance (weights) of STI for Riga transport system was conducted by Yatskiv and Budilovich (2017a). The application form was taken from the SUMMA project (SUMMA, 2003) and adapted/translated for local use is presented in Appendix 1. The indicators used for analysis were proposed in the SUMMA project (SUMMA, 2003), represented in Table 2.7. Respondents were offered to assess each of the indicators of importance using Likert scale: (5) – Very Important; (4) – Important, (3) - Essential, (2) – Rather, not important, (1) – Not important.

Table 2.7. The questionnaire "Assessment the importance of sustainable transport issues for Riga Transport System" and results analysis

N	Criteria	Indicators	Min	Max	Mode*	Median	Sum
1	Accessibility	Access to public transport	3	5	5	5	48
2		Access to basic services	3	5	5	5	50
3		Accessibility of origins and destinations	3	5	4	4	45
4	Health and safety	Accident-related fatalities and serious injuries	1	5	-	3	33
5		Exposure to transport noise	2	5	3	3	38
6		Exposure to air pollution	2	5	3	3	36
7		Walking and cycling as transport modes for short distances	2	5	3	4	41
8	Cost-effectiveness	Energy efficiency	1	5	3	3	35
9		Generation of non-recycled waste	1	5	-	2	36
10		Public subsidies	1	4	2	2	26
11	Impact on competitiveness and generation of wealth	Gross value added	1	4	3	2	25
12		External transport costs	1	4	3	3	31
13		Benefits of transport	1	4	-	3	36
14	Consumption of natural capital	Land take	1	4	3	3	30
15		Consumption of solid raw materials	1	5	-	3	32
16		Damage to habitats and species	2	4	-	3	34
17	Production of pollutants (local and global)	Emission of greenhouses gases	1	4	3	3	31
18		Emission of air pollutants	1	4	4	3	31
19		Runoff pollution from transport infrastructure	2	4	3	3	36
20		Discharge of oil and waste at sea	1	4	3	3	32
* where mode exists							

Representatives of municipalities and researchers presented the focus group. Despite the small number of respondents (totally 11), it should be noted that they are knowledgeable and reliable experts in this matter. The descriptive statistics of estimations made by experts represented in Table 2.7 shows that for the Riga city, the most significant sustainability issues concern accessibility and the less important refer to environmental indicators. It is important to mention that the estimation of the indicators' weights by more representative samples and citizens' opinions is recommended. Riga is divided into 58 districts; the development of these areas is not even, and the inhabitants of each of them have their attitude towards mobility and sustainability. For instance, residents of the district located near the port in favour of noise and air pollution, while others are not satisfied with the availability of public transport. The thesis aim is to analyse the possible STI and then analyse how the planned new multimodal HUB influenced it.

As the questionnaire results showed, the accessibility of Riga Transport system is one of the most critical indicators. Therefore, the main aspects that should analyse in decision making at the stage of new transport object planning are measures of accessibility before and after object preparation.

The analysis of accessibility indicator and transport system accessibility level is a thesis subject. The overview of the accessibility definition is given in the next chapter of the thesis.

The accessibility is the quality parameter of the urban transport system. The transport system accessible is the central aspect of urban life. The analysis of the accessibility in the intermodal trip is one of the thesis goals. To reach this goal, the analysis of the interchange and interchange accessibility need to be conducted.

2.8. Conclusions

For the development of the Riga transport system (RTS), there is a large number of documents that have been produced in different spatial levels and focused on the improvement of traffic and transport situations. These documents have different scopes, purposes and timescales, but a visible roadmap for this implementation does not exist.

The Riga transport system is represented by different kinds of public transport mode. Moreover, it can be defined as a good connection for residents in its daily use.

After providing the survey of the expert was defined that for TS in Riga main quality indicator is accessibility. Moreover, infrastructure analysis using the impact analysis is the main goal for decision-makers. The before-and-after analysis of TS accessibility helps to identify how the HUB needs to be improved or where it is required to promote the public transport network based on the criteria of accessibility measurement.

For a holistic approach to estimate the functioning of the urban TS and evaluate the expected outcome of new infrastructures and services, it is necessary: to define the accessibility indicators; to develop the simulation model; to design and execute the simulation experiments to evaluate the proposed solutions in the aspect of sustainability issues.

3. THE THEORETICAL ASPECTS OF ACCESSIBILITY

3.1. Accessibility definition

Today the concept of accessibility has a comprehensive meaning. Along with other quality services (Table 1.8), the accessibility component is one of the essential elements of the transport system. After the expert survey that was conducted during research preparation (Table 2.7), it was concluded that the accessibility of Riga Transport system is one of the most important indicators. Therefore the main aspects that should be analysed in decision making at the stage of RPTH planning are measures of accessibility before and after reconstruction.

Jackiva and Budilovich in (2017b) defined accessibility as a central part of UPTS. The term “accessibility”, as used in The European Observation Network for Territorial Development and Cohesion (ESPON), expresses how easily people in one region can reach people in another region. Accessibility of a region is indirectly a measure for the potential for activities and enterprises in the region to reach markets and activities in other regions. Accessibility plays a significant role in European policy discussions related to the development of regions and cities as well as the European territory as such (European Union, 2009).

Accessibility refers to the ease of reaching destinations expressed in travel time, travel costs and travel distances for different modes (Dr Susanne Böhler-Baedeker, 2016).

Accessibility can be defined as the ease of access with which an individual can reach a location to perform an activity. Providing a link between transportation and land-use models, accessibility can be seen as an indicator to assess transport and land-use policies, especially in urban structures. The definition used will depend on the goal of the study. Morris (1979) gives the first definition of accessibility. The accessibility theme is one of the studied or researched fields: Song (1996), Handy (1997), Kwan (1998), Geurs & Wee (2004), Litman (2012), Zhang (2016), Hawas (2016), Silva (2017) and others define, analyse and calculate the accessibility.

There are several concepts of "accessibility" definition. Accessibility can be seen as one of the most important outputs of the transport system, as a central concept in the context of evaluating transport projects and can be defined as the multisided concept.

However, Geurs and Van Wee (2004) define accessibility as ‘the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations using a (combination of) transport mode(s). Geurs and Ritsema (2001) determined four main components of accessibility, see Table 3.1.

Table 3.1. Interdependent components determining accessibility (Geurs & Rirsema (2001)

Accessibility components	Components description
Transport component	Distance, travel time, travel costs, travel effort between origin and destination
Land-use or spatial component	The number and spatial distribution of supplied destinations, the spatial distributions of the demand for activities, the confrontation between "demand" and "supply."
Temporal component	The availability of activities at different times of the day
Individual component	Need, abilities, opportunities, the times in which individuals participate in specific activities

Useful for further theoretical contributions (research) definitions are compiled in Table 3.2. All definitions are divided by dimensions that Geurs and Ritsema determined (2001).

Table 3.2. Accessibility definition categorised by dimensions: (1) spatial, (2) transport, (3) temporal, (4) individual

Source	Definition	Components			
		1	2	3	4
Hansen (1959)	"the opportunity which an individual or type of person at a given location possesses to take part in a particular activity or set of activities."	+			+
Wachs (1973)	"the average opportunity which the residents of the area possess to take part in a particular activity or set of activities")	+	+		+
Dalvi (1976)	the ease with which any land- use activity can be reached from a location using a particular transport system	+	+		
Hack (1976)	"the accessibility of a point in a system is a function of its location in space concerning all other points in the system" and "implies relative nearness either in the sense of a direct linkage or a minimum expenditure of travel cost or time."	+	+		
Leonardi (1978)	"the consumer surplus, or net benefit, that people achieve from using the transport and land-use system."	+	+		+
Morris (1979)	- as the ease with which an individual can reach a location to perform an activity - an indicator to assess transport and land-use policies, especially in urban structures	+ +	 +		
Bums (1979)	the freedom of individuals to decide whether or not to participate in different activities			+	+
Ben-Akiva (1979)	the benefits provided by a transportation/land-use system	+	+		
(U.S. Department of Environment, 1996)	"the ease and convenience of access to spatially distributed opportunities with a choice of travel."	+	+		
Geurs (2001)	the extent to which the land use–transport system enables (groups of) individuals or goods to reach activities or destinations using a (combination of) transport mode(s)	+	+	+	+
Geurs (2004)	…accessibility should relate to the role of the land-use and transport systems in society, which, in our opinion, will allow individuals or groups of individuals to participate in activities in different locations. Focusing on passenger transport, we define accessibility as the extent to which land- use and transport systems enable (groups of) individuals to reach activities or destinations using a (combination of) transport mode(s). Access is used when talking about a person's perspective, accessibility when using a location's perspective	+	+		+
Bertolini (2005)	the amount and diversity of places that can be reached within a given travel time and cost with as little as the possible use of non-renewable, or	+	+		

Source	Definition	Components			
		1	2	3	4
	challenging to renew, resources, including land and infrastructure				
Verseckiene (2016)	Public transport accessibility is defined as the quality of transit, serving a particular location and the ease with which people can access that service.		+	+	+
Preston (2007)	In transportation planning, accessibility is primarily defined as the potential for an individual to reach opportunities	+	+		+
Paez (2012)	Accessibility, defined as the potential for reaching spatially distributed opportunities (for employment, recreation, social interaction, etc.), can be considered one of the main outputs of spatial development, the typical result of a transportation network and the geographical distribution of activities.	+	+		
Van Wee (2013)	The extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s) at various times of the day (perspective of persons), and the extent to which land-use and transport systems enable companies, facilities and other activity places to receive people, goods and information at various times of the day (perspective of locations of activities)	+	+	+	+
Cascetta (2013)	"the ease in meeting one's needs in locations distributed over space for a subject located in a given area."	+			
Curl (2015)	Accessibility is a fundamental concept in transport planning, and over time, it has been defined and measured in numerous ways but is generally understood to be the ability of people to reach destinations.	+	+		
Litman (2016)	Accessibility generally refers to physical access to goods, services and destinations. In roadway engineering, access refers to connections to adjacent properties. ….. accessibility refers to the relative ease of reaching a particular location or area. …. accessible design (also called universal design) refers to facilities designed to accommodate people with disabilities. ……. accessibility refers to people's ability to use services and opportunities.	+	+		+
Gulhan et al. (2013)	Accessibility, which refers to the ease of reaching goods, services, activities and destinations	+			+
(ELTIS, 2016)	SUMP objective to ensure that all citizens are offered transport options that enable access to key destinations and services. Accessibility can be improved by reducing the distance between places where activities are undertaken through land-use planning measures (i.e. high-density development and mixed-use development); and by providing better mobility/transport options. When judging the accessibility of a destination or activity, attention should be paid to the needs of all social groups, including groups such as children, older people and disabled people	+	+	+	+
Rodrigue (2017)	Accessibility to other terminals (at the local, regional and global scale) as well as how well the terminal is linked to the regional transportation system is of importance	+	+	+	

The land-use or spatial component of access is included in all definitions. The second one is the Transport component, that is for the author point of view more significant in the accessibility aspect. Individual and Temporal component seems to be not so relevant.

As Jarv et al. (2018) discussed: Location-based accessibility modelling as a function of time, exist two temporal dimensions of accessibility static and dynamic (Table 3.3). Until now, there is a limitation of the possibility to use dynamic data. Regarding the Riga city, it is also an actual problem – only static temporal dimension is used.

Table 3.3. Examples of potential data sources for dynamic accessibility modelling given the three core components of accessibility, in comparison (Jarv et al. (2018))

	Temporal dimension	Spatial dimension	Data sources
People	Static	Predefined location	Registers and databases (e.g. census, population register)
	Dynamic	*De facto* locations in time	Active mobile devices (GPS, mobile positioning)
			Passive mobile devices (mobile phone CDR data)
			Location-based sensors (WiFi, Bluetooth)
			Smart card transactions (transit, bank, customer cards)
			Geo-located social media
Transport	Static	predefined routes	Transport network with speed limits (e.g. national road network)
	Dynamic	De facto routes by travel mode in time	Private car: Online navigation services
			Car navigator data
			Floating car GPS-data
			Location-based services
			Public transport: GTFS data
			Online journey planners
			Cycling and walking: OpenStreetMap,
			Mobile sports applications
Activities	Static	Predefined locations	Register-based data (e.g. enterprise register)
	Dynamic	De facto locations are given the availability in time	Service websites
			Geo-located social media
			Location-based social networks (Foursquare; Google Places, Yelp)

The concept of accessibility thereby goes beyond the framework of the transport system and its purely temporal dimension, associating it with a spatial dimension. Accessibility should reflect the spatial organisation and the quality of the transport system that provide individuals (alone or in groups) the opportunity to participate in the activities located in different parts of the region suggested by Geurs et al. (2004). Litman (2012) provided an overview of literature into ‘accessibility' and found out different factors that affect accessibility: transportation demand, mobility, transportation options, user information, integration of the transport system, affordability, mobility substitutes, land-use factors, transport network connectivity, roadway design and management, prioritisation and inaccessibility. He concluded that there is no single indicator to capture accessibility. It depends on the goal of the study of how accessibility should be measured. According to the definition, the level of accessibility depends on the location of activities, quality and quantity of infrastructures, and the needs of people and companies. The level of accessibility has an impact on the economy because:

- functioning transport system in combination with the land;
- use system is a condition for economic development;

- accessibility is not only relevant for the economy but fulfils a social role (Van Wee, 2013).

Litman (2015) discussed that sustainable transportation indicators (STI) should reflect accessibility-based planning, that tends to consider additional planning objectives (improved mobility for non-drivers, energy conservation, improved safety, etc.) and additional solutions (improving alternative modes, more efficient pricing, more accessible land use development). Litman (2013) suggested that accessibility-based planning recognise the following factors that affect accessibility: mobility, the quality of transport options, transport network connectivity, land use accessibility – accessibility-based planning.

Transport accessibility can be analysed by different methods, and in recent years many methods were used for it. Accessibility impacts of transport projects can be assessed using transport modelling for planning sustainable mobility. So, the transport models should at least be able to provide accessibility as an output, or results with which accessibility measures can be calculated. The level of detail of the indicator depends upon the level of detail of the transport model used. Other typologies of accessibility measurements, defined by Geurs et al. (2004), identify three broad classes of indicators: cumulative opportunities, gravity-based, and utility-based.

Accessibility is affected by many factors like mobility, quality and affordability of travel options, mobility substitutes, but in terms of multimodality, connectivity of the transport system and land use features are the most important. Geurs et al. (2001) examined accessibility under the view of the combination of transport modes and the easiness to make a combined transit trip. The quality and location of a transport terminal, as well as the connection between links and modes, also affect the accessibility level of the terminal (Litman, 2012).

The land-use component addresses the spatial distribution of opportunities and the relationship between supply and demand concerning these opportunities. The transport component expresses the characteristics of the transport system, and the disutility for an individual to reach a chosen destination. The temporal component relates to the timetabling of activities, ranging from work hours to shop opening times, and the time available for someone to participate in or take advantage of those activities. The individual component reflects the needs, abilities, perceptions and limitations experienced by individuals due to variables such as health status, income, gender, and level of education.

Table 3.4 compiles a list of factors that affect accessibility and the degree to which they are considered in current transport planning. Multi-modal transportation planning requires consideration of all these factors (Litman, 2014). The table indicates factors that affect accessibility, how they are currently considered, and potential improvements for more comprehensive planning.

Table 3.4. Summary of Factors Affecting Accessibility (Litman, 2014)

Name	Description	Current Consideration	Improvements
Transport Demand	The amount of mobility and access to people and businesses would choose	Motorised travel demand is well measured, but nonmotorized demand is not	More comprehensive travel surveys, statistics and analysis of travel demands
Mobility	Travel speed and distance	Primarily evaluates motor vehicle traffic speeds and vehicle mileages travelled	A more comprehensive evaluation of mobility by other modes
Transport Options (modes)	The quality (speed, convenience, comfort, safety, etc.) of transport options, including walking, cycling, public transit, etc.	Motor vehicle travel speed and safety are usually considered, but other modes and other travel factors are often overlooked	More multi-modal evaluation (speed, convenience, comfort, safety, etc. of walking, cycling, transit, etc.)
User information	Availability of reliable information on mobility and accessibility options	It is sometimes considered for particular modes or locations, but seldom comprehensive	More comprehensive and integrated information to help users navigate transport systems
Integration	The degree of integration among transport system links and modes	Automobile transport is generally well integrated, but not connections between other modes	More integrated planning to improve travellers' ability to connect between system components
Affordability	The cost to users relative to their incomes	Automobile operating costs and transit fares are usually considered	A more comprehensive evaluation of transport costs relative to users incomes
Mobility Substitutes	Telecommunications and delivery services that substitute for physical travel	Not usually considered in transport planning	Consider mobility substitutes as part of the transport system
Land Use Factors	Land use density and mix	It is usually considered in land use planning, but less in transport planning	Measure how land-use factors affect travel distances and costs
Transport Network Connectivity	The density of road and path connections, and therefore the directness of travel between destinations	Transport planning is starting to consider roadway connectivity impacts accessibility	Measure how roadway connectivity affects travel distances and costs
Transport Management	How to transport management affects accessibility	Limited consideration	Consider how various transport management strategies affect access
Prioritisation	Strategies that favour more efficient travel activity	Limited consideration	Consider transport prioritization strategies
Inaccessibility	The value of inaccessibility and isolation	It is not generally considered in transport planning	Recognise the value of sometimes limiting access

Litman (2016) suggested that transportation can be evaluated as effects of planning decisions. Table 3.5 compares three common perspectives used to measure transportation.

Table 3.5. Transportation Evaluation Perspectives (Litman, 2016)

	Vehicle Travel	Mobility	Accessibility
Definition of Transportation	Vehicle travel	Person and goods movement	Ability to obtain goods, services and activities
Measurement units	Vehicle miles	Person-miles and ton-miles	Trips, generalized costs
Modes considered	Automobile and truck	Automobile, truck and transit	Automobile, truck, transit, cycling and walking
Common indicators	Vehicle traffic volumes and speeds, roadway Level of Service, costs per vehicle-mile, parking convenience	Travel distance and speeds, road and transit Level of Service, cost per person-mile, travel convenience	Quality of available transportation choices. Distribution of destinations. Cost per trip
Consumer benefits considered	Maximum motor vehicle travel and speed	Maximum personal travel and goods movement	Maximum transport choice and cost-efficiency
Consideration of land use	Treats land use as an input, unaffected by transportation decisions	Recognises that land use can affect travel choice	Recognises that land use has significant impacts on transportation
Favoured transportation improvement strategies	Roadway and parking facility improvements to increase capacity, speed and safety	Transportation system improvements that increase capacity, speeds and safety	Management strategies and improvements that increase transport system efficiency and safety
Transportation Demand Management (TDM)	Generally considers vehicle travel reductions undesirable	Supports TDM strategies that improve personal and freight mobility	Supports TDM whenever it is cost-effective

3.2. Accessibility measurement

Several authors have written review articles on accessibility measures, focusing on individual perspectives, such as location accessibility (Handy and Niemeier, 1997; Song, 1996), individual accessibility (Kwan, 1998; Pirie, 1979), economic benefits of accessibility (Koenig, 1980; Niemeier, 1997) or other, different perspectives (Geurs and van Wee (2004)).

There are four basic types of accessibility measures generally used (Van Wee, 2013):

1. Infrastructure – based accessibility measures, analysing the (observed or simulated) performance or service level of transport infrastructures, such as the length of infrastructure networks, the density of those networks (e.g. kilometre road length per square kilometre), level of congestion, and average travel speed on the road network. This type of accessibility measure is typically used in transport planning. Some of these measures focus only on the supply of infrastructure, while others also use demand factors.

2. Location-based accessibility measures, analysing accessibility at locations, typically on a macro-level. The measures describe the level of accessibility to spatially distributed activities, such as ‘the number of jobs within 30 minutes' travel time from origin locations'. More complex

location-based measures explicitly incorporate capacity restrictions of supplied activity characteristics to include competition effects.

3. Person-based accessibility measures, analysing accessibility at the individual level, such as ‘the activities in which an individual can participate at a given time'. This type of measure is founded in the space-time geography (Hagerstrand, 1970) that measures limitations on an individual's freedom of action in the environment, that is, the location and duration of necessary activities, the time budgets for flexible activities and travel speed allowed by the transport system.

4. Utility-based accessibility measures, analysing the (economic) benefits that people derive from access to the spatially distributed activities. This type of measure has its origin in economic studies and is increasingly receiving attention in accessibility studies (de Jong et al., 2007; Geurs et al., 2010).

Table 3.6 compiles the accessibility measures of different researches that are divided into four types of accessibility.

Table 3.6. Review of different measures for accessibility assessment

Sources	Accessibility measures			
	Infrastructure based	**Location-based**	**Person-based**	**Utility-based**
Geurs et al. (2001)	Average travel time Average speed on the road network Level of congestion Average delays		Level of (dis)comfort Physical effort Reliability Stress Accident risks Information Status	Travel distance Travel time or costs The contour measures Potential measures Measures based on balancing factors of spatial interaction models Measures derived from time-space geography
(SUMMA, 2003)	Accessibility on the whole network Level of satisfaction of users of the regional public transport network	Availability and quality of railway transport and transport in general Number of sites with basic services (shops, schools, hospitals etc.) Access to services in rural areas	Passenger journey time and length per mode, purpose (commuting, shopping, leisure) and location (urban/rural) Access to transport services The speed of journeys on the whole network satisfaction level of railway users Access for disabled people Accessibility of the regional public transport network, commercial speed of the regional PTS	Regional access to markets: the ease (time, money) of reaching economically important assets (consumers, jobs), by various modes (road, rail, aviation)
Geurs et al. (2004)	Infrastructure-based measures	Contour measure Potential measure Adapted potential measures Balancing factors	Person-based measures	Logsum benefit measure Space-time measure Balancing factor benefit measure
Paez (2012)		Gravity Population serviced or market shares	Cumulative opportunities Presence of at least one facility within the predetermined distance	The costs of travel: mean travel cost to the nearest facilities
Litman (2012)	*Smart growth:* Implementation of policy and planning practices that lead to more accessible, clustered, mixed, multimodal development *Mobility.* Passenger transport (by mode and purpose): total passengers, total passenger-km, passenger-km per capita, passenger-km per GDP	Land use: Average number of basic services (schools, shops, and government offices) within walking distance of homes	Land use mix: Number of job opportunities and commercial services within 30-minute travel distance of residents Children: % of children who can walk/bicycle to schools, shops, parks from their homes Electronic: Portion of the population with Internet service	

Sources	Accessibility measures			
	Infrastructure based	Location-based	Person-based	Utility-based
Van Wee (2013)	Supply- oriented measures-network level Supply- oriented measures – connectivity of locations to transport networks Supply- oriented measures – network connectivity Demand- and supply-oriented measure	Cumulative opportunities Potential or gravity-based accessibility Actual accessibility	Space-time approach	Utility of accessibility
Koopmans et al. (2013)	the 'level of services' approach	a contour-based approach, e.g. making maps of the number of people or jobs that can be reached within a given amount of time the market potential (or gravity) method, a travel cost-weighted measure of the amount of economic activity which can be reached	the extent to which an individual can participate in activities at a given time, incorporating spatial and temporal constraints	generalised transport costs measures: all costs made by travellers for their trip, including time, out-of-pocket costs and comfort/quality log sum measures: account for both realised transport costs and destination utility
Litman (2015)	Bicycle and pedestrian activity and safety Bicycle and pedestrian level of service Average vehicle occupancy Transit productivity Bicycle and pedestrian mode share Carbon intensity	Mixed land uses Transit accessibility Land consumption	Vehicle miles travelled per capita	Transportation affordability Distribution of benefits by income group
Alonso (2015)	The coverage ratio of PT Congestion Accidents	Motorisation rate/% of crowning households A density of the public transport network % of residents with public transit service within 500 m. Parking spaces in the city centre	Time spent Transport fatalities per inhabitant Distance travelled Quality of accessibility for people with disabilities	Costs of transport for users Quality of public transport Affordability of PT by lower-income residents
Buzasi (2015)	Number of accidents		Average distance Social Average travel time Number of journeys Number of journeys by car % of journeys by car Vehicle occupancy rate	

Accessibility analysis can help identify who has access to and therefore, benefits from services and who might be disadvantaged. The most suitable way of measuring accessibility is the time taken to travel to destinations (Reference to validate this statement).Figure 3.1. presents three dimensions that are related to three accessibility levels: macro, meso and micro. Each level or dimension deals with different geographical scale:

- the macro level deals with EU scale level or international;
- the meso level refers to the analysis of accessibility on a regional level;
- the micro-level – city level.

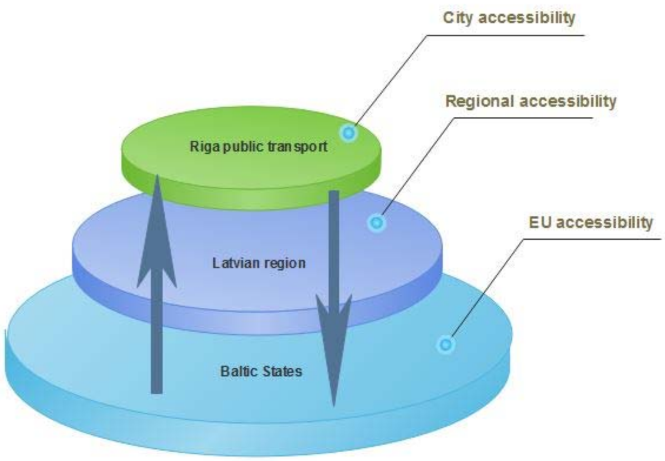


Figure 3.1. Accessibility scale in spatial levels

Boisjoly and El-Geneidy (2016) write that accessibility measures can be translated into relative accessibility indicators to compare the levels of accessibility across groups or modes (Niedzielski et al. , 2014; Páez et al., 2010) or a region (Manaugh et al., 2012; Widener et al, 2015). Handy (1997) suggested that zonal relative accessibility allows policy-makers to assess the geographic distribution of opportunities and transportation services.

Curl et al. (2015) suggested that accessibility is measured, in spatial and transport planning, using a range of objective measures designed to assess the level of accessibility provided by the transport and land-use system, usually to improve accessibility for the population.

The two most fundamental questions concerning accessibility measures defined by Baradaran (2001) are for whom, and what, and the most straightforward description of accessibility is the state of connectivity. Moreover, an accessibility measure is a powerful tool for determining the need and the effectiveness of land use, whether it can be used as a particular purpose or not. The measures of accessibility mainly consist of two parts: an attraction/activity element and a transportation element suggested by Handy et al. (1997). The activity/attraction element considers the spatial distribution of particular activities, for example, the location of shopping centres which attracts people. It can also be represented as the attractiveness of a location for a particular activity. Besides, the transport element considers the easiness of travel between the locations and can be measured by travel distance, time or cost. Accessibility can be measured by generally three different methods: cumulative opportunity method, gravity-based method and utility-based method.

The gravity-based measure developed by Hansen (1959) is still the most widely used general method for measuring accessibility, which is also called the potential location accessibility measure. This **gravity-based accessibility measure** adapted by El-Geneidy et al. (2006) can be expressed as follows:

$$A_i = \sum_{j=}^{n} D_j e^{-\beta c_{ij}} \quad (1)$$ where,

A_i is a measure of accessibility from zone i to all opportunities (D) in the different zones j
c_{ij} is the cost of travel between i and j (Sheikh Ariful Alam, 2013)

It was offered to use the groups of indicators for accessibility assessment to identify the aspects of planning efficiently operated transportation hub, based on the list offered by de Stasio et al. (2011):

Accessibility as the outcome of two functions and determined for the area i:

$$A_i = \sum_j g\left(W_j\right) f\left(c_{ij}\right) \quad (2)$$ where,

W_j is the attractiveness to be reached in area j
c_{ij} is the “effort” for reaching area j from area i

The functions $g\left(W_j\right)$ and $f\left(c_{ij}\right)$ are called “activity function” and “**impedance function**”, respectively. According to the form of the functions, different types of accessibility indicators are calculated (de Stasio C., Fiorello D., Maffii S., 2011)

Travel cost, where $g\left(W_j\right)$ has value “1” or “0” depending on the destination zone (“1” for zones where attractiveness exceeds a given threshold) and the impedance function is travel time or travel cost itself.

Daily accessibility, where $f\left(c_{ij}\right)$ is expressed in terms of travel time and only destinations within 24h (or another threshold) are considered.

Potential accessibility, where the impedance function is generally nonlinear, (e.g. exponential), also the activity function may take account of agglomeration effects, economies of scale and therefore can be nonlinear.

The accessibility indicators can be calculated as Interconnectivity Ratio and Closeness Centrality. **Interconnectivity Ratio** proposed by Krygsman (2004) is the proportion of access and egress time to/from the network to the total trip travel time and calculated for the area i:

$IR_i = \sum_j (AT_{ij} + ET_{ij}) / \sum_j TotT_{ij}$ (3) where,

AT_{ij} is the access time to the network for reaching area j from the area I
ET_{ij} is the egress time from the network for reaching area j from the area I
$TotT_{ij}$ is the total travel time for reaching area j from area i

This indicator stems from the consideration that access and egress stages are the weakest part of a multimodal chain, and their contribution to the total travel disutility is often substantial.

Closeness Centrality is applied to multimodal transport, derived from the graph theory and provide measures of nodes "centrality" within a graph, i.e. its relative importance. It is defined by the inverse of the impedance between the node i and all other nodes in the network

$CC_i = (N-1) / \sum_j Dist_{ij}$ (4) where,

$Dist_{ij}$ is the impedance between nodes i and j (i,j ϵ N and i≠j)
N are all nodes in the network

Closeness Centrality increases when the impedance between the zones is reduced but does not provide any specific information on how the existing interconnections work. This aspect can be considered in the definition of the impedance and can be measured in alternative ways: distance, travel time, travel cost. Other measures of impedance where a penalty for transfer time is applied could be used to emphasise the role of interconnectivity.

The approach requires using the given measures above the measuring actual TS accessibility and modelling the planning TS accessibility. At that moment, multidimensional analysis of the current state of accessibility and the future state could not be analysed because of the lack of data about all the needed aspects for measures calculation.

3.3. Public transport accessibility

The attempt to develop public transport (PT) accessibility measures have been discussed in the studies since the 1950s and continues to receive growing attention as Schoon et al. suggested (1999). The SUMMA project (2003) fulfilled among the above measures groups the following ones for PT accessibility:

- Infrastructure-based: level of satisfaction of users of the public transport network;
- Person-based: accessibility of the public transport network, commercial speed of the regional PTS.

Mamun and Lownes (2011) point out the following measures: Service Coverage, Time-of-Day, Waiting Time, Service Frequency, Demographic data, Vehicle Capacity, Route Coverage, Travel Time, Travel Cost, Hours of Service, Walking Route, Access distance, Comfort & parking, Network connectivity, Vehicle Capacity. Alonso et al. (2015) represented the density of public transport network as location-based accessibility measure and the quality of public transport as utility-based one.

Accessibility indicators extend the quality of access to the UPTS system, including interface with other modes (European Union, 2002). They could refer to the external interface, the internal interface and ticketing. Concerning the internal interface, some examples are the presence of lifts and/or escalators as measures of satisfaction, the average walking time between travel points and average access, egress and interchange times as measures of performance. Ticketing indicators relate to the ease of obtaining a ticket and/or performance of ticket selling services. Table 3.7 shows the summary of PTS accessibility definitions, components and recommended indicators for UPTS service accessibility estimation (Pticina, 2015).

Table 3.7. Definitions of public transport accessibility and accessibility indicators (Pticina, 2015)

Source	Definitions	Indicators	
Hillman and Pool (1997)	The combination of walk time to a stop and the average waiting time for service at that stop	travel time	Public Transportation Accessibility Level (PTAL)
EN13816 (2002)	Accessibility is access to the PT system including interface with another transport mode	external interface	to pedestrians, to cyclists, to taxi users, to private car users
		internal interface	entrances/exits, internal movement, transfer to other PTS modes
		ticketing	acquisition on the network, acquisition of network, validation
TRB (2003b)	A measure of the ability of all people to get to and from the nearest transit stop or station and their actual origin or destination	transit stop, accessibility, accessibility to persons with disabilities	network connectivity index, response (access) time, fleet composition, transit service accessibility index, number of are media sales outlets
Tyrinopoulos and Aifadopoulo (2008)		easy accessibility to elderly and disabled persons; the distance between the origin point and the ticket selling point; the distance between the ticket selling point and the embarkation stop point; distance and time between the interchange points; journeys execution at the terminal stations	
EUROSTAT (2014)	A number of people that can be reached by transport where the attractiveness of destinations is defined by their population size, subject to the car travel time to reach them.	accessibility by multimodal road accessibility	
Cascetta and Cartenì (2014)	Accessibility indicators extend the quality of access to the PPT system, including interface with other modes.	internal interface	lifts, escalators, the average internal walking time between travel points, weighted by passenger numbers; average access, egress and interchange time, weighted by passenger numbers
		ticketing	ease of obtaining a ticket; quality of the integrated fare; performance of ticket selling service integrated fare

3.4. Conclusions

The accessibility is the main feature of the transport system that needs to be estimated and analysed. Accessibility analysis affects the development of the whole urban transport system. This indicator also affects spatial levels; which need to be analysed separately. The potential accessibility today is an essential factor in the development of territories, regions and cities. Providing a link between transportation and land-use models, accessibility can be seen as an indicator to assess transport and land-use policies, especially in urban structures. The concept of accessibility thereby goes beyond the framework of the transport system and its purely temporal dimension, associating it with a spatial dimension. Accessibility should reflect the spatial organisation and the quality of the transport system that provide individuals (alone or in groups) with the opportunity to participate in the activities located in different parts of the region (Geurs K.T., van Wee B., 2004). Accessibility is affected by many factors like mobility, quality and affordability of travel options, mobility substitutes, but in term of multimodality - connectivity of the transport system and land use features are most important. Geurs (2001) examined accessibility under the view of the combination of transport modes and the easiness to make a combined transit trip. However, Litman (2012) suggested that the quality and location of a transport terminal, as well as the connection between links and modes, also affect the accessibility level of the terminal.

Moreover, accessibility can be defined as the ease with which an individual can reach a location to perform an activity. Public transport accessibility is defined as the quality of PT, serving a particular location and the ease with which travellers can access public transport service.

The decision-making process should involve integrated institutions, networks, stations, user information, and fare payment systems and consider all significant impacts. The main question in the research – how multi-modal transportation planning requires an evaluation of factors that are affecting accessibility and how they are currently considered in the planning of the infrastructure object.

4. EVALUATING RIGA TRANSPORT SYSTEM ACCESSIBILITY

4.1. The impact analysis of new interchange development

Transport System (TS) development is the main goal for the municipalities. For the development of the Riga transport system (RTS), there is a large number of documents that have been produced in the past few years and focus on the improvement of traffic and transport conditions. These documents have different scopes, purposes and timescales, but a visible roadmap for this implementation is missing, see Figure 2.1 and Figure 4.2

Moreover, none of these documents describes the procedure step by step, what needs to be done for new transport infrastructure objects and particularly – interchanges' development. After literature analysis, participating in the summer schools and workshops regarding the transport system and interchange analysis, that was organised during the project ALLIANCE (http://alliance-project.eu/), the procedure of the impact analysis that needs to be conducted in such cases, has been crystallised.

Yatskiv and Budilovich (2017a) discussed the project Riga Central Multimodal Public Transportation Hub (HUB) and provided the procedure for the evaluation of accessibility measures of RTS before the planned reconstruction.

For the analysis of the new HUB influence, the procedure of the impact analysis was implemented. At the first stage, it is necessary to prepare the system analysis of the concrete city's TS and define the most significant indicators of sustainable development for evaluation. In the case of Riga, based on the conclusions of expert interviews (Table 2.7), accessibility was determined as the most significant indicator. Stakeholders' definition and their appropriate involvement are one of the primary procedure goals. The impact analysis procedure with the defined indicator is presented in Figure 4.1.

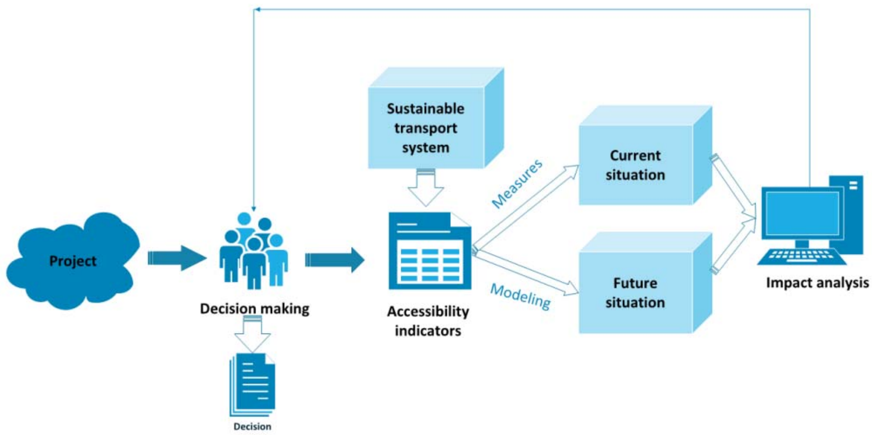


Figure 4.1. The procedure of impact analysis with the defined indicator

The structure of the process and documentation for new interchange project analyses are presented in Figure 4.2. For the new interchange design and implementation, several regulations from different spatial levels (EU, national, local) exist. Since the interchange is part of TS, any project associated with its implementation should be considered at an acceptable level for all groups of passengers with considered PT quality components (Table 1.8)

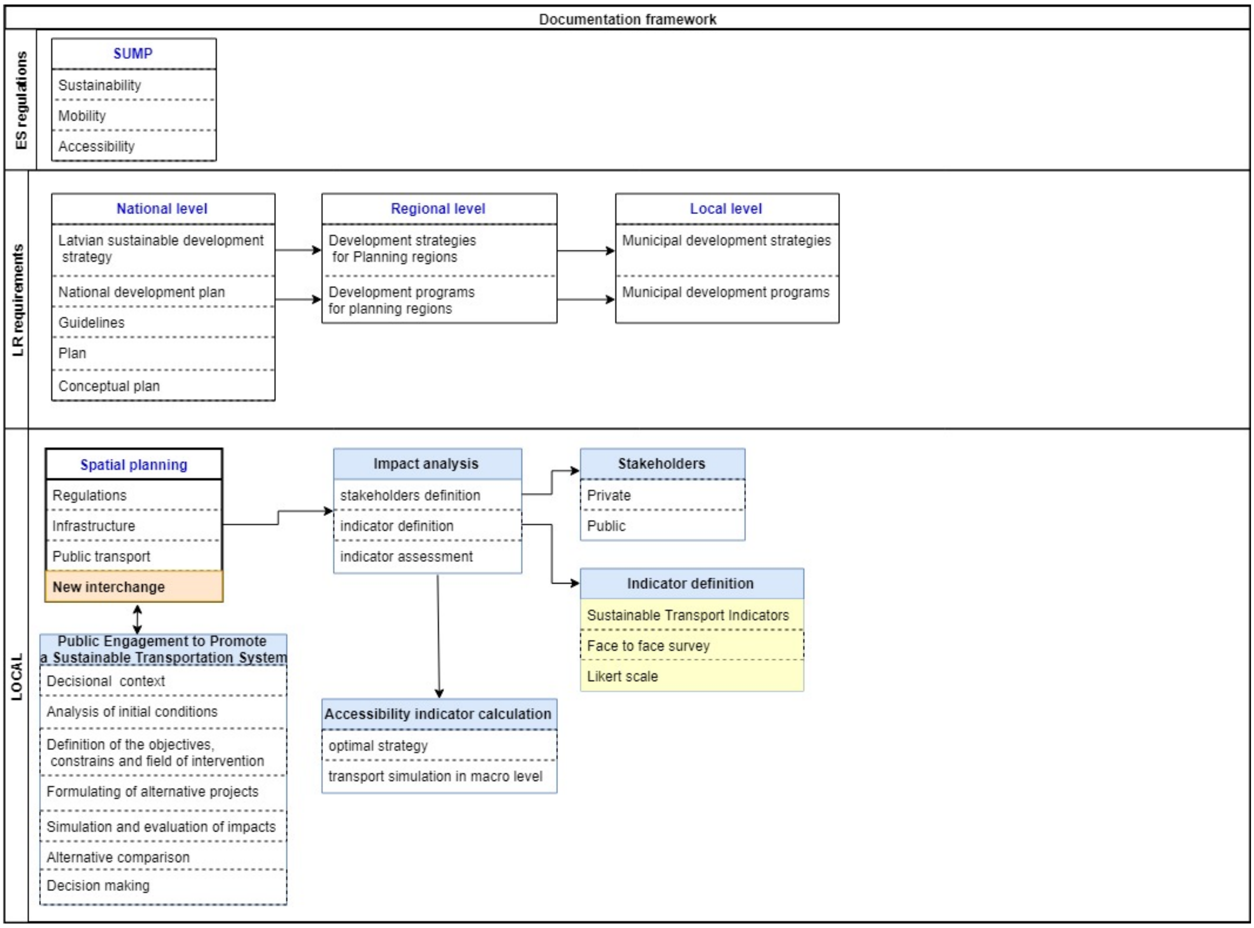


Figure 4.2. The new interchange project analysis process

For the thesis Subject analysis one of the four the Riga interchanges was chosen – RICT.

The entire spectrum of analysis and synthesis of interchange is demonstrated. It was impossible to realise everything due to the amount of needed data and complexity of the evaluation process, so the part of the necessary information was kindly presented of the RICT chairwoman Vaira Gromule.

The sustainable indicator that was defined in the second chapter of the research – accessibility needs to be evaluated. The analysis of the new infrastructure object development can be complicated, that why is advised to analyse the existing object in our case the interchange Riga international coach terminal (RICT). The indicator evaluations help to analyse the accessibility level of the RICT.

4.2. The evaluation of Riga transport system accessibility

The body of the paragraph is published in the author paper "Evaluating Riga Transport System Accessibility" in collaboration with the author Yatskiv (Jackiva) I. (Yatskiva (Jackiva) I., 2017b).

For a complete analysis of the accessibility, both data on demand and supply are needed. However, there is no information about demand because the travel survey in Riga agglomeration was not done. The main idea of the paragraph is to analyse the accessibility of PT. That is why the auto-assignment methodology was not discussed. The existing auto-assignment data (journey time and the traffic flow) was taken to analyse, and simulation was not done. The data was taken only for the comparison of the results.

Riga development strategy until 2025 (RD PAD, 2005) defined that the indicator of average travelling time, PT must be not higher than 37 minutes in 2005, but in the future – 30 minutes. Using the above-described methodology, the PT impedance was calculated. The simulation results of the travelling time by public transport and by car from zones are displayed in Figure 4.3 and Figure 4.4. Colours in the figures mean intervals from 0 to 48 minutes (green: 0–8, yellow: 8–16, light blue: 16–24, blue: 24–32, orange: 32–40, red: 40–48, purple: >48) and distribution shows how long it takes to get from all zones to one, where the new HUB is planned. Circles represent the TAZ of the city, which are used for the simulation.

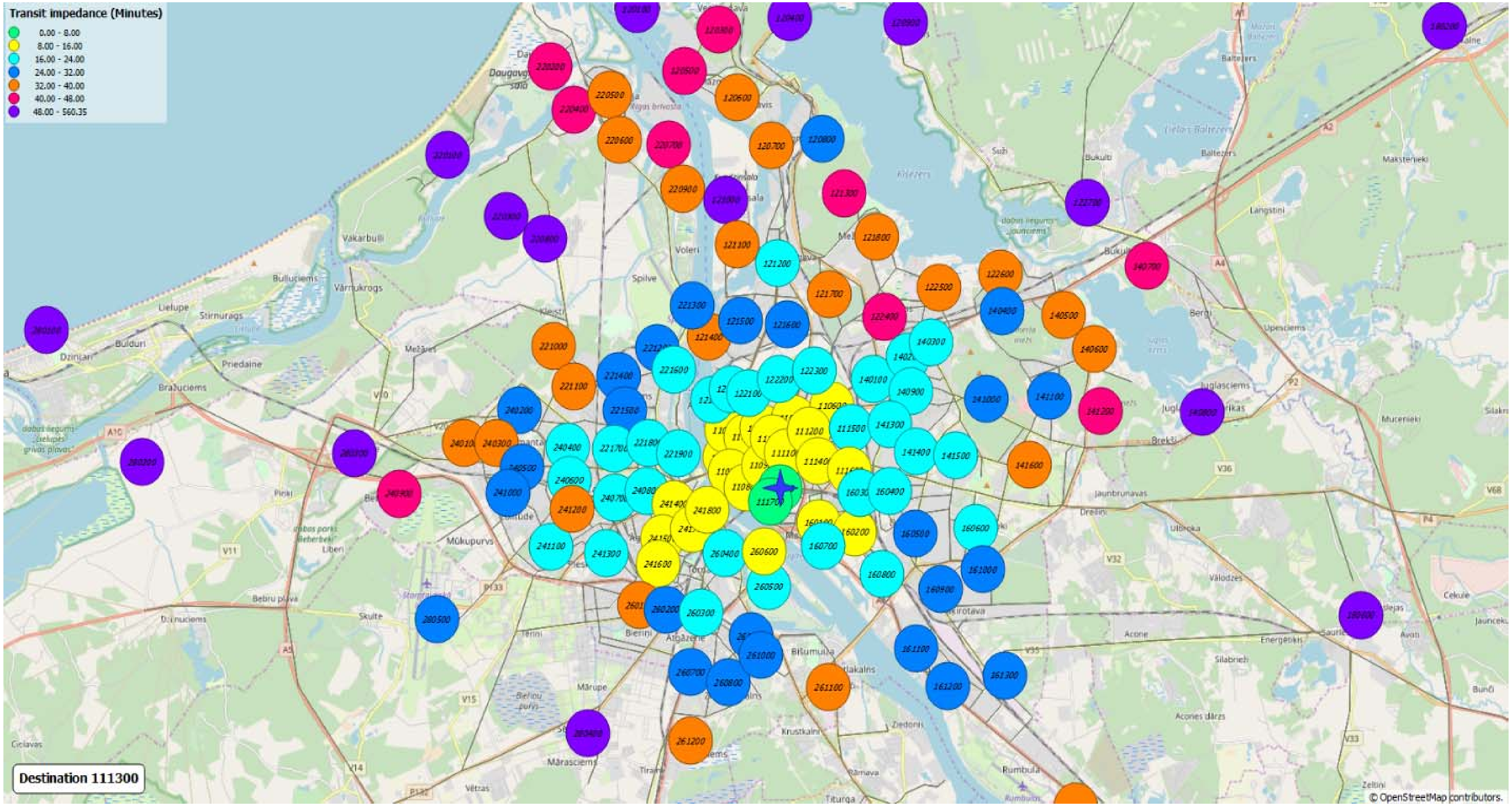


Figure 4.3. Results of accessibility by PT calculation (in min, EMME)

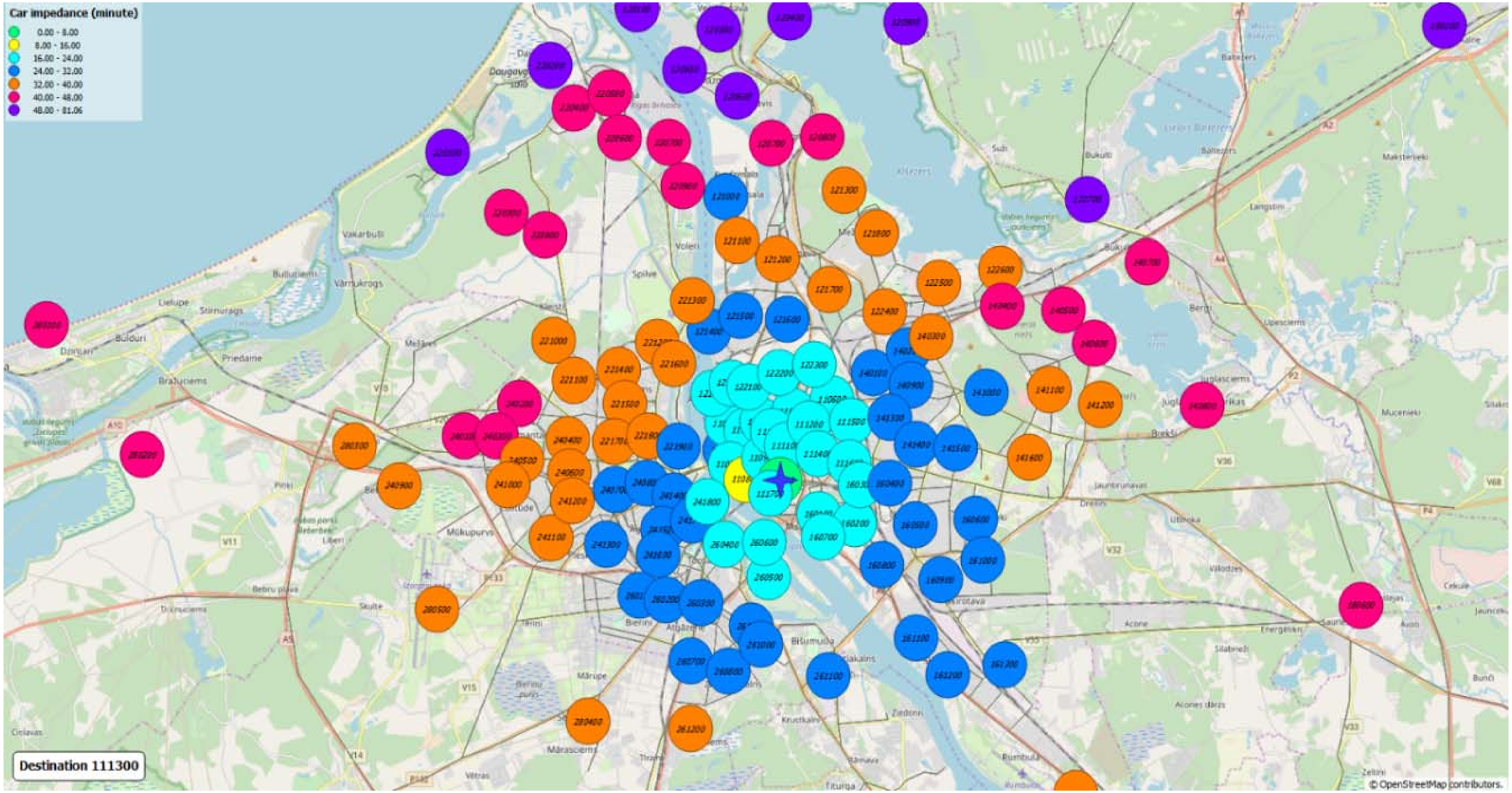


Figure 4.4. Results of accessibility by car calculation (in min, EMME)

As mentioned, for modelling are used 180 TAZ. The task was to analyse the accessibility by PT in Riga, so, the rest of the territory of Latvia was not accounted for in the research.

Data from Figure 4.3 and Figure 4.4 show that travelling by car is faster than travelling by PT. It means that residents from 31% of zones can reach the centre by car in the interval of time between 24 and 32 minutes, while the respective proportion by PT is 20%. The results show that only 77% of the total number of zones have good accessibility by PT to reach the centre. As for travelling by car this results is 93%. The zone analysis is presented in Figure 4.5.

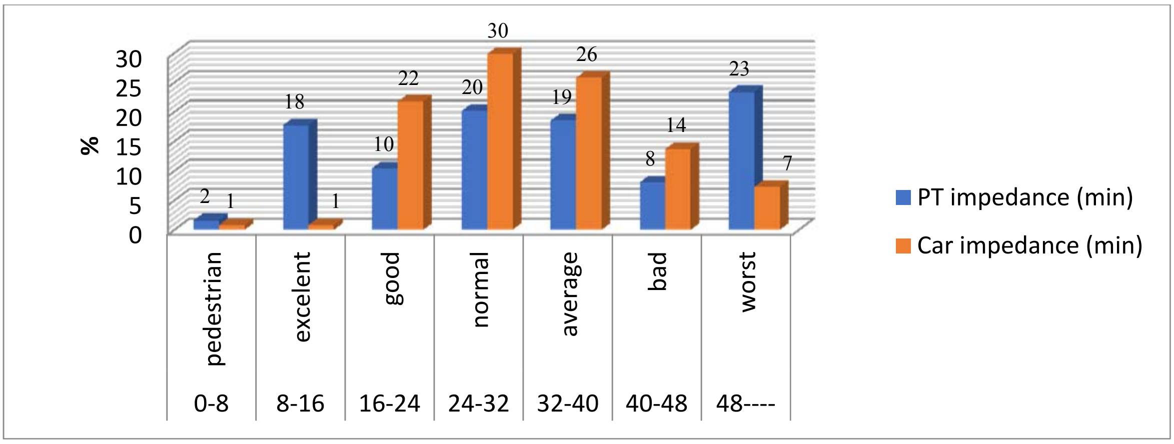


Figure 4.5. Representation of zones accessibility by PT and cars

All zones having high travel time are situated in a suburb and the periphery territories. The simulation results reveal that the most significant part of city zones with a low level of accessibility is situated in the core territory. The research will analyse the accessibility by PT and by car from all zones to one (centre) for the current UTS situation without new HUB construction.

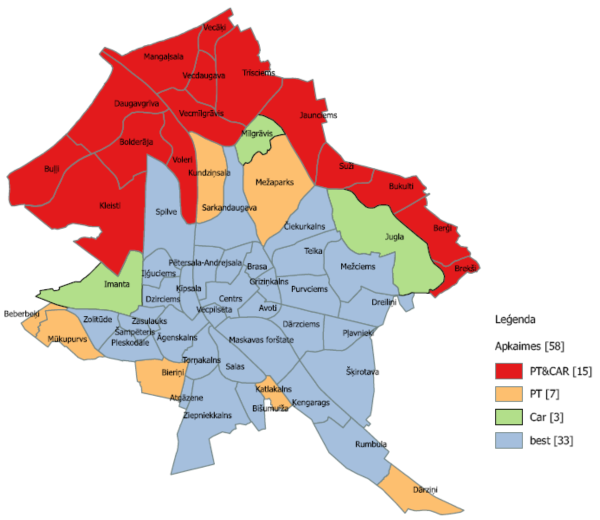


Figure 4.6. Accessibility of the city centre by PT and cars

From an overview of zones with high of travel times that need to be improved, we can conclude that 14 zones situated in the north and north-west, have substantial accessibility problems both by car and PT (Figure 4.6). Figure 4.6 presented colours mean that the red colour:

problematic zones for PT and cars, camel: problematic zones for PT, green: problematic zones for cars, blue: no problematic zones. It means that UTS needs to be deeper analysed to solve the problem of accessibility.

The results indicate that it is necessary to continue to popularise the movement by PT, for example, to continue developing the policy of various benefits for travel by PT. Also, it is necessary to create multi-modal hubs and introduce the multimodal principles in RTS for passenger convenience and travel time-saving. It is also necessary to create a route that would connect peripheral areas because now the major part of routes has the terminus of the route in the city centre. The demand of passengers must be analysed to other routes.

Moreover, it is recommended to continue to implement the planned transport infrastructure and conduct an ex-ante holistic analysis of RTS state after its implementation.

4.3. Case study: Riga International Coach Terminal (RICT) as an interchange and its influence on the transport system sustainability

4.3.1. The methodology of RICT analysis

At present above, RICT is one of the most important transportation hubs in the country. It was registered in the Coach terminal register of Ministry of Transport, and its core business is the provision of services to passengers and overland passenger transportation companies. Coach terminal relationship with passenger carriers is governed by mutual agreements based on the laws of the Republic of Latvia, terms of the Cabinet of Ministers and other state institution legislation.

The Board of the Riga International Coach terminal operates by statutes and decisions of the shareholders. According to the concept of the development of coach terminal, the Board's mission is to create RICT as a passenger transfer and complex services point in the European passenger transport network.

RICT is a leader in the area of passenger bus transportation services in Latvia (151 803 routes in 2018). From all routes, 15% take international routes, and 83% accrues to the long-distance routes. RICT serves approximately more than 1.7 million passengers per the year 2018.

The analysis of the influence of the new HUB into existing TS is the goal of research. The analysis of the interchange in this system gives an overview of the analysis process that needs to be done. For this aspect, the following activities for the current situation of RICT analysis were done:

1. RICT stakeholders' definition;
2. RICT accessibility analysis for the intermodal trip (long-distance);
3. RICT analysis:

A. the survey of traveller satisfaction

B. decision tree creation for the quality indicator benchmarking

C. stakeholders' survey of quality services

D. GAP analysis between users and stakeholders

E. interchange accessibility level evaluation

4. A meta-analysis of interchanges: RICT and EU best practices;
5. Information services implementation in the Riga interchanges.

Figure 4.7 explains the process and activities that were provided for analysis of the TS and RICT.

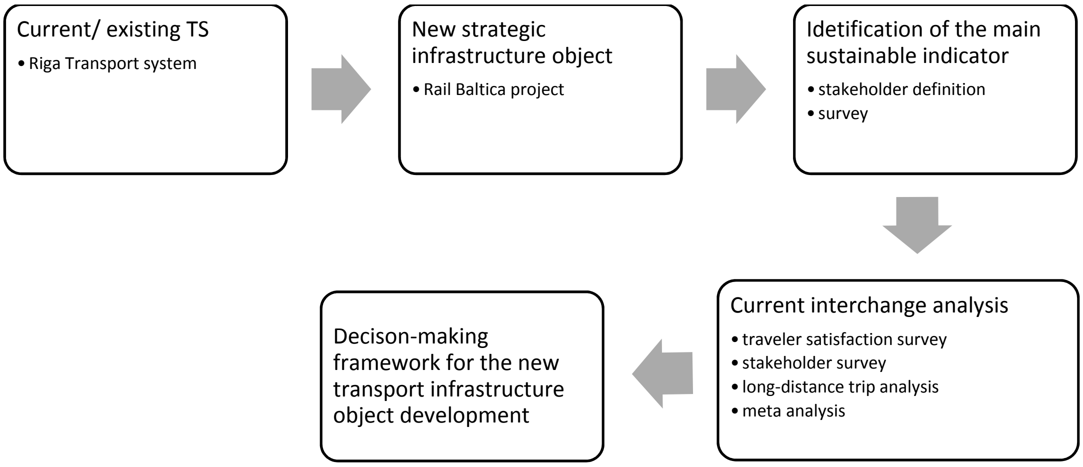


Figure 4.7. Chain of process and activities for RICT analysis

4.3.2. RICT stakeholders' definition

As it was described in the previous chapter of the thesis, firstly, it is necessary to define the involved stakeholders. RICT is a private joint-stock company, with three shareholders: municipality company (49.99%), private companies (14.17%) and individuals (35.84%). The management of the interchange is under the supervision of the central government, while the private sector bears the financial responsibility. According to the scheme (Figure 1.11), the stakeholders that are involved in the decision-making process in RICT are represented in Table 4.1.

After the stakeholder definition, it seems that the decision-making process between the dedicated parts is very complicated, mainly because private, state and other authorities are involved in the processes.

Table 4.1. RICT stakeholders

Transport actors	Government/ authorities	Local communities/neighbourhood actors	Business and commercial	Others (academics, stakeholders' specific to the context)
modal operators: regional coach, international coach users: travellers	Local government: Riga City Council, Riga planning region	Faith leaders	Local chambers of commerce/ business associations	Universities and educational/ training establishment
other related transport service operators: taxi (Air Baltic, Panda, Redcab….)	Politicians: Ministry of transport, Auto transport direction, EU directive	Local community organisations/ groups (sports group, scouting movements): Union of municipality Governments	Retailers or retail/ commercial groups that will use or rent space in the interchange for a commercial purpose: Bank, Café, Shops, Kiosk, Pharmacy, International coach companies	Special interest groups (environmental groups)
car/bike sharing groups	traffic/transport police/emergency service	Transport users group: people with disability, families with children 3+	Local major employers	Expert and consultants
other mobility providers: Association of Paneuropean coach terminals APC	health and safety executives/local hospital	Representatives of a marginal/minority or hard to reach groups		Financial actors
tourist agency: LIVE Rīga, Maks Travel agency, Latvia tours	neighbouring town council representatives	Local environmental groups: Baltic environment forum (Latvia)		
other partners: Ticket reservation (Bezrindas.lv, Bus Europe, BTI)				

4.3.3. RICT accessibility analysis for the intermodal trip (long-distance)

The body of the paragraph is published in the author paper "Accessibility to Riga Public Transport Services for transit passengers" in collaboration with the authors: Yatskiv (Jackiva) I., Gromule V. (Yatskiva (Jackiva) I., 2017c).

Riga development strategy until 2025 (RD PAD, 2005) defined that indicator of average travel time, PT must be not higher than 37 minutes in 2005, but in 2025 – 30 minutes. The transport planning experts' point of view is that the access to stops from the household must be not higher than 8 minutes. This time does not regulate in normative acts. That is why, for analysis, the access time was taken 10 min and for egress -8 min as defined by Krygsman (2004).

Based on the above-presented methodology, the long-distance journey time and their distribution between inter- and intra- parts were analysed. Table 4.2 represents results of travel time's calculation for the journey for/to RLC to/for four most problematic zones in Riga City – with high travel time to the centre (40 and 48 min).

Table 4.2. Journey time from/to regional Latvia cities from/to different zones in Riga City

Intercity				Intracity				Sum of journey time, hours	Intracity time to total journey time, %
From/to	Riga (RICT)			Riga City (RICT – Riga City directions)					
	Access time, min	Journey time, hours	Delay time, min	Access time from RICT until PT stop	City directions	Journey time (minimum), min	Egress time, min		
Ventspils	10	3.23	6	5	Dārziņi	48	8	4.51	28.43
			6		Brekši	48		4.51	28.43
			9		Čiekurkalns	40		4.43	27.09
			3		Mārupe	48		4.46	27.63
Liepaja	10	3.58	6	5	Dārziņi	48	8	4.86	26.39
			6		Brekši	48		4.86	26.39
			9		Čiekurkalns	40		4.78	25.10
			3		Mārupe	48		4.81	25.62
Rezekne	10	4.20	6	5	Dārziņi	48	8	5.48	23.40
			6		Brekši	48		5.48	23.40
			9		Čiekurkalns	40		5.40	22.22
			3		Mārupe	48		5.43	22.70
Daugavpils	10	3.59	6	5	Dārziņi	48	8	4.87	26.33
			6		Brekši	48		4.87	26.33
			9		Čiekurkalns	40		4.79	25.05
			3		Mārupe	48		4.82	25.57
Valmiera	10	2.07	6	5	Dārziņi	48	8	3.35	38.27
			6		Brekši	48		3.35	38.27
			9		Čiekurkalns	40		3.27	36.70
			3		Mārupe	48		3.30	37.34
Valka	10	3.42	6	5	Dārziņi	48	8	4.70	27.29
			6		Brekši	48		4.70	27.29
			9		Čiekurkalns	40		4.62	25.97
			3		Mārupe	48		4.65	26.50

Table 4.2 compiles the intercity journey times from RLC to Riga (RICT) and the estimated average times of delay. The delay time was included because there is a considerable problem to access the PT stops from RICT (especially for analysing destinations). Intracity trips were taken for four areas with high travel time to the centre (40 and 48 min). The accessing time from RICT until PT stop was evaluated and equal to 5 min and egress time is calculated from the bus stop until the household. Average of delay time was estimated based on macro modelling. The ratio between the intracity part of full travel and total time is presented in the last column.

Table 4.3 presents data about intercity and intracity journey time for/to BS to Riga City. After analysing the analysis of the results, it can be suggested that travelling by PT (intracity part) for international journeys takes a quarter of the total travel time. And for regional trips (result analysis from Table 4.2) the intracity part takes more than 25% of total travel time. It should be taken into account that the minimum delay and the access/egress times have been used in estimation. Therefore, to attract more passengers for using public transport for long distances need to carefully analyse the intracity part of long-distance travel and try to do this part more convenient.

Table 4.3. Journey time from/to Baltic states capitals from/to different zones in Riga City

Intercity				Intracity				Sum of journey time, hours	Intracity time to total journey time, %
From/to	Riga (RICT)			Riga City (RICT – Riga city directions)					
	Access time, min	Journey time, hours	Delay time, min	Access time from RICT until PT stop	City directions	Journey time (minimum), min	Egress time, min		
Vilnius	10	3.90	6	5	Dārziņi	48	8	5.19	24.71
			6		Brekši	48		5.19	24.71
			9		Čiekurkalns	40		5.11	23.48
			3		Mārupe	48		5.14	23.98
Tallinn	10	4.2	6	5	Dārziņi	48	8	5.48	23.40
			6		Brekši	48		5.48	23.40
			9		Čiekurkalns	40		5.40	22.22
			3		Mārupe	48		5.43	22.70

The quality of the trip, especially in the transfer node of the multimodal journey is also very important to assess.

The long-distance trips between Baltic State capitals are trendy for businesspersons who go for meeting and conference and, of course, they respect quality, comfort and affordability of coach carries. The analysis of the user's satisfaction will be described below.

4.3.4. Analysis of indicators that leads to a high level of traveller's satisfaction

4.3.4.1. The survey of traveller satisfaction (A)

The body of the paragraph is published in the author paper "Assessing the Design and Operation of Riga's International Coach Terminal" in collaboration with the authors: Tsami M., Magginas V., Adamos G., Yatskiv (Jackiva) I. (Tsami M., 2018a).

The survey of traveller satisfaction provides the data for analysis of the quality and comfort of the RICT passengers. The survey, organized by the Transport and Telecommunication Institute in cooperation with RICT. The questionnaire was divided into three sections. The first one consisted of general trip information questions, such as origin and destination, trip stage, travel purpose, trip duration and means of transport used to travel to and from the terminal. The second section was dedicated to passenger satisfaction questions. In this part, each passenger was required to assess a number of indicators for each of the eight groups. Passengers were asked to rate each indicator on a Likert scale, with 1 being the lowest possible score and 5 being the highest. In this section, passengers also chose the three most important aspects of an interchange from a list of eight items. These items were information, waiting areas, safety and security, services, shops and cafes, transport communication between different modes, access to the interchange and other (in which case the respondents were asked to specify their answer). The last section contained questions aiming at personal information, such as gender, age, education level, employment status and net-income per month. The poll was realized in Spring 2017, including a pilot implementation (17% of the total sample), a face-to-face survey (45% of the total sample), an online survey (15% of the total sample) and a focus group (students) survey (23% of the total sample). Achieving a response rate of 95%, the final sample was determined to 239 users. The application form example was taken from the City-HUB project (City-HUB Project, 2015) and adapted into local needs (the questionnaire was translated into Latvian and Russian languages), see in Appendix 2.

The sample data analysis represents that 62% of the respondents are women and the rest 38% men. 35% of the users are between 18-25 years old; the 30% of them between 41-65, the 28% between 26-40, the 3% of them younger than 17, the 3% older than 66 years old, and the rest 1% preferred not to answer this question — indicative characteristics of the sample presented in Table 4.4.

Regarding the education level of the respondents, it was observed that the majority of them (55%) is highly educated, the 24% have received a secondary level of education, the 15% holds a secondary professional level diploma, and the rest 6% are primarily educated.

Also, the majority of respondents (41%) live in households with 1-2 people, 22% in households with three people and the rest 37% in households with more than four people. Focusing on the respondent employment status, it was indicated that the 64% of them are employed, the 24% are students, the 3% are unemployed, and the rest 9% respondents stated a different status.

Lastly, regarding the monthly net-income of respondents, the 28% of them have income 200-499 EUR, the 27% 500-799 EUR, the 28% greater than 800 EUR, and the rest 17% lower than 200 EUR.

Table 4.4. Indicative characteristics of the sample

Characteristics		Proportion (%)
Gender	Female	62
	Male	38
Age	<17 years	3
	18-25 years	35
	26-40 years	28
	41-65 years	30
	>66 years	3
	Would prefer not to say	1
Education	High	55
	Secondary	24
	Secondary professional diploma	15
	Primary	6
Employment status	Employed	64
	Unemployed	3
	Student	24
	Other	9
Trip purpose	Work	17
	Education	10
	Leisure or visiting family and friends	59
	Other	14
The frequency of using RICT	More than four days a week	5
	3 or 4 times a week	7
	Once or twice a week	10
	Few times a week	20
	Less frequently	58

Adamos (2019) suggested that nowadays, an interchange is more than just a simple node in a network; it has many elements. In this context, identifying and monitoring users' requirements is vital to achieving the most appropriate policy measures for urban transport interchanges, because they are particularly affected by the provided quality of service.

For each indicator used to assess the quality of service in RICT, absolute, and relative frequency distributions were estimated (Table 4.5), referring to each point of the ordinal scale (1 to 5). In all cases, the total number of the absolute and relative frequency distributions sum up to the total sample (239 respondents) and 1 (or 100%), respectively. Frequency distributions facilitate the analysis of qualitative data and have been previously applied in surveys evaluating passenger satisfaction at interchanges (Eboli, 2009).

Table 4.5. Absolute and relative frequency distribution of travellers' satisfaction

Criteria	Indicators	Very dissatisfied		Dissatisfied		Neither		Satisfied		Very satisfied	
		Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Travel information	Availability and ease of use of travel information at the terminal	5	0.02	12	0.05	44	0.18	103	0.43	75	0.31
	Availability of travel information (timetables, routes, delays) before your trip	7	0.03	14	0.06	42	0.18	97	0.41	79	0.33
	Accuracy and reliability of travel information displays for bus/trains at the terminal	3	0.01	14	0.06	46	0.19	102	0.43	74	0.31
	Ticket purchase	4	0.02	16	0.07	46	0.19	81	0.34	92	0.38
Wayfinding information	Signposting to different facilities and services	9	0.04	24	0.10	68	0.28	86	0.36	52	0.22
	Signposting to transfer between transport modes	17	0.07	40	0.17	69	0.29	79	0.33	34	0.14
	Information and assistance provided by staff	9	0.04	29	0.12	68	0.28	79	0.33	54	0.23
Time and movement	Transfer distances between different modes	4	0.02	19	0.08	65	0.27	90	0.38	61	0.26
	Co-ordination between different transport operators or transport services	9	0.04	33	0.14	76	0.32	87	0.36	34	0.14
	Use of your time (transferring & waiting)	7	0.03	34	0.14	71	0.30	81	0.34	46	0.19
	Distance between the facilities and services	4	0.02	18	0.08	51	0.21	84	0.35	82	0.34
	Ease of movement due to number of people	4	0.02	36	0.15	61	0.26	80	0.33	58	0.24
Access	Ease of access to the terminal	1	0.00	17	0.07	51	0.21	89	0.37	81	0.34
	Ease of access from the terminal	2	0.01	12	0.05	53	0.22	85	0.36	87	0.36
Comfort and convenience	General cleanliness of the terminal	17	0.07	41	0.17	74	0.31	70	0.29	37	0.15
	Temperature, shelter from rain and wind, ventilation, air conditioning	6	0.03	35	0.15	69	0.29	72	0.30	57	0.24
	General level of noise of the terminal	11	0.05	32	0.13	82	0.34	79	0.33	35	0.15
	Air quality, pollution (e.g. emissions from vehicles)	17	0.07	46	0.19	79	0.33	66	0.28	31	0.13
	Number and variety of shops	22	0.09	44	0.18	88	0.37	49	0.21	36	0.15
	Number and variety of coffee-shops and restaurants	28	0.12	49	0.21	77	0.32	47	0.20	38	0.16
	Availability of cash machines	14	0.06	33	0.14	66	0.28	81	0.34	45	0.19
	Availability of seating	22	0.09	51	0.21	67	0.28	62	0.26	37	0.15
	Availability of mobile phone signal and Wi-Fi	13	0.05	36	0.15	53	0.22	65	0.27	73	0.30
	Comfort due to the presence of information screens	6	0.03	31	0.13	69	0.29	87	0.36	46	0.19
Station attractivenes s	The surrounding area is pleasant	27	0.11	60	0.25	80	0.33	45	0.19	27	0.11
	The internal design of the terminal	35	0.15	60	0.25	83	0.35	38	0.16	23	0.10
	The external design of the terminal	32	0.13	49	0.21	90	0.38	44	0.18	24	0.10
Safety and security	Safety getting on and off the transport mode	5	0.02	28	0.12	87	0.36	90	0.38	29	0.12
	Safety whilst inside the terminal	19	0.08	44	0.18	79	0.33	66	0.28	31	0.13
	Feeling secure in the transfer & waiting areas (during the day)	11	0.05	39	0.16	88	0.37	57	0.24	44	0.18
	Feeling secure in the transfer & waiting areas (during the evening/night)	37	0.15	58	0.24	73	0.31	38	0.16	33	0.14

Criteria	Indicators	Very dissatisfied		Dissatisfied		Neither		Satisfied		Very satisfied	
		Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
	Feeling secure in the surrounding area	26	0.11	67	0.28	75	0.32	43	0.18	27	0.11
	Lighting	6	0.03	22	0.09	61	0.26	100	0.42	50	0.21
Emergency situation handling	Information to improve your sense of security	17	0.07	45	0.19	91	0.38	62	0.26	24	0.10
	Signposting to emergency exits	8	0.03	35	0.15	70	0.29	75	0.31	51	0.21
	Location of emergency exits in case of fire	14	0.06	33	0.14	74	0.31	74	0.31	44	0.18
Overall satisfaction	Overall score of user satisfaction	1	0.00	21	0.09	96	0.40	101	0.42	20	0.08

4.3.4.2. *Correlation and regression analysis*

For the data analysis, descriptive statistics and bivariate correlations between the variables were applied in the study. Table 4.6 shows the descriptive statistics (average rating - M, standard deviation - SD) and the correlations between the service factors. Findings reveal that the most highly rated service factors are “Access” (M=4.0, SD=0.89), followed by “Information” (M=3.8, SD=0.77) and “Time and movement” (M=3.7, SD=0.77). Station attractiveness received the lowest rating from travelers (M=2.9, SD=1.06). The average rating of the interchange was 3.5 (SD=0.79). Table 4.6 also reveals that the overall satisfaction correlates most significantly with “Station attractiveness”, and less significantly with “Access”.

Table 4.6. Average ratings, standard deviations and correlations between service factors

Service factors	Average	SD	1	2	3	4	5	6	7	8
1. Overall satisfaction	3.5	.79	-							
2. Information	3.8	.77	.631*	-						
3. Time and movement	3.7	.77	.629*	.730*	-					
4. Access	4.0	.89	.490*	.596*	.589*	-				
5. Comfort and convenience	3.4	.83	.722*	.626*	.659*	.496*	-			
6. Station attractiveness	2.9	1.06	.734*	.529*	.606*	.458*	.726*	-		
7. Safety and security	3.2	.92	.732*	.549*	.632*	.438*	.714*	.713*	-	
8. Emergency situation handling	3.4	.97	.664*	.563*	.514*	.477*	.622*	.582*	.639*	-
*p-value<0.01										

A multiple regression analysis was conducted to examine the effect of selected factors (indicators) on the general satisfaction level of travellers, and a prediction model was developed (Table 4.7). The power of the model was evaluated according to the value of the adjusted R square (adjusted R^2), as it is not prone to increase with the addition of new independent variables in the model as compared to R^2. It is also used when comparing equations' performance in adjusting in more than one not interrelated data sets (Draper (1997); Janssen (1995)). Constructs were built by the combination of the measured indicators, using alpha test (Cronbach, 1951), where Cronbach a>0.6. A confidence level of 95% and a confidence interval of 5% were assumed.

A regression model was developed, associating the overall satisfaction of travellers to factors such as “Information”, “Access”, “Station attractiveness” and “Emergency situation handling”. The regression is significant and explains 64% of the variance. Results showed that the most significant predictors of satisfaction are “Information” and “Station attractiveness”. Analytically, the relationship of each predictor (service factor) with travellers’ level of satisfaction is presented in Table 4.7.

The regression model can be represented:

Y = 0.785 + 0.317 “Information” + 0.007 “Access” + 0.316 “Attractiveness” + 0.171 “Emergency”

Table 4.7. Regression analysis: Overall satisfaction of travellers at RICT

Service factor	B	Std. Error	Beta	t	Sig.
Information	0.317	0.56	0.310	5.667	<0.05
Access	0.007	0.044	0.008	0.157	0.876
Station attractiveness	0.316	0.037	0.427	8.518	<0.05
Emergency situation handling	0.171	0.041	0.21	4.152	<0.05
Constant	0.785	0.164	-	4.781	<0.05
Adjusted R^2 = 0.64; F (4, 238) = 106.88					

The correlation degree among the individual criteria and their relationships with the criterion addressing the overall satisfaction level was also tested (Table 4.8). Results showed that the criteria, which mostly affect the overall satisfaction of users positively seem to be wayfinding information (β=0.707, p-value<0.05), then access (β=0.615, p-value<0.05) and last time and movement (β= 0.615, p-value<0.05).

Table 4.8. Bivariate correlations of the individual criteria and their relationship with the criterion addressing the overall satisfaction level

Criteria	1.	2.	3.	4.
1. Overall satisfaction	-			
2. Wayfinding information	0.707*	-		
3. Time and movement	0.548*	0.590*	-	
4. Access	0.615*	0.627*	0.487*	-
**p-value<0.05*				

After traveller satisfaction survey result analysis was defined as three main criteria such as "Access", "Time and movement", "Wayfinding information", the data were analysed through descriptive and inferential statistics presented in Table 4.9.

Table 4.9. List of evaluation criteria and indicators

Criteria	Indicators	Average rating (M)	Standard deviation (SD)
Access	Ease of access to the interchange	3.97	0.94
	Ease of access from the interchange	4.02	0.93
Time and movement	Distances between different transport operators or transport services	3.77	0.97
	Coordination between different transport operators or transport services	3.43	1.03
	Use of time at the interchange	3.52	1.06
	The distance between the facilities and services	3.93	1.0
	Ease of movement due to the number of people inside the interchange	3.64	1.06
Wayfinding information	Signposting to different facilities and services	3.62	1.05
	Signposting to transfer between transport modes	3.31	1.12
	Information and assistance provided by staff	3.59	1.08
Overall satisfaction	Level of services provided by the interchange	3.50	0.79

4.3.4.3. decision tree for the quality indicator benchmarking (B)

The body of the paragraph is published in the author paper "A decision tree approach for achieving high customer satisfaction at urban interchanges" in collaboration with the authors: Tsami M., Adamos G., Nathanail Ef., Yatskiv (Jackiva) I., Magginas V. (Tsami M., 2018b).

A decision tree was used to model how the performance evaluation of the selected indicators affects the overall satisfaction level of the terminals. Decision trees are decision making support tools that are used in data mining and artificial intelligence research and visualise the decision-making process in the form of tree-shaped structures. In these structures, there are three kinds of nodes. The first node (root node) represents the primary criterion of the decision making the procedure and is where the first branches of the structure are created. The inner (chance) nodes represent specific criteria or requirements, which based on their fulfilment by the items under consideration, form the rest of the branches of the decision tree, and the nodes found at the lowest level of the tree (leaf nodes) represent the possible outcomes of the process based on the different combinations of fulfilled criteria or requirements (Allmuali et al., (2002); (Kumar, 2014); (Song, 2015)).

Decision trees are commonly applied for decision analysis, facilitating the identification of a strategy most likely to reach a goal (Breiman et al. (1984), Quinlan (1993), Tsami (2014)). In this case, the goal is to have satisfied users and therefore, it is crucial to indicate all these elements that lead to a high level of overall satisfaction. In the framework of the study, the Weka J48 tree was used. J48 is one of the most reliable decision tree models, as well as a reliable classification method when compared to different approaches. J48 – an open Java implementation of the C4.5 algorithm (Breiman et al. (1984), Quinlan (1993)). C4.5 is a well-known, supervised learning algorithm, used for data mining and classification problems in machine learning. The algorithm (C4.5) learns a mapping from attribute values to classes, applied to classify new, unseen instances. Beginning with the root node that represents the entire dataset, the algorithm splits data into smaller subsets that denote the partitions of the original dataset that satisfy specified attribute value tests. This process continues until all instances in the subset fall in the same class, and therefore, the tree growth is terminated. A decision tree was used to model how the performance evaluation of the selected indicators affects the overall satisfaction level of the terminals. The goal is to have satisfied users and therefore, it is crucial to indicate all these elements that lead to a high level of overall satisfaction. In the study, the Weka J48 tree was used as an open Java implementation of the C4.5 algorithm.

In total, 37 attributes (Table 4.10) were analysed using the J48 classifier tree with the pruning values of 0.25 and a test mode the evaluation on training data. The developed tree had 51 nodes and 26 leaves (end nodes).

A list of representative indicators, grouped into eight groups, were used and evaluated by terminal's users. These groups deal with mobility provision, way-finding information, time and movement issues in the terminal, accessibility, comfort, station image and attractiveness, safety and security, and handling of emergencies.

This methodology works towards helping the decision-makers understand the users' perspectives and predict the most important factors contributing to their satisfaction, by studying the developed decision tree, and act accordingly to accommodate their needs. The results of the evaluation of the 37 indicators by the terminal users are presented in Table 4.11, which shows the average rating (M) and the standard deviation (SD) in columns 4 and 5, respectively. Results showed that users were mostly highly or moderately satisfied with the majority of the features and services related to the terminal's accessibility level: "Ease of access from the interchange"

(M=4.02, standard deviation SD=0.93) and “Ease of access to the interchange” (M=3.97, SD=0.94).

Table 4.10. List of attributes and coding

Attribute	Code
Availability and ease of use of travel information at the terminal	A1
Availability of travel information (timetables, routes, delays) before your trip	A2
Accuracy and reliability of travel information displays for bus/trains at the terminal	A3
Ticket purchase (ticket offices, ticket machines, etc.)	A4
Signposting to different facilities and services	B1
Signposting to transfer between transport modes in all parts of the terminal	B2
Information and assistance provided by staff	B3
Transfer distances between different transports modes	C1
Co-ordination between different transport operators or transport services	C2
Use of your time (transferring & waiting) at the terminal	C3
The distance between the facilities and services	C4
Ease of movement due to the number of people inside the terminal	C5
Ease of access to the terminal	D1
Ease of access from the terminal	D2
General cleanliness of the terminal	E1
Temperature, shelter from rain and wind, ventilation, air conditioning	E2
The general level of noise of the terminal	E3
Air quality, pollution (e.g. emissions from vehicles)	E4
Number and variety of shops	E5
Number and variety of coffee-shops and restaurants	E6
Availability of cash machines	E7
Availability of seating	E8
Availability of mobile phone signal and Wi-Fi	E9
Comfort due to the presence of information screens	E10
The surrounding area is pleasant	F1
The internal design of the terminal (visual appearance, attractiveness, etc.)	F2
The external design of the terminal (visual appearance, attractiveness, etc.)	F3
Safety getting on and off the transport mode (train, bus, taxi, bicycle, etc.)	G1
Safety while inside the terminal	G2
Feeling secure in the transfer & waiting areas (during the day)	G3
Feeling secure in the transfer & waiting areas (during the evening/night)	G4
Feeling secure in the surrounding area of the terminal	G5
Lighting	G6
Information to improve your sense of security	H1
Signposting to emergency exits	H2
Location of emergency exits in case of fire	H3
An overall score of user satisfaction with the service in the terminal	I

The criterion "Travel information", addressed by four individual indicators also received a high rating. For example, respondents consider that the available information for ticket purchase is more than adequate (M=4.01, SD=1.0).

On the other hand, travellers seem not to be satisfied with the station design, since the indicators describing "Station attractiveness" received the lowest rating: "The internal design of the terminal" (M=2.81, SD=1.16), "The external design of the terminal" (M=2.91, SD=1.15) and "The surrounding area is pleasant" (M=2.93, SD=1.17).

Also, the correlation degree among the individual indicators and their relationships with the criterion satisfaction level was investigated and measured by the Spearman correlation coefficient (Column 6). In this case, it was observed that the indicators that mostly affect positively the overall satisfaction of users seem to be: "The internal design of the terminal" ($\beta=0.675$, p-value<0.05), "The surrounding area is pleasant" ($\beta=0.674$, p-value<0.05), "Safety getting on and off the transport mode" ($\beta=0.639$, p-value<0.05), "The external design of the terminal" ($\beta=0.635$, p-value<0.05) and "Safety whilst inside the terminal" ($\beta=0.630$, p-value<0.05).

The starting node in the two selected tree paths is "Surrounding area". This indicator has been attributed to an average rating of 2.93 and showed the highest correlation with overall satisfaction (Spearman 0.674). According to both paths, in order to achieve the highest overall satisfaction (5), the threshold value of "Surrounding area" is 3, in the first occurrence of the indicator as a node and 4 in the second. So, it is expected that the overall satisfaction is rated lower, which is true, as the average value of the responses is estimated to 3.49. Same observation stands for the indicator concerning the interior of the station "Temperature, shelter from rain and wind, ventilation, air conditioning". The requirement for reaching the highest satisfaction is that this indicator receives a rating above 4. This indicator has been attributed to the value of 3.58, and with a high correlation with the overall satisfaction (Spearman 0.622), it justifies the lower rate of the latter.

"External design" is rated 2.91, which is also reflected in the actual overall satisfaction, as there is a high correlation between the two indicators (Spearman 0.635). However, according to the paths, if the previously mentioned indicators have a higher rating, the overall satisfaction is not affected negatively. Thus, "External design" is not required to have a high rating in order to achieve high overall satisfaction.

Table 4.11. Evaluation of indicators

Criteria	Indicators	Code	Average rating (M)	Standard deviation (SD)	Spearman correlation coefficient
Travel information	Availability and ease of use of travel information at the terminal	A1	3.97	0.94	0.474*
	Availability of travel information (timetables, routes, delays) before your trip	A2	3.95	1.00	0.452*
	Accuracy and reliability of travel information displays for bus/trains at the terminal	A3	3.96	0.92	0.531*
	Ticket purchase (ticket offices, ticket machines, etc.)	A4	4.01	1.0	0.416*
Wayfinding information	Signposting to different facilities and services	B1	3.62	1.05	0.492*
	Signposting to transfer between transport modes in all parts of the terminal	B2	3.31	1.12	0.557*
	Information and assistance provided by staff	B3	3.59	1.08	0.516*
Time and movement	Transfer distances between different transports modes	C1	3.77	0.97	0.377*
	Co-ordination between different transport operators or transport services	C2	3.43	1.03	0.453*
	Use of your time (transferring & waiting) at the terminal	C3	3.52	1.06	0.606*
	The distance between the facilities and services	C4	3.93	1.00	0.507*
	Ease of movement due to the number of people inside the terminal	C5	3.64	1.06	0.488*
Access	Ease of access to the terminal	D1	3.97	0.94	0.472*
	Ease of access from the terminal	D2	4.02	0.93	0.486*
Comfort and convenience	General cleanliness of the terminal	E1	3.28	1.15	0.591*
	Temperature, shelter from rain and wind, ventilation, air conditioning	E2	3.58	1.09	0.622*
	The general level of noise of the terminal	E3	3.39	1.05	0.521*
	Air quality, pollution (e.g. emissions from vehicles)	E4	3.20	1.12	0.539*
	Number and variety of shops	E5	3.13	1.17	0.512*
	Number and variety of coffee-shops and restaurants	E6	3.07	1.25	0.578*
	Availability of cash machines	E7	3.46	1.13	0.519*
	Availability of seating	E8	3.17	1.2	0.487*
	Availability of mobile phone signal and Wi-Fi	E9	3.63	1.22	0.583*
	Comfort due to the presence of information screens	E10	3.56	1.04	0.562*
Station attractiveness	The surrounding area is pleasant	F1	2.93	1.17	0.674*
	The internal design of the terminal (visual appearance, attractiveness, etc.)	F2	2.81	1.16	0.675*
	The external design of the terminal (visual appearance, attractiveness, etc.)	F3	2.91	1.15	0.635*
Safety and security	Safety getting on and off the transport mode (train, bus, taxi, bicycle, etc.)	G1	3.46	0.93	0.639*
	Safety whilst inside the terminal	G2	3.19	1.14	0.630*
	Feeling secure in the transfer & waiting areas (during the day)	G3	3.35	1.11	0.619*
	Feeling secure in the transfer & waiting areas (during the evening/night)	G4	2.88	1.3	0.600*
	Feeling secure in the surrounding area of the terminal	G5	2.90	1.17	0.576*
	Lighting	G6	3.69	0.99	0.624*
Emergency	Information to improve your sense of security	H1	3.13	1.07	0.615*

situation handling	Signposting to emergency exits	H2	3.52	1.1	0.553*
	Location of emergency exits in case of fire	H3	3.42	1.13	0.613*
Overall satisfaction	An overall score of user satisfaction with the service in the terminal	I	3.49	0.79	-
**p-value<0.05*					

The two indicators "Ease of movement" and "Information and assistance by the staff" have a lower correlation with the overall satisfaction, as compared to the previous indicators. It is required that they get a rating above 4 and 3, respectively, to lead to a high overall satisfaction. From the responses, the first received a rating below the threshold (3.64) and the second above (3.59).

"Ticket purchasing" has a low correlation with overall satisfaction (0.416). Although it received a rating 4.01, it did not lead to the highest overall satisfaction rating (5 or 4).

Interpreting the decision tree development can be concluded that the surrounding area atmosphere is the most significant indicator for users (parent node of the tree). Based on the tree results, the tree developed is highly accurate (almost 90% correctly classified instances). Results showed that eleven paths are leading to a perception of satisfaction and two paths leading to the best reasonable satisfaction. These two paths are the following:

- "The surrounding area is pleasant" >3, "Number and variety of coffee-shops and restaurants" >2, "The external design of the interchange (visual appearance, attractiveness, etc.)" >2, "Temperature, shelter from rain and wind, ventilation, air conditioning" >4, "Ease of movement due to number of people inside the interchange" >4, "The surrounding area is pleasant" >4, "Information and assistance provided by staff (e.g. at customer information points)" >3.
- "The surrounding area is pleasant" >3, "Number and variety of coffee-shops and restaurants" >2, "The external design of the interchange (visual appearance, attractiveness, etc.)" >2, "Temperature, shelter from rain and wind, ventilation, air conditioning" >4, "Ticket purchase (ticket offices, ticket machines, etc.)" ≤3. Both paths that have the highest evaluation scores deal with indicators that improve the general perception of quality in the interchange (number and variety of coffee-shops and restaurants, the external design of the interchange (visual appearance, attractiveness, etc.), temperature, shelter from rain and wind, ventilation, air conditioning). The main difference between the two paths is that the first includes more indicators and is even more focused on the perceived hospitability of the interchange facilities and the quality of offered services – the result of the analysis presented in Figure 4.8.

When testing the eleven indicators according to the education level of users, statistically significant differences were met in two indicators: signposting to transfer between transport modes (p-value=0.003) and overall satisfaction (p-value=0.009). In the first case, respondents holding a secondary professional level diploma gave the highest rating (M=3.81, SD=1.01), while on the other hand, the primarily educated were the most satisfied users of the terminal (M=3.79, SD=0.80). Employment status that is focusing on the four different cases, results showed statistically significant differences in the indicators “ease of access from the interchange” (p-value=0.046) and “overall satisfaction” (p-value=0.008). The ease of access from the interchange was rated higher from students (M=4.23, SD=0.914) and users with any other employment status (M=4.23, SD=1.02). Also, it was observed that the overall satisfaction of users travelling for work was higher (M=3.6, SD=0.79), compared to the rating of users travelling for “education” (M=3.5, SD=0.8) or “leisure/meeting with friends and relatives” (M=3.4, SD=0.79). However, these differences were not statistically significant (p-value>0.05). Also, users that do not make any transfers at the terminal were (significantly) more satisfied (M=3.6, SD=0.79) than those that make at least one transfer (M=3.3, SD=0.79) (p-value<0.05). Lastly, when grouping sample into commuters (frequent use of the station) and non-commuters, and testing the overall satisfaction, it was indicated that commuters are more satisfied (M=3.6, SD=0.8) than non-commuters (M=3.4, SD=0.79), but this difference was not statistically significant (p-value>0.05).

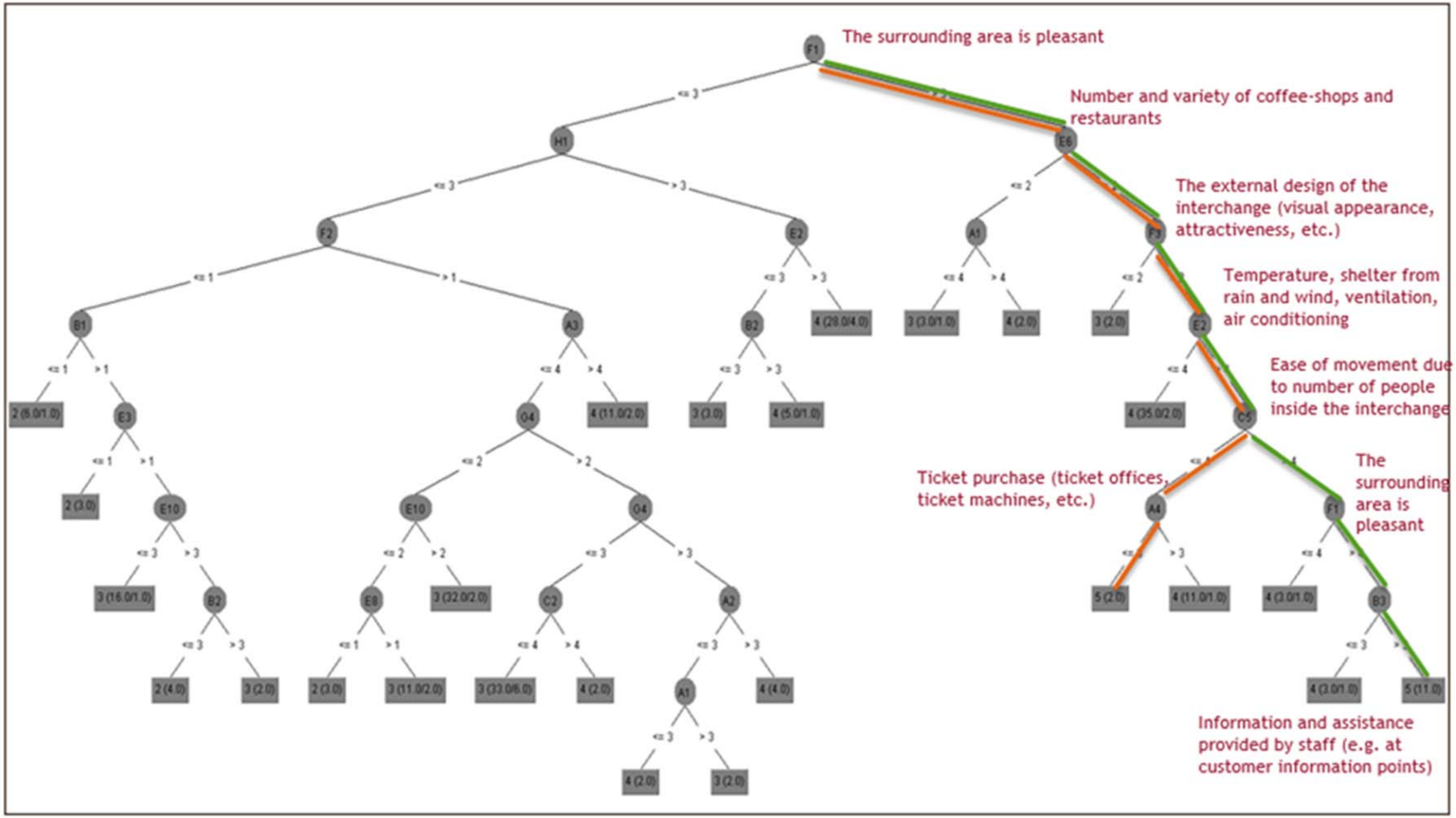


Figure 4.8. The two paths of the assessing of design and operations

4.3.5. GAP analysis between stakeholder’s estimation in service quality

4.3.5.1. The stakeholder’s satisfaction survey (C)

The results of the stakeholders' survey show that the people who work in the RICT and surrounding territory are satisfied with:

- terms of the ownership and management structure;
- the availability of space;
- the quality of transfer between modes;
- safety and security;
- the range of retail establishments;
- the quality of journey planning and real-time information.

4.3.5.2. GAP analysis between users and stakeholders (D)

The part of the paragraph was presented in the conference “European Transport Conference 2018. 10 - 12 October 2018. Dublin Castle, Dublin, Ireland”.

After the traveller and stakeholder’s satisfaction surveys necessary to understand whether there are any GAPs between users: travellers, and involved stakeholders, such as operators and public authorities, based on their expectations and the level of their satisfaction.The judgment most frequently expressed by travellers is “satisfied”, followed by “neither satisfied nor not satisfied”. Specifically, results show that the interchange-users evaluate better than aspects such as “Travel and wayfinding information”, “Time and movement”, and “Access”. On that hand, it seems that they are moderately satisfied with the design of the interchange, and the level of comfort and security provided. Overall, travellers state that they are satisfied with the quality of services in RICT.

Based on the feedback received from stakeholders, there is no cooperation between the different operators, meaning that there is not adequate connectivity between transportation modes. Regulation changes by the Road Transport Administration and respective political decisions are indicative factors that could facilitate the required connectivity. Also, in 2019, changes in regulations are expected, according to which the State will partially compensate RICT costs. Stakeholders involved in RICT consider that the interchange is fruitful in terms of the ownership and management structure, the availability of space, the quality of transfer between modes, safety and security, the range of retail establishments, and the quality of journey planning and real-time information.

Table 4.12. Comparison of travellers and stakeholder's satisfaction criteria

Services factors	Travellers		Stakeholders	
	M	SD	M	SD
Access	4.0 (1)	0.89	3.2	1.64
Information	3.8 (2)	0.77	4.1 (1)	0.56
Time and move	3.7 (3)	0.77	3.9 (2)	0.59
Comfort and convenient	3.4	0.83	3.8 (3)	0.76
Station attractiveness	2.9	1.06	3.2	0.84
Overall Satisfaction	3.5	0.79	3.8	1.39

After the descriptive statistics and the correlations between the service factors were defined that the most highly rated service factors are "Access", followed by "Information" and "Time and movement". Overall satisfaction correlates most significantly with "Station attractiveness", and less significantly with "Access".

Comparing travellers versus stakeholders' perspectives, it seems that there are some contradictory findings. For example, travellers are very satisfied with access to and from RICT – the factor received the highest rating, but the same factor has the lowest rating from the representative sample of stakeholders. Also, the travellers' overall satisfaction seems to be affected mostly by information (M=3.8, SD=0.77), and station attractiveness, which received the lowest rating (M=2.9, SD=1.06). It means that improving the attractiveness of the interchange would contribute to the increase in the level of the travellers' satisfaction. Nevertheless, stakeholders stated that they are satisfied with parameters that define how attractive the interchange is: the surrounding area (M=3.2, SD=0.84), the internal design (M=3.6, SD=0.89) and the external design (M=3.2, SD=1.48).

4.3.5.3. Interchange accessibility level evaluation (E)

The main goal of the thesis is to evaluate the transports system of Riga City. The 3.2 chapter of the thesis explains the possibility of the system evaluation using the accessibility measure calculation. The impedance function was described and calculated in the 4.2 chapter. The interconnectivity ratio (I) and closeness centrality (II) will be evaluated in the paragraph below.

(I) The interconnectivity ratio (IR)

The Interconnectivity Ratio, as proposed for public transport networks, is mostly a "network" index, and it is a reflection of the relative time catchment. […] It represents that part of the trip time that the user is physically occupied or willing to "sacrifice", to reach the public transport system and their final destination. (Krygsman et al., 2004).

The interconnectivity ratio was calculated using the formula (3) by EMME software:

$IR_i = \sum_j (AT_{ij} + ET_{ij}) / \sum_j TotT_{ij}$ where,

$AT_{ij} + ET_{ij}$	average total walking times for each of OD (access time, egress time and walking time)
$TotT_{ij}$	average total walking times for each of OD + average total boarding time + average in-vehicle time

The parameter for the simulation is the same as described in chapter 4.2 of the thesis. The model simulates the peak-morning time with static assignment algorithm. Therefore, it does not include full timetables of public transport. Firstly, the average total walking times (included walking times used between transit lines) for each OD was calculated. After that, the in-vehicle time and the waiting time were calculated. In Riga case, the interconnectivity ratio is the sum of total time: actual walk time, in-vehicle times and waiting times. The analysis was prepared in condition to calculate the total time from each of the zones to the one zone, where the new interchange is located – RICT. The calculation results are represented in Figure 4.9 and Table 4.13.

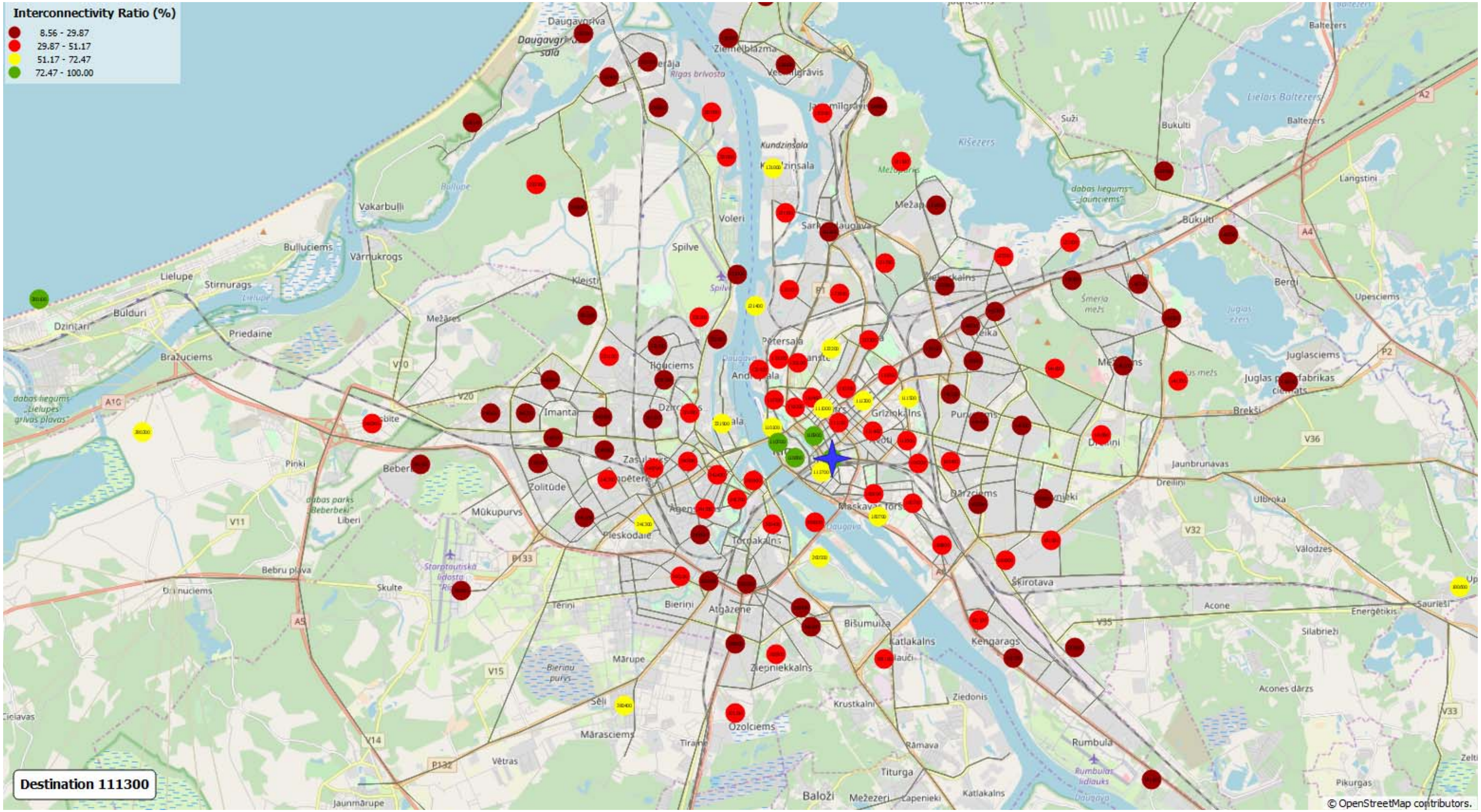


Figure 4.9. The results of the interconnectivity ratio calculation (Source: EMME software)

Table 4.13. Results of the interconnectivity ratio calculation

IR	zone number	% of zones
0.09-0.30	58	47
0.30-0.51	50	40
0.51-0.72	11	9
0.72-0.94	5	4

Only 4% of the zone has the highest value of the IR – highlighted in green. 9% of zones (highlighted in yellow) have value 0.51-0.72. The average value from 0.30-0.51 is for 40% of zones, and it can be suggested from the accessibility point of view. However, 47% of zones have low IR (highlighted in brown) 0.09-0.30.

(II) Closeness centrality (CC)

Closes Centrality is similar to traditional accessibility indexes, being focused on total travel impedance, and so it is "blind" concerning the quality of interconnections. CC analysed the closeness of each node (in our case, TAZ) with the central node where the new HUB will be developed.

The CC was calculated by the formula (4) using the EMME software:

$$CC_i = (N-1)/\sum_j Dist_{ij}$$

where,

$Dist_{ij}$ path cost that corresponds to the first link cots value

N all RTMS TAZ in the network

Firstly, the time on the road from each node to one (RICT) was calculated. As a result, we have got the *path cost that corresponds to the first link cots value* (59884.64). Secondly, for calculating the *(N-1)* was written the script in Python (Appendix 8). The script sums the total impedances to all other reachable nodes in the network and stores the result into an additional node attribute. Need to be noted, that if no valid auto mode path exists to a given node, it will be ignored in the calculation. The results of the calculation are represented in Figure 4.10 and Table 4.14.

Table 4.14. Results of closeness centrality calculation

CC	zone number	% of zones
0.55-0.96	52	42
0.96-1.37	46	37
1.37-1.77	3	2
1.77-2.18	5	4

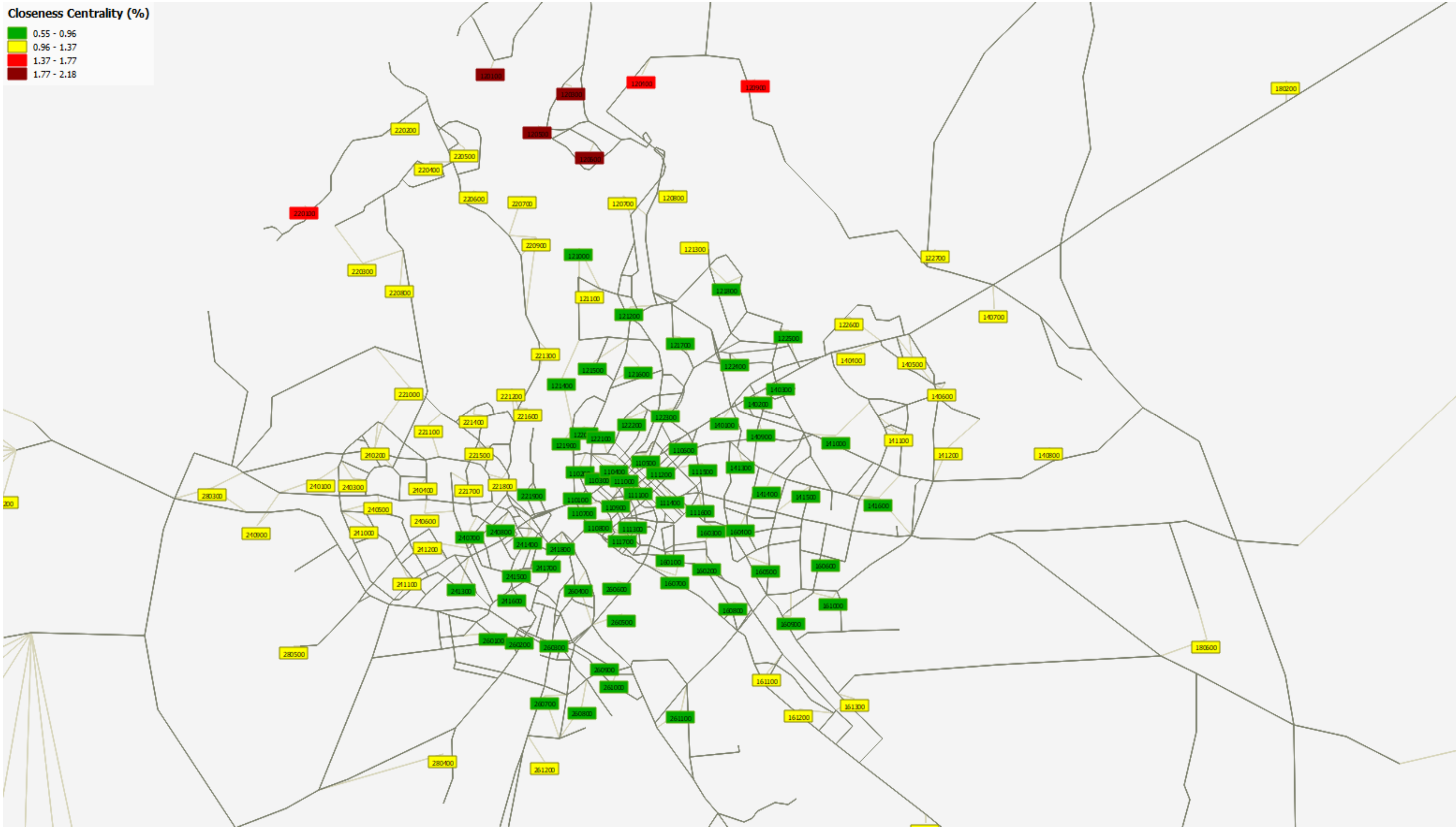


Figure 4.10. The result of closeness centrality calculation (Source: EMME software)

Table 4.15. Table of accessibility measures evaluation

EMME zone ID (TAZ)	IR	CC	impedance (min)	
	%	%	car	pt
1219	29.87-51.17	0.55-0.96	16-24	16-24
1220	29.87-51.17	0.55-0.96	16-24	16-24
1221	29.87-51.17	0.55-0.96	16-24	16-24
1223	29.87-51.17	0.55-0.96	16-24	16-24
1603	29.87-51.17	0.55-0.96	16-24	16-24
2604	29.87-51.17	0.55-0.96	16-24	16-24
1102	29.87-51.17	0.55-0.96	16-24	8-16
1103	29.87-51.17	0.55-0.96	16-24	8-16
1104	29.87-51.17	0.55-0.96	16-24	8-16
1105	29.87-51.17	0.55-0.96	16-24	8-16
1106	29.87-51.17	0.55-0.96	16-24	8-16
1111	29.87-51.17	0.55-0.96	16-24	8-16
1114	29.87-51.17	0.55-0.96	16-24	8-16
1116	29.87-51.17	0.55-0.96	16-24	8-16
1601	29.87-51.17	0.55-0.96	16-24	8-16
1602	29.87-51.17	0.55-0.96	16-24	8-16
2418	29.87-51.17	0.55-0.96	16-24	8-16
2606	29.87-51.17	0.55-0.96	16-24	8-16
1604	29.87-51.17	0.55-0.96	24-32	16-24
1608	29.87-51.17	0.55-0.96	24-32	16-24
2407	29.87-51.17	0.55-0.96	24-32	16-24
2408	29.87-51.17	0.55-0.96	24-32	16-24
1215	29.87-51.17	0.55-0.96	24-32	24-32
1216	29.87-51.17	0.55-0.96	24-32	24-32
1410	29.87-51.17	0.55-0.96	24-32	24-32
1609	29.87-51.17	0.55-0.96	24-32	24-32
1610	29.87-51.17	0.55-0.96	24-32	24-32
2608	29.87-51.17	0.55-0.96	24-32	24-32
2601	29.87-51.17	0.55-0.96	24-32	32-40
2611	29.87-51.17	0.55-0.96	24-32	32-40

EMME zone ID (TAZ)	IR	CC	impedance (min)	
	%	%	car	pt
2207	29.87-51.17	0.96-1.37	40-48	40-48
2203	29.87-51.17	0.96-1.37	40-48	48-----
1117	51.17-72.47	0.55-0.96	16-24	0-8
1222	51.17-72.47	0.55-0.96	16-24	16-24
1607	51.17-72.47	0.55-0.96	16-24	16-24
2605	51.17-72.47	0.55-0.96	16-24	16-24
1110	51.17-72.47	0.55-0.96	16-24	8-16
1112	51.17-72.47	0.55-0.96	16-24	8-16
2219	51.17-72.47	0.55-0.96	24-32	16-24
2413	51.17-72.47	0.55-0.96	24-32	16-24
1214	51.17-72.47	0.55-0.96	24-32	32-40
1210	51.17-72.47	0.55-0.96	24-32	48-----
1101	51.17-72.47	0.55-0.96	24-32	8-16
1113	72.47-100	0.55-0.96	0-8	0-8
1115	72.47-100	0.55-0.96	16-24	16-24
1107	72.47-100	0.55-0.96	16-24	8-16
1109	72.47-100	0.55-0.96	16-24	8-16
1108	72.47-100	0.55-0.96	8-16	8-16
1401	8.56-29.87	0.55-0.96	24-32	16-24
1402	8.56-29.87	0.55-0.96	24-32	16-24
1409	8.56-29.87	0.55-0.96	24-32	16-24
1413	8.56-29.87	0.55-0.96	24-32	16-24
1414	8.56-29.87	0.55-0.96	24-32	16-24
1415	8.56-29.87	0.55-0.96	24-32	16-24
1606	8.56-29.87	0.55-0.96	24-32	16-24
2603	8.56-29.87	0.55-0.96	24-32	16-24
1605	8.56-29.87	0.55-0.96	24-32	24-32
2602	8.56-29.87	0.55-0.96	24-32	24-32
2607	8.56-29.87	0.55-0.96	24-32	24-32
2609	8.56-29.87	0.55-0.96	24-32	24-32

EMME zone ID (TAZ)	IR	CC	impedance (min)	
	%	%	car	pt
2410	8.56-29.87	0.96-1.37	32-40	24-32
1614	8.56-29.87	0.96-1.37	32-40	32-40
2210	8.56-29.87	0.96-1.37	32-40	32-40
2409	8.56-29.87	0.96-1.37	32-40	40-48
1615	8.56-29.87	0.96-1.37	32-40	48-----
1208	8.56-29.87	0.96-1.37	40-48	24-32
1404	8.56-29.87	0.96-1.37	40-48	24-32
2402	8.56-29.87	0.96-1.37	40-48	24-32
1405	8.56-29.87	0.96-1.37	40-48	32-40
1406	8.56-29.87	0.96-1.37	40-48	32-40
2205	8.56-29.87	0.96-1.37	40-48	32-40
2206	8.56-29.87	0.96-1.37	40-48	32-40
2401	8.56-29.87	0.96-1.37	40-48	32-40
2403	8.56-29.87	0.96-1.37	40-48	32-40
1407	8.56-29.87	0.96-1.37	40-48	40-48
2204	8.56-29.87	0.96-1.37	40-48	40-48
1408	8.56-29.87	0.96-1.37	40-48	48-----
2208	8.56-29.87	0.96-1.37	40-48	48-----
2202	8.56-29.87	0.96-1.37	48-----	40-48
1227	8.56-29.87	0.96-1.37	48-----	48-----
1204	8.56-29.87	1.37-1.77	48-----	48-----
1209	8.56-29.87	1.37-1.77	48-----	48-----
2201	8.56-29.87	1.37-1.77	48-----	48-----
1206	8.56-29.87	1.77-2.18	48-----	32-40
1203	8.56-29.87	1.77-2.18	48-----	40-48
1205	8.56-29.87	1.77-2.18	48-----	40-48
1201	8.56-29.87	1.77-2.18	48-----	48-----
1202	8.56-29.87	1.77-2.18	48-----	48-----
2411	8.56-29.87	0.96-1.37	32-40	16-24
1411	8.56-29.87	0.96-1.37	32-40	24-32

EMME zone ID (TAZ)	IR	CC	impedance (min)	
	%	%	car	pt
2414	29.87-51.17	0.55-0.96	24-32	8-16
2415	29.87-51.17	0.55-0.96	24-32	8-16
2417	29.87-51.17	0.55-0.96	24-32	8-16
1217	29.87-51.17	0.55-0.96	32-40	32-40
1225	29.87-51.17	0.55-0.96	32-40	32-40
1416	29.87-51.17	0.55-0.96	32-40	32-40
1611	29.87-51.17	0.96-1.37	24-32	24-32
2218	29.87-51.17	0.96-1.37	32-40	16-24
2212	29.87-51.17	0.96-1.37	32-40	24-32
1211	29.87-51.17	0.96-1.37	32-40	32-40
1226	29.87-51.17	0.96-1.37	32-40	32-40
2211	29.87-51.17	0.96-1.37	32-40	32-40
2412	29.87-51.17	0.96-1.37	32-40	32-40
2612	29.87-51.17	0.96-1.37	32-40	32-40
1213	29.87-51.17	0.96-1.37	32-40	40-48
1412	29.87-51.17	0.96-1.37	32-40	40-48
1207	29.87-51.17	0.96-1.37	40-48	32-40
2209	29.87-51.17	0.96-1.37	40-48	32-40
2610	8.56-29.87	0.55-0.96	24-32	24-32
2416	8.56-29.87	0.55-0.96	24-32	8-16
1212	8.56-29.87	0.55-0.96	32-40	16-24
1403	8.56-29.87	0.55-0.96	32-40	16-24
1218	8.56-29.87	0.55-0.96	32-40	32-40
1224	8.56-29.87	0.55-0.96	32-40	40-48
1612	8.56-29.87	0.96-1.37	24-32	24-32
1613	8.56-29.87	0.96-1.37	24-32	24-32
2216	8.56-29.87	0.96-1.37	32-40	16-24
2217	8.56-29.87	0.96-1.37	32-40	16-24
2404	8.56-29.87	0.96-1.37	32-40	16-24
2406	8.56-29.87	0.96-1.37	32-40	16-24

After CC analysis, it can be suggested that 42% of all TAZ have a good closeness score from 0.55-0.96. 37% have a score from 0.96 till 1.37, but worst results of closeness are for 6% of zones.

The tree accessibility measures results, such as impedance, interconnectivity ratio and closeness centrality, are compiled in Table 4.15. The fields are highlighted accordingly, the evaluated scores and provide different scopes of value. The suggestion can be that for different goals there is a need to use a different kind of measures. A similar result – good accessibility results appears only 11% of all TAZ. All these zones are situated in the centre where the new HUB will be developed.

4.3.6. Meta-analysis between the RICT and EU interchanges

The part of the paragraph is published in Budilovich (Budiloviča) et al. (2019).

The parameters were analysed: the beginning of operating, scale, transport mode accommodation, the daily number of passengers, accessible of people with disabilities, services, access on feet, extra services, see Table 4.16. The interchange spatial scale, presented in Table 4.16, is divided into local (L), regional (R), national (N) and international (I).

Table 4.16. Interchange comparison

Interchange	**Operating since**	**Scale**	**Transport mode accommodation**							**Daily no. of passengers**	**Accessible. for people with disab.**	**Services parking, renting, taxi**	**Access on feet**	**Extra**
			interurban	regional	Metropolitan bus	Urban bus	Metro lines	Tram line	train					
Moncloa Madrid	1995	L, R, N, I			56	3	2		-	266 099	+	-	+	bus tunnels
Kamppi Helsinki	2005	L, R, N, I	15	40		21	1	2	-	57 060		+		
Ilford Railway Station London	1839/1980	L, R		+		+			+	21 000		+	+	
New Railway Station Thessaloniki	1961	L, R, N, I		+		+	1			152 506		+		
Kobanya-Kispest Station Budapest	1978/2011	L, R, N, I		+		+	+		+	145 758		+		
RICT	1964	L	-	+	+	-	-	-	-	5 480	+	+	+	

The Moncloa interchange was built in 1995, and expansion took place in 2008. It is situated at an entrance point to the city of Madrid, which is also a location with high historical value, as there are several monuments in the station's vicinity. It accommodates 56 metropolitan bus lines, three urban bus lines and two metro lines, which serve 59 989, 96 789 and 109 321 passengers per day, respectively. Some facts that are worth noticing are that the interchange does not offer car parking services and its bicycle parking space is very limited (10 spots), but at the same time, it has entrances on all sides, which during its renovation in 2008 were made safer and more easily accessible. Another exciting feature of the interchange is the existence of dedicated bus tunnels is offering easy and fast access to the interchange for bus passengers. Finally, the station is designed in such a way as to help people with disabilities move and orient themselves inside the facilities (Monzon, 2016).

The Kamppi station started its operation in 2005, and a shopping centre was established in 2006. It is located in the central area of Helsinki, 500 meters from the Kamppi interchange. It is a significant interchange, mainly at the local and regional level, at the same time accommodating some national routes and an international bus route to St. Petersburg. About 57 060 passengers use the station daily (19 360 through its 21 local bus lines, 8 500 through the 40 offered regional bus lines, 7 500 through its 15 interurban bus lines and 8 500 through its metro line). The station also offers two tram lines, as well as five more in close vicinity. Finally, it provides passengers with bicycle centres offering to park, repairing and renting services and with car parking and taxi service (Monzon, 2016).

The Ilford Railway Station was built in 1839 and was rebuilt in 1980. It is located in the central area of the suburban town of London Borough of Redbridge. It is of local and regional significance and is considered as an important transport interchange. It offers train services to the centre of the London city, while at the same time being a hub of bus services, providing bus routes to the city and its suburbs. Through its offered railway routes, it serves 21 000 passengers per day. The means of transport that the station can accommodate are rail, bus, car (for drop off purposes or for leaving it at the provided parking area), bicycle (with provided bicycle parking facilities, for which however concerns regarding its security were voiced during a passenger survey) and taxi. In order to enhance its accessibility, the station formulated a plan to improve the pedestrian environment, to make accessing it on foot easier (Monzon, 2016).

The New Railway Station of Thessaloniki was built in 1961 and has seen no changes in infrastructure ever since, except the construction of a shopping centre. The station is located close to the centre of the city and is near the city's port. It is an interchange mainly of local and regional but of national importance and serves 6 000 passengers by regional rail, 130 000 by urban bus and 22 500 by suburban bus per day. The station also offers a direct bus line to the airport, taxi service, kiss- and park-and-ride facilities and facilities that help passengers access the station by bicycle. In that regard, it is also worth noting that there is a cycle path leading from the city centre to the station. There is also a metro line under construction, which is expected to start operating in the following years (Monzon, 2016).

The Kobanya-Kispest station was constructed in the years between 1978 and 1980. In 2008, it was expanded to accommodate a metro and a bus terminal and park-and-ride facilities, while a shopping mall was also created. In 2011, the interchange was renovated for the first time except for the railway station, which causes some problems to its accessibility, as its old design might prove problematic, especially to people with disabilities. The interchange is located in the Budapest city and provides local, regional, national and international routes. The railway serves 9 886 passengers daily, while 67 967, 74 650 and 3 141 make use of its metro, local bus and suburban bus services, respectively. The interchange also offers a direct bus line to the airport, as well as bicycle and park-and-ride facilities (Monzon, 2016).

Based on the acquired information, RICT is of high regional importance, as it provides on average 350 regional bus routes per day. It also offers 70 international bus routes per day, which makes it an interchange of international importance. To this end, the station can be compared in terms of role, with Kamppi interchange and Kobanya-Kispest, which accommodate international lines. However, the number of offered routes reveals that RICT is much more oriented towards international transport than Kamppi and Kobanya-Kispest. The number of passengers that use the station yearly amounts to approximately 2 million per year, which is translated into 5,480 passengers per day. This number puts RICT much lower in terms of passengers served than all of the other interchanges. In terms of services offered and facilities, the station provides assistance and guidance to people with disabilities through specialised staff, while also providing a lift and two parking lots. It shows that the station tries to keep up with good practices, even though through a different method compared to Moncloa, which adopts a more conventional approach. Taking into account this information, RICT seems to be more similar to Kappa and Kobanya-Kispest in terms of role and size (with a much lower number of passengers served per day) however, and it can also be compared to Moncloa about the accessibility measures for people with disabilities.

RICT seems to be more similar to Kamppi and Kobanya-Kispest regarding of role and size (with a much lower number of passengers served per day) however; it can also be compared to Moncloa about the accessibility measures for people with disabilities

The meta-analysis shows that the RICT interchange has the average value of the three parameters (satisfaction rate, access, satisfaction with signposting) between the highest and the lowest one, see Table 4.17. Compared to the results of the surveys taking place in the stations mentioned above, RICT shows an overall satisfaction rate with a mean of 3.50, which is higher than Thessaloniki (3.13) and Ilford (3.16), but lower than Kamppi (3.94), Kobanya-Kispest (3.61) and Moncloa (3.92).

By combining the indicators for the distance between transport means and facilities, ease of movement and time in the interchange, a mean value can be calculated that expresses the satisfaction of the passengers of “time” they spent in the station and their movement inside it. This mean was found to be 3.70, which is higher than the relevant indicators calculated in all other five stations.

Using the same method, the combination of the indicators measuring the satisfaction levels of cooperation between transport modes and ease of access to and from the interchange can give a general idea of how easily accessible the interchange is. The mean value of this indicator is 3.81, which is higher than the respective values of Ilford (3.33) and Thessaloniki (3.73) and lower than Moncloa (4.19), Kobanya-Kispest (4.31) and Kamppi (4.29).

Finally, the grouping method was used for the indicators measuring passenger satisfaction with the signposting (of both facilities and transport modes) and the provided information by the station's staff. The mean that was calculated was equal to 3.50, which is again higher than Thessaloniki and Ilford (both at 3.26), lower than Moncloa (3.81) and Kobanya-Kispest (3.70) and at the same level with Kamppi.

Table 4.17. Meta-analysis between interchanges

Interchange	Satisfaction rate	Access	Satisfaction with signposting & station’s staff
Moncloa Madrid	3.92	4.19	3.81
Kamppi Helsinki	3.94	4.29	3.70
Ilford Railway Station London	3.16	3.33	3.26
New Railway Station Thessaloniki	3.13	3.73	3.26
Kobanya-Kispest Station Budapest	3.61	4.31	3.70
RICT	3.50	3.81	3.50

The comparison between the station and the interchanges with which it shows similarities:

- that passengers are less satisfied with the station's accessibility compared to Kamppi and Kobanya-Kispest;
- passengers seem to be more satisfied in the area of time spent, and information provided in the station compared both to Kobanya-Kispest (3.52) and Kamppi (3.69);
- regarding ease of access, and taking into account the accessibility measures adapted for helping people with disabilities, the station was rated lower compared to Moncloa;
- findings are significant in the context of future tasks of Riga Municipality to develop the Central Multi-Modal Public Transport Hub that integrates the Riga Central Railway Station and RICT;

- the local situation regarding the organisation of transport in the Riga City is moving to integration soft modes, and functional integration appears to be essential for transport policies to play a role in interchange “time penalty” reduction;
- GAPs in the information chain compromise the quality of the process in RICT;
- the complex workflows in RICT can be effectively improved through state-of-the-art technology: ticket validation systems, a real-time information system for all modes of transport, either in panels at RICT, or via smartphone applications.

The main point to solve is to be more integrated with the help of the same technology platforms and integration of all stakeholders on public policy.

4.3.7. Comparing analysis of the Information Systems, Ticketing and other ITS Services integration

The body of the paragraph is published in the author paper “A Cross-Case Analysis of Riga Interchanges’ Information Services and Technologies” that was presented on 17-20 October 2018 at The 18h International Multidisciplinary Conference Reliability and Statistics in Transportation and Communication (RelStat-2018) held in Riga, Latvia (Yatskiv (Jackiva) I., 2019).

One of the fundamental services that need to be provided by interchange is an information service.

Many EU projects have investigated information services successfully functioning in the systems of public transport in European countries in the last decade: for instance, POLITE (2018) and TTRANS (2018) and others.

Yatskiv et al. (2015) analysed the information systems for public transport in Latvia. Findings revealed that clear information systems are needed for the provision of accessible, efficient and seamless information. The information should be integrated with different operators and modes and mainly if it is provided to multimodal passenger terminal users (Adamos, 2018).

Adamos et al. (2019) after the analysis of the stakeholders and travellers of RICT point of view, suggested that the primary quality services for users are information systems, ticketing and other ITS services. Travel information and intermodal services are spread across all interchange zones, such as access-egress zone, arrival-departure-transfer and the facilities-retailing (Monzon, 2016)

Methodology for the research was developed in the following way: (1) Stakeholder definition; (2) Questionnaire preparation; (3) Face to face survey; (4) Cross-case analysis. Firstly, the stakeholders that are appropriate for answering the questions were defined and contacted by the authors. RICT was represented by the Chairwoman of the Board of Directors, the Airport by a member of the Board and the Riga Central Railway Station by a member of the Organisation. In the case of the PORT, two persons, one from the terminal board and the second from the ferry operator side, gave their feedback.

The questionnaire consists of 11 questions about the information provision, information integration and uniformity, ticketing and ITS systems at the interchange (ITS). The application form example was taken from the City-HUB project (City-HUB Project, 2015) and adapted into local needs, see in Appendix 4.

The question about ITS systems is divided into 23 short questions, and the stakeholder was asked to answer if he/she considers whether several services are "in use", "needed" or "not needed."

The face-to-face survey was carried out in August and September 2018. The purpose of the survey was to:

- Investigate the level and quality of the information provided to travellers through-out the whole journey, in the trip planning phase and during the trip, especially at the interchange points, through previous research and case study analysis.
- Assess whether integrated online information is given at the interchange points, including incident information.
- Check if there is cooperation among the information systems of various operators.
- Understand integrated ticketing issues for the use of public transport and acceptance of intermodality, i.e. changes during the trip.
- Define the possibility of ticket purchasing systems, especially mobile solutions.
- Investigate if it is possible to separate the emergency information given at the interchange points from the daily incident and breakdown information.

A cross-case analysis was applied amongst the four interchanges. Information about ticketing, disabilities, weakest and strongest parts of each interchange was analysed. Also, the indoor and outdoor services were considered in the analysis. The authors provided the survey regarding information services implementation in Riga City interchanges. The representatives of the four main interchanges were interviewed, and their answers were generalised and analysed by cross-case methods.

The analysis of the ticketing services of all interchanges is given in Table 4.18. "Mobile applications", "internet", "ticket machine", "ticket offices" and "No Near Field Communication (NFC) Payment" are the most common services used in RICT, RIX and RS. RIX offers additional ticketing services such as "Airport operator" and "Tourism companies". In PORT the purchase of tickets is possible via "internet", "ticket offices", "ticketing machines" and "No NFC Payment".

Table 4.18. Ticketing services in the interchanges

Ticketing Services	RICT	PORT	RIX	RS
Mobile applications	Bezrindas.lv, Mobili-ty.lv		AirBaltic Air tickets, Sky-scanner	Pasažieru vilciens, Mobility.lv
Internet	x	x	x	x
Homepage	x		x	x
Ticket offices	x	x	x	x
Ticket machines	x	x	x	x
No NFC Payment	x	x	x	x
By phone	x			
Airport operator			x	
Tourism companies			x	

Regarding the availability of services for people with disabilities (Table 4.19) RICT meets five out of six standards analysed: "request help 36h before the trip" (other interchanges have 48h), "apply for service by phone or email", "informative video about assistance available", "tactical guidelines for visual impaired" and "Three specialised summon boards". In the case of PORT there are only two possibilities of this kind of services, such as "request help 48h before the trip" and "apply for service by phone or email". It has to be mentioned that only RS provides the service "Boarding the departing train and disembarking from the arriving train using mobile platforms".

Table 4.19. Provided services for people with disabilities in the interchanges

Services for people with disabilities	RICT	PORT	RIX	RS
Request help 48h before the trip	x (36h before)	x	x	x
Apply for service by phone or email	x	x	x	x
Informative video about assistance available	x		x	x
Has tactical guidelines for visual impaired	x			
Three specialised summon boards	x			
Boarding the departing train and disembarking from the arriving train using mobile platforms				x

When assessing the indoor-outdoor services provided in the interchanges (Table 4.20), it was observed that RICT is more convenient in the indoor services, while RIX provides the option of "Smart ticketing exclusively". Outdoor service "Facilities and layout are available on the internet" is available in all interchanges. The option "Journey planner for long-distance PT for pre-trip planning" is provided by RICT and RS, and "Matrix barcodes" only in RICT.

Special services that can be defined as indoor-outdoor like "Area or terminal fleet management with the aid of cameras" are met in all interchanges. "Tactile maps of the interchange for the visually impaired' are used in RICT, RIX and RS, but not in PORT.

Based on the analysis of the ITS systems (Table 4.20), it can be concluded that 12 services are in use in all interchanges, one service is needed at all interchanges (Intelligent Indoor-Navigation System), and one service is not needed in any interchange (Information with hearing aids (e.g. "T-coil")).

Table 4.20. Indoor-outdoor provided services in the interchanges: (1) indoor; (2) outdoor; (3) indoor & outdoor

	RICT			**PORT**			**RIX**			**RS**		
Indoor-outdoor services	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Electronic departure time displays and disturbance information	x			x			x			x		
Multi-language information	x			x			x			x		
Smart ticketing							x					
Information centre with personal service	x						x			x		
Guidance and warning surfaces for the visually impaired (VI)	x									x		
Tactile maps of the interchange for the VI	x											
Intelligent automated passenger or people counting	x						x			x		
Intelligent security systems (e.g. CCTV)	x			x			x			x		
Journey planner for long-distance PT for pre-trip planning		x									x	
Facilities and layout available on the internet		x			x			x			x	
Matrix barcodes (e.g. QR-Codes)		x										
Guidance and warning surfaces for the VI								x				
Area or terminal fleet management with the aid of cameras			x			x			x			x
Tactile maps of the interchange for the VI			x						x			x

The cross-case analysis facilitates the identification of strengths and weaknesses of the Latvian interchanges, see Table 4.22.

Table 4.21. Intelligent System. Services in the Interchanges: (1) in use; (2) needed; (3) not needed

Services	RIX			RICT			PORT			RS		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Journey planner for local PT for pre-trip planning		x				x			x	x		
Journey planner for long-distance PT for pre-trip planning		x		x					x			
Information for interchange facilities and layout available on the internet (or via call centre) for pre-trip planning (important especially for the disabled)	x			x			x			x		
Smart ticketing [speeds up transfer]	x				x				x			x
Electronic departure time displays based on *timetables* (for multiple stops)	x			x			x			x		
Electronic departure time displays based on *timetables* (at stops)	x			x			x			x		
Electronic departure time displays based on *real-time information* (for multiple stops, incl. fleet monitoring systems)	x			x			x			x		
Electronic departure time displays based on *real-time information* (at stops)	x			x			x			x		
Departure times via audio calls	x			x			x			x		
Real-time disturbance information provided via *displays*	x			x			x			x		
Real-time disturbance information provided via *audio calls*	x			x			x			x		
Multi-language information	x			x			x			x		
Public access information kiosk/internet kiosk restricted for PT information (not for open internet surfing)				x					x	x		
Information centre with personal service	x			x			x			x		
Audio services for the visually impaired (e.g. a special dedicated information area with a push-button)			x	x			x			x		
Guidance and warning surfaces for the VI	x			x				x			x	
Tactile maps of the interchange for the VI	x			x				x		x		
Information with hearing aids ("T-coil")			x			x			x			x
Matrix barcodes (QR-codes) for additional information with mobile phones (for departure times for a specific stop or platform)	x				x				x			x
Intelligent Indoor-Navigation System					x			x			x	
Intelligent security systems (e.g. CCTV)	x						x			x		
Area or terminal fleet management with the aid of cameras, in-vehicle systems, Variable Message Signs etc. for guiding buses, taxis, P&R etc.	x						x			x		
Intelligently automated passenger or people counting (infrared, video, thermal, etc.)	x			x				x		x		

Concluding, only by integrating and linking data of all stakeholders, it is possible to combine a traveller's mobility demand with mobility services and provide the basis for more efficient, accessible and affordable mobility.

Table 4.22. Strengths and weaknesses of the studied interchanges

	Strengths	Weaknesses
RIX	1. Fast way to travel for those who use the smart ticket 2. Technological advancement and investment in information technology 3. Infrastructural development 4. Service for passengers with reduced mobility 5. Mobile solutions for the ticket purchasing 6. Location and access to PT	1. No journey planner services 2. Tickets are not valid for multiple modes and operators 3. No warning surfaces for visually impaired inside the airport
RICT	1. Integrated information (15 + operators) 2. Mobile solutions for the ticket purchasing 3. Journey planner for long-distance PT 4. Central location to downtown, access to PT 5. Terminal adjusted for passengers with disabilities	1. Infrastructural development 2. Tickets are not valid for multiple modes and operators 3. No smart ticketing
RS	1. The infrastructure contains several systems that allow avoiding unpleasant incidents 2. The most punctual trains in Europe 3. Mobile solutions for the ticket purchasing 4. Central location to downtown, access to PT 5. Call Centre available (24/7) 6. Mobile platforms for passengers with disabilities	1. No journey planner services 2. Tickets are not valid for multiple modes and operators 3. One operator
Port	1. Infrastructural development 2. Central location to downtown	1. Terminal need upgrade 2. One main operator 3. No journey planner services 4. No mobile solutions for ticket purchasing 5. Tickets are not valid for multiple modes and operators 6. Less accessible by PT 7. Working hours

5. FINDING AND RECOMMENDATIONS

5.1. RICT analysis findings

The summaries of all activities (surveys, data analysis) that were done for RICT analysis are reprinted in Figure 5.1. Four surveys were organised and conducted by the author (highlighted in yellow):

1. The traveller satisfaction survey
2. The stakeholder satisfaction survey
3. Survey for information services implementation in Riga terminals
4. Site visits and interview of the practitioners

For interchange (RICT) evaluation, the following types of data were defined, collected and analysed:

1. Defined RICT stakeholders
2. Intermodal long-distance trip analysis
3. The analysis of traveller satisfaction
4. GAP analysis between travellers and practitioners
5. Meta-analysis between five EU interchanges
6. Analysis of the information services implementation in the interchanges

After the result analysis, it can be suggested that:

- accessibility within the Baltic States is an essential factor in the development of territories, regions and cities;
- the role of Riga public transport system in determining the level of accessibility for different spatial aspects;
- the sustainable planning approach involves the identification the most demanded travels in different spatial levels and then analyse how better coordinate and integrate various parts of long-distance trips for following infrastructure investments, which develop the public transport's competitiveness in the long term;
- transport infrastructure and services need to be integrated right from planning to operate, and maintenance and the integration is a long-term process that involves many stakeholders;
- the accessibility needs to be analysed from the time aspect.

The main focus is accessibility for the passenger when changing from one mode of transport to another. For ex-ante analyses, accessibility indicators are summaries of modelling outputs based on travel times between pairs of nodes. The measuring of the using the access time to/from city centre, accessibility is calculated based on the shortest journey time during the morning/evening peak hours by PT from the nearest node (station) in the network. The shortest possible journey time might be achieved by using one service or through an interchange between different services, whether services are provided by the same or different operators with the same or different transport mode.

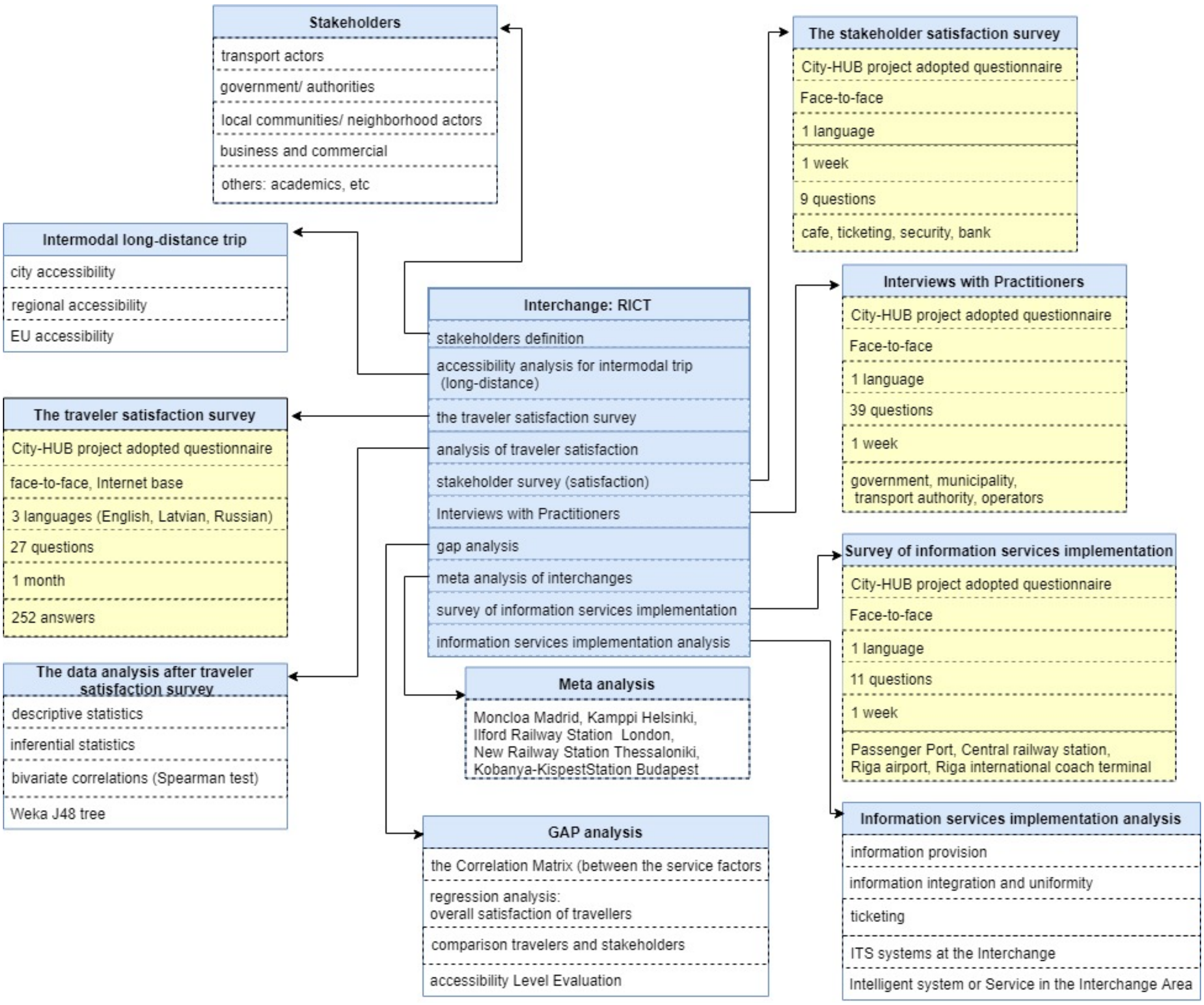


Figure 5.1. The activities prepared/provided for interchange analysis

The following conclusions regarding the RICT can be done:

- RICT users are less satisfied with the station's accessibility compared to Kamppi and Kobanya-Kispest;
- RICT users are more satisfied regarding time spent and information provided in the station compared both to Kobanya-Kispest (3.52) and to Kamppi (3.69);
- ease of access - the station was rated lower compared to Moncloa;
- findings are essential in the context of future tasks of Riga Municipality to develop the Central Multi-Modal Public Transport Hub that integrates the Riga Central Railway Station and RICT;

- the local situation regarding the organisation of transport in the Riga City is moving to integration soft modes, and functional integration appears to be essential in order for transport policies to play a role in interchange “time penalty” reduction;
- GAPs in the information chain compromise the quality of the process in RICT;
- the complex workflows in RICT can be effectively improved through state-of-the-art technology: ticket validation systems, a real-time information system for all modes of transport, either in panels at RICT, or via smartphone applications;
- the main point to solve is to be more integrated with the help of the same technology platforms and integration of all stakeholders on public policy.

5.2. Recommendations for RICT as example of urban interchange

After RICT quality analysis, was observed that there are some GAPs between the two sides of analysis, i.e. in terms of access to and from the interchange, or the attractiveness of the internal and external area.

The follow recommendations for RICT development are in line with the main challenges that the specific interchange faces or it is expected to face in the near future, like the restrictions of development due to the rules of the Riga Historical Centre, the integration of RICT into the Rail Baltica project, and also the frequent changes in the national regulatory framework:

- **Information provision and ticketing**: development of journey planners for long-distance public transport for pre-trip planning, information for interchange facilities and layout available on the internet for pre-trip planning, smart ticketing
- **Infrastructure and services**: redesign of the interchange in a more friendly and sustainable way, development of green zones/areas, the creation of sidewalks and cycling facilities, development of short- and long-term parking spaces
- **Accessibility**: enhancement of the connectivity of the interchange with existing and new destinations, providence for people with disabilities
- **Integration**: both service integration at the interchange (design and layout of access and egress modes, transfer time) and also physical integration with the rest of the network (maximisation of the seamlessness of the door-to-door travelling)

5.3. The framework of transport interchange accessibility analysis that incorporates the objectives of sustainable development in transport system planning

The body of the paragraph published the 11th International Scientific Conference Transbaltica 2019: Transportation Science and Technology, 4-5 May 2019, Vilnius, Lithuania (Yatskiv (Jackiva) I., 2019b).

Development or redevelopment of a strategically important infrastructure facility is a challenge for a city of any size.

A systematic approach for this problem solving should be created, which includes an analysis of the existing situation and the situation when the object will be built. The solution of this task is influenced by various factors, such as the definition of stakeholders, the analysis of the existing transport system, the analysis of documents and rules for the implementation of the object, as well as external standards and political opinion.

In the framework of the thesis, the introduction of a new transport infrastructure object Rail Baltica is being considered.

In order to understand the impact of a new facility on the transportation network, it is necessary to understand and analyse what requirements are necessary for implementation. It is also necessary to take into account multimodality, mobility and sustainable development of the network. One of the main components of the transport network is interchange - HUB. Analysis of various interchange and their comparison with each other is also carried out in work.

Data is needed to analyse and evaluate the current situation. To analyse the factors affecting the transport network, RICT was selected, with the assistance of managers, the possibility of data collection was created. For data collection, questionnaires were created, and polls were conducted: travellers, operators, stakeholders. With the help of surveys, a large amount of information was collected, which was analysed by various methods and GAPs were identified using analysis. One of the vital decision-making tools is the transport flow simulation model. Three accessibility indicators were calculated using the existing model, and the results analysed.

All of the above can be combined in the decision-support process framework. The presented framework can be adapted to the cities of different size.

The central research goal is to prepare the methodology of the new Hub development and analyse how the new object will effect to the urban transport system. Figure 5.2 represents the developed decision support framework that includes a holistic approach to analyse all aspects of sustainable transportation. A decision-support framework can identify the approaches and tools that decision-makers should use for creating policy and programs that move urban transport city towards sustainability.

Planning or changing something in the urban system (creation of a new infrastructure facility), it is necessary to evaluate the impact of these changes, not generally, but in the context of each transport system by system analysis. It needs to pay attention to the next question: *Are strategic transportation project activities sufficient to maintain or improve the current quality levels in the long-term*?

Multi-modal transportation planning should have integrated institutions, networks, stations, user information, and fare payment systems it needs to consider all significant impacts, including long-term, indirect and non-market impacts such as equity and land-use changes. One of the key-stone question in this study - multi-modal transportation planning requires consideration of the factors that affect accessibility and whether they are currently considered in planning?

As known, the interchange is one of the significant parts of UTS and the keystone in multimodality supporting. That is why the central role of the framework for the decision-making process development is the interchange. To the interchange development influence the different kind of spatial rules and regulations, such as national, regional and local levels. Many aspects implement to the interchange development or reconstruction, such as location, design the interchange, design the surrounding areas and others.

How to comprehensively analyse indicators affecting the quality of services provided by the interchange, was analysed based on the suggested framework and the example of one of the main interchanges of the Riga City – RICT. The question is – should spatial and transport planning be better coordinated to match transport demand to access needs? Using the before-and-after analysis of RTS accessibility helps to identify how the interchange needs to be improved or where it is required to promote the public transport network based on the criteria of accessibility measurement.

This kind of analysis gave the criteria or approached for SUMP preparation. However, the SUMP has only the heuristic approach, but can provide the methodology for transport simulation model development and can implement the regulations for it.

For future research, using the above write steps and changing something to solve a specific task, could be developed a city Business model.

The framework is universal and can be adapted for a different kind of interchange in the different size of cities, considering local requirements. The using of framework helps authorities to structure the opportunities and to define the TS system GAPs and after, solve them.

5.3.1. The user guideline

The guideline is based on the provided research and developed decision-support framework (Figure 5.2). The city authorities and other interested organizations can follow the suggestions as follows:

1. To define the transport system primary indicator on the basis of a survey;
2. To define the needed data for the transport modelling (the necessary data need to be collected);
3. To model the transport system before the new infrastructure object development;

4. To analyse the interchange services (in case of redeveloping of the existing one):
   - to define the stakeholders;
   - to provide the traveller satisfaction survey;
   - to provide the stakeholder's point of view analysis;
   - to create the decision support tree.
5. To analyse the results and to prepare if necessary the additional analysis
6. All findings, solutions and results should be collected and formulated on the basis of the sustainable development and EU regulations requirements.

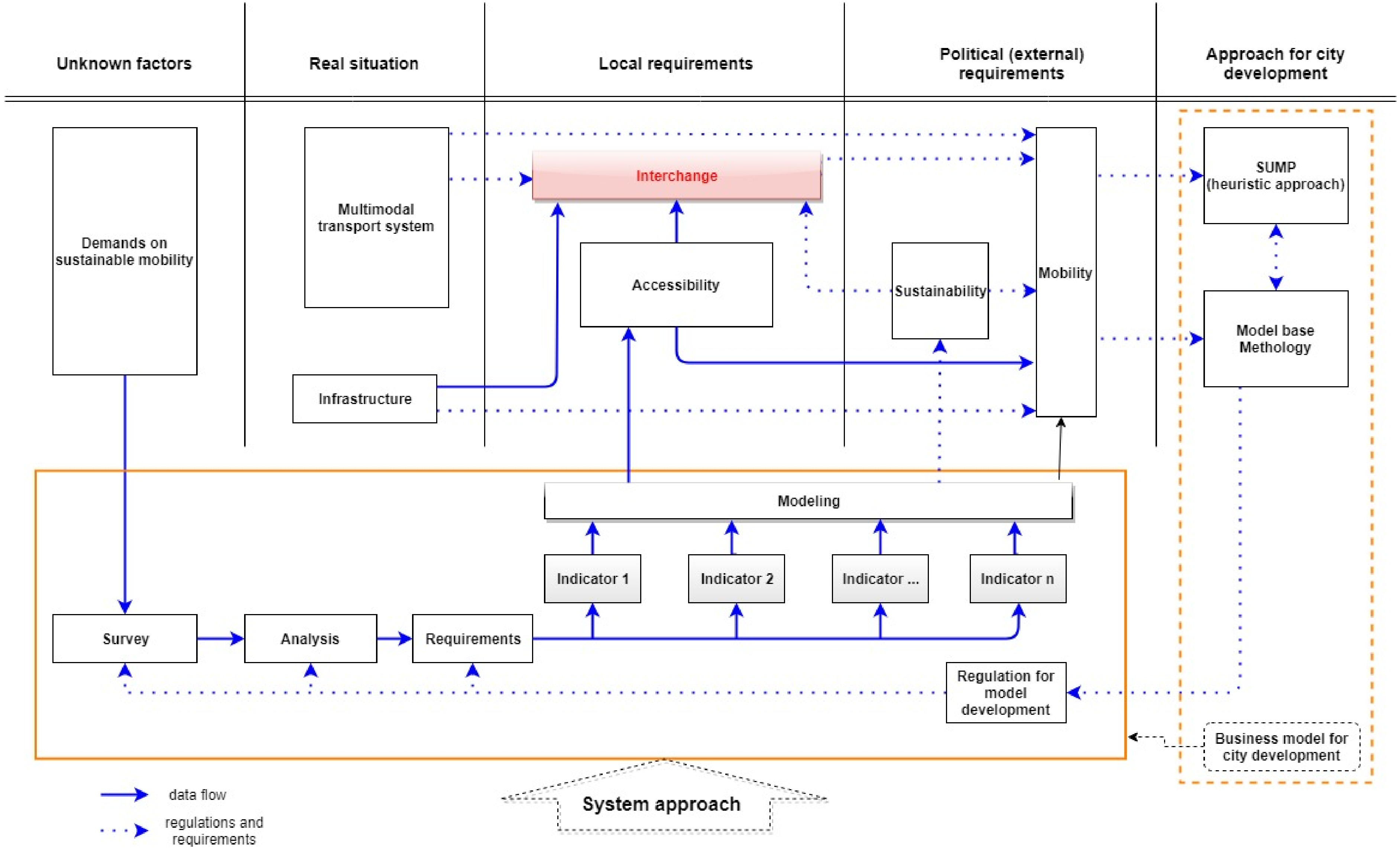


Figure 5.2. The framework of transport interchange accessibility analysis that incorporates the objectives of sustainable development in transport system planning

RECOMMENDATIONS

After provided data and situation analysis, the following recommendations for city authorities and public agencies are offered:

1. For the new infrastructure object of the transport system implementation, it is necessary to create a working group of all interested representatives (stakeholders): government authorities, city authorities, residents, transport planners and others. At the moment, there is a public discussion and coordination with all the institution, but it is all formal.
2. The city needs to create clear rules, criteria and indicators for the analysis of the urban transport system, such as analysis of environmental impact, analysis of the social impact aspects. In the present, only the impact of the transport infrastructure is currently being analysed.
3. It is necessary to develop a permanent system for collecting different types of data using various sources of information, such as household surveys, population mobility surveys, the creation of a database/platform (repositories) for collecting and storing information about transport researches.
4. Necessary to create an analytical department for the analysis of information and continuous monitoring of the developed criteria.
5. It is necessary to create a classification of public transport stops, railway stations, as well as stops for regional buses. Create criteria, requirements for location, design and development standards for the quality of services provided. Develop and implement definitions: stop, interchange, hub, a hub for long-distance trips and multimodal station.
6. For sustainable planning of urban transport systems, it is necessary to analyse/research all traffic participants: pedestrians, bicycles, freight transport, logistics (delivery/services) in the city, public and rail transport. It is also necessary to analyse the accessibility of social and transport facilities by all transport modes.
7. The urban planning process should be sustainable in all stages of the decision-making process.

CONCLUSIONS

The research is devoted to enhancing the methodology of public transport system planning of incorporation the objectives of sustainable development. The thesis was focused on the decision problem of a multimodal transport interchange in the context of sustainable issues.

The critical review of existing researches was performed and was focused on the next keywords: sustainable transport system, SUMP, mobility and accessibility, multimodality, transport interchange were presented.

The methodology that can be used for the Riga Central Multimodal Public Transportation Hub project decision making process development was proposed. Using the before-and-after analysis of TS accessibility helps to identify how the interchange needs to be improved or where it is required to promote the public transport network based on the criteria of accessibility measurement – establishing sustainability indicators rather than simple mobility indicators give the possibility to implement the sustainability goals and objectives in the process of transportation planning. At the beginning of the study, a limitation of the research was imposed that only before the new analysis of the development of interchange will be implemented of the reason for the lack of data for analysis.

For a holistic approach to estimate the functioning of the urban TS and evaluate the expected outcome of new infrastructures and services, it is necessary: to define the accessibility indicators; to develop the simulation model; to design and execute the simulation experiments to evaluate the proposed solutions in the aspect of sustainability issues.

In many countries, improving accessibility is an important government goal. For the development of the RTS exist a large number of documents that have been produced in the past few years and focused on the improvement of traffic and transport situations. These documents have different scopes, purposes and timescales, but the visible roadmap for this implementation does not exist in the Riga City.

The following conclusions could be suggested:

1. The analysis of literature and other sources of the sustainable urban development definition and analysis is carried out with a focus on sustainable transportation issues.

2. The analysis of the existing situation of the Riga transport system was conducted: SWOT analysis, analysis of the decision-making process using the transport simulation model, given the recommendations to improve the development of all transport modes. An expert survey was conducted to determine (identify) the most significant indicator of sustainable urban planning - accessibility.

3. The analysis of the accessibility and its indicators was conducted. Moreover, based on existing data, measures have been selected (defined) for accessibility calculation.

4. Based on the fact that one of the key objects in the multimodal transport system is an interchange, and it is important for the city to know the influence of this object before reconstruction and after on the transport system and its service quality, RICT was selected for analysis, which will be reconstructed in the near future. Different types of surveys were conducted, a decision tree on quality indicators was compiled, a comparative analysis between the leading European coach stations was conducted, and 4 cases were developed to improve the quality of passenger service:

Case 1 (Riga TS accessibility analysis). The accessibility for PT comparing with the travel by private cars was assessed and analysed. Accessibility is calculated on the base of the shortest journey time during the morning peak hours by PT and by private cars. The results of the accessibility analyses demonstrate issues about the development of an integrated roadmap to implement equal access for all citizens

Case 2 (RICT inter-intra city (long) trip analysis). Accessibility that is focusing on long-distance travel involves the entire urban TS, and long-distance interchanges play an important role at local, regional, national and international level

Case 3 (RICT passenger satisfaction survey). The passenger satisfaction survey consists of two parts of the analysis:

1. To analyse the level of satisfaction based on different quality indicators (using descriptive and infernal statistics approaches).

2. The decision tree paths indicate the indicators that need greater attention from the side of decision-makers for the increase of the overall passenger satisfaction level.

Case 4 (RICT stakeholders survey: a questionnaire about the quality of services provided)

1. Understanding the GAPs between users, i.e. travellers, and involved stakeholders, such as operators and public authorities, based on their expectations and the level of their satisfaction.

2. Interchange accessibility level evaluation.

3. Level of ITS services, integration of information systems, ticketing and other.

5. Moreover, the following analysis for RICT was provided:

- comparing the analysis of 4 passenger interchanges in Riga highlighted that they are characterised by multiple stakeholder involvement and a precise governance model, addressing the provision of reliable information to travellers, is very important for proper centralised management;
- meta-analysis with best practices in the EU.

Based on the mentioned above cases and analyses using RICT data, concrete recommendations were provided.

6. As the final step, the decision-support framework for the urban public transport system sustainable planning and transport interchange accessibility analysis that incorporates the objectives of sustainable development was developed.

Decision-makers: authorities and operators may find a methodological guide for implementing measures towards multimodal passenger interchange service improvement because few instruments and tools analysed in this thesis helping them to improve one of the important aspects of sustainable transportation development - multimodality level of the PTS. The role of interchange in the multimodal service providing is presented, and the relationship between the accessibility (as the main basis for multimodality providing) and overall satisfaction of users were analysed.

A framework for decision-maker will help them to systematise the actions that must be performed when developing a new infrastructure object. Besides traditional methods of accessibility analysis based on time impedances and applied in Riga city authorities for TS planning, three other indicators founded in literature and including multimodality aspects was applied to real data of Riga transport system. These indicators, including as sustainable measures in the developed framework demonstrate to decision-makers how the infrastructure project with significant impact on multimodality should be analysed. These indicators support multimodality analysis in general and interchange service quality in particular.

REFERENCES

Action plan on urban mobility, 2009. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS.* Brussels, 30.9.2009: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009DC0490&from=EN.

Adamos G., Budilovich E., Yatskiv I., Nathanail E., Tsami M., Magginas V., 2019. *Quality of service in urban transport interchanges: understanding the gaps between users and operators expectations.* Dublin: European Transport Conference 2018.

Adamos, G., 2018. *Operation and management of intermodal transport systems: passenger inter-changes.* Riga: 2nd summer school, project Alliance: http://alliance-project.eu/.

ALLIANCE project, 2018. *2nd Summer school: Sustainable Transport Interchanges Program-Public Transport Systems: From research to decision making.* Riga, Latvia: TRANSPORT AND TELECOMMUNICATION INSTITUTE.

Allmuali H., Kaneda S., Akiba Y., 2002. *Development and Applications of Decision Trees.* Expert Systems Vol.1: Academic Press.

Alonso A., Monzón A., Cascajo R., 2015. *Comparative analysis of passenger transport sustainability in European cities.* Ecological Indicators: 48, 578-592.

Banister D., Berechman Y., 2001. *Transport investment and the promotion of economic growth.* Journal of Transport Geography: 9(2001), pp. 209-218.

Banister, D., 2008. *The sustainable mobility paradigm.* Transport Policy: 15(2), pp.73-80.

Baradaran S., Ramjerdi F., 2001. *Performance of Accessibility Measures in Europe.* The Journal of Transportation and Statistics: pp. 31-48.

Ben-Akiva M., Lerman S., 1979. *Disaggregate Travel and Mobility-Choice Models and Measures of Accessibility.* Behavioural Travel Modelling: edited by D. A. Hensher & P. R. Storper: London, pp. 654-79.

Bertolini L., Le Clercq F., Kapoen L., 2005. *Sustainable accessibility: a conceptual framework to integrate transport and land use plan making.* Two test – applications in the Netherlands and a reflection on the way forward: Transport Policy, 12.

Boisjoly G., El-Geneidy A., 2016. *Daily fluctuations in transit and job availability: A comparative assessment of time-sensitive accessibility measures.* Journal of Transport Geography 52, 73–81: https://doi.org/10.1016/j.jtrangeo.2016.03.004.

Boschmanna E., Kwana M., 2008. *Toward Socially Sustainable Urban Transportation: Progress and Potentials.* International Journal of Sustainable Transportation: 2(3), pp. 138-157.

Breiman L., Friedman J.H., Olshen R.A., Stone C.J., 1984. *Classification and regression trees. Monterey.* CA: Wadsworth.

Brundtland, G. H., 1987. *Our Common Future.* Sustainability for all: https://www.activesustainability.com/sustainable-development/do-you-know-when-sustainability-first-appeared/.

Budilovich (Budiloviča) E., Magginas V., Adamos G., Yatskiv (Jackiva) I., Tsami M., 2019. *Investigating the Accessibility Level in Riga's International Coach Terminal: A Comparative Analysis with European Interchanges.* In: Nathanail E., Karakikes I. (eds) Data Analytics: Paving the Way to Sustainable Urban Mobility: CSUM 2018. Advances in Intelligent Systems and Computing, vol 879. Springer, Cham. pp 839-846.

Budiloviča, E., 2018. *Pilsētas transports.* In: Nacionālā enciklopēdija: Riga: Latvijas Nacionālā bibliotēka, pp.601-604.

Bums, L., 1979. *Transportation, Temporal, and Spatial Components of Accessibility.* Lexington, MA: Lexington Books.

Buzási A., Csete M., 2015. *Sustainability Indicators in Assessing Urban Transport Systems.* Budapest University of Technology and Economics: Periodica Polytechnica Transportation Engineering, 43(3), pp.138-145.

Cascetta E., Cartenì A., Montanino M., 2013. *A new measure of accessibility based on perceived opportunities.* Procedia – Social and Behavioral Sciences 87: pp. 117–132.

Cascetta E., Cartenì A., 2014. *A quality-based approach to public transportation planning: theory and a case study.* International Journal of Sustainable 8(1): pp. 84-106.

Cascetta E., Pagliara F., 2013. *Public Engagement for Planning and Designing Transportation Systems.* Procedia - Social and Behavioral Sciences: Elsevier.

Cascetta, E., 2009. *Transportation systems analysis. Models and Applications.* Springer Optimization and Its Applications: VOLUME 29.

Center for Sustainability, 2004. *Transportation Research Laboratory.* www.trl.co.uk: www.c4s.info.

Cervero, R. M. J., 2009. *Rail and Property Development in Hong Kong.* Urban Studies: 46(10) 2019-2043.

CES, 2006. *Vijayawada City Development Plan (Chapter 4.6 Traffic and Transportation). Project: Comprehensive Traffic and Transportation Study for Vijayawada City.* Consulting engineering services Ltd., India (CES): Document: 2006042/TT/Rep-02/Chap-3.

City-HUB project, 2013. *Deliverable D3.2.* Guide for Efficient and Smart Design: City-HUB project.

City-HUB Project, 2015. *Deliverable D5.2.* City-HUB: Handbook.

Cyclist infrastructure development plan, 2018. *Velosatiksmes attīstības plans 2018.-2020.gadam.* Riga council: RD.

CLOSER project, 2016. *Project Closer |CLOSER Project (7thFP).* s.l.:Closer-project.eu. http://www.closer-project.eu/.

Collins English Dictionary, 2018. *A system of buses, trains, etc, running on fixed routes, on which the public may travel.* HarperCollins: Retrieved 2018-01-30.

Cronbach, L., 1951. *Coefficient alpha and the internal structure of tests.* Psychometrical: 16(3), 297–334.

CST, 2005. *Defining Sustainable Transportation.* Centre for Sustainable Transportation: https://www.wellingtonpark.org.au/assets/wellingtonpark_CSTdefiningsustainabletransportation2005.pdf.

Curl A., Nelson J.D., Anable J., 2015. *Same question, different answer: A comparison of GIS-based journey time accessibility with self-reported measures from the National Travel Survey in England.* Computers, Environment and Urban Systems 49: 86–97.

Curtis C., Scheurer J., 2010. *Planning for sustainable accessibility: Developing tools to aid discussion and decision-making.* Progress in Planning 74 (2010): 53–106.

Dalvi M., Martin K., 1976. *The Measurement of Accessibility: Some Preliminary Results.* Transportation 5: 17–42.

de Jong G.,Daly A., Pieters M., 2007. *The logsum as an evaluation measure: review of the literature and new results.* Transportation Research Part A: Policy and Practice, 41, 874–889.

de Stasio C., Fiorello D., Maffii S., 2011. *Public transport accessibility through co-modality: Are interconnectivity indicators good enough?.* Research in Transportation Business & Management: 2, pp.48-56.

Dr Susanne Böhler-Baedeker, 2016. *Improving the efficiency of the transport system in urban nodes of the TEN-T core network.* Rotterdam: Rupprecht Consult.

Draper N., Smith H., 1997. *Applied regression analysis (2nd edition).* John Wiley and Sons: Inc.

Eboli, L. M. G., 2009. *An ordinal logistics regression model for analyzing airport passenger satisfaction.* EuroMed Journal of Business: Vol. 4, Issue: 1, pp. 40-57.

EC, 2000-2003. *European Commission: Benchmarking European Sustainable Transport: European Commission.* EU: Directorate-General for Energy and Transport.

EC, 2001-2005. *SUSTAINABLE TRANSPORT in EUROPE and LINKS and LIAISONS with AMERICA.* European Commission: https://trimis.ec.europa.eu/project/sustainable-transport-europe-and-links-and-liaisons-america.

EC, 2005. *Thematic strategy on the urban environment.* European Commission: COM (2005) 718.

ECMT, 2004. *Assessment and Decision Making for Sustainable Transport.* European Conference of Ministers of Transport: https://doi.org/10.1787/9789282113134-en.

ECR, 2008. *Sustainable Transport Project. Case Studies.* EC: ECR Europe& Boxwood.

Edwards, B., 2011. *Sustainability and the Design of Transport Interchanges.* Abingdon: UK: Routledge.

El-Geneidy A., Levinson D., 2006. *Access to Destinations: Development of Accessibility Measures.* Minnesota Department of Transportation: https://www.lrrb.org/pdf/200616.pdf.

Eltis platform Portal, 2003. *Benchmarking and management in public transport.* EU: EU-funded urban transport research project results.

ELTIS, 2016. *The urban mobility observatory.* EC: http://www.eltis.org/guidelines/sump-guidelines.

EN13816, 2002. *Transportation - Logistics and services - Public passenger transport - Service quality definition, targeting and measurement.* Brussels: European Standards.

EN15140, 2006. *Public passenger transport - Basic requirement and recommendations for systems that measure delivered service quality.* Brussels: European Standards.

ENDURANCE, 2015. *Project ENDURANCE.* EU: http://epomm.eu/endurance/index.php?id=2795.

English Oxford Living Dictionaries, 2018. *Buses, trains, and other forms of transport that are available to the public charge, set fares and run on fixed routes.* Oxford University Press: Retrieved 2018-01-30.

Enoch M.P., 2012. *Sustainable Transport, Mobility Management and Travel Plans.* 1st Edition, Routledge: Ashgate Press.

ESCAP, 2012. *Sustainable Urban Transportation Systems-UN CC: Learn.* United Nations Economic and Social Commission for Asia and the Pacific and CITYNET: https://www.uncclearn.org/sites/default/files/inventory/unescap20_0.pdf.

ETF, 2006-2008. *Trade Union Vision on Sustainable Transport.* European Transport Workers' Federation: EU.

Eur-lex.europa.eu, 2016. *EUR-Lex-32013R1315-EN-EUR-Lex.* EU: http://eur-lex.europa.eu/legal-content/EN/TXT.

European Commission, 2007. *GREEN PAPER-Towards a new culture for urban mobility.* Brussels: 25.9.2007 COM (2007) 551 final.

European Commission, 2007. *Sustainable Urban Transport Plans. Preparatory Document in Relation to the Follow-Up of the Thematic Strategy on the Urban Environment.* Brussels: Available at https://ec.europa.eu/transport/sites/transport/files/themes/urban/studies/doc/2007_sutainable_urban_transport_plan.pdf.

European Commission, 2013. *A CONCEPT FOR SUSTAINABLE URBAN MOBILITY PLANS.* Brussels: 17.12.2013.

European Innovation Partnership for Smart Cities and Communities, 2012. *SMART CITIES AND COMMUNITIES - EUROPEAN INNOVATION PARTNERSHIP.* Brussels, 10.7.2012 : https://www.kowi.de/Portaldata/2/Resources/fp7/com-2012-smart-cities-en.pdf.

European Union, 2009. *Territorial Dynamics in Europe, Trends in Accessibility.* LUXEMBOURG: ESPON.

EUROSTAT, 2014. *Statistical Office of the European Communities.* EUROSTAT: EU.

Geurs K.T., van Wee B., 2004. *Accessibility evaluation of land-use and transport strategies: review and research directions.* Journal of Transport Geography: 12(2), pp.127-140.

Geurs K.T., Zondag B., de Jong G. and de Bok M., 2010. *Accessibility appraisal of integrated land-use/transport policy strategies: more than just adding up travel time savings.* Transportation Research Part D 15: 382–393.

Geurs, K., 2001. *Accessibility measures: review and applications.* Bilthoven: RIVM report 408505 006, National Institute of Public Health and the Environment.

Goerigk, M. S. M. S. A., 2013. *Evaluating line concepts using travel times and robustness.* Public Transport: Zitiert von: 43 Ähnliche Artikel Alle 6 Versionen.

Gorev A.E, 2010. *Основы теории транспортных систем.* Санкт-Петербург: Министерство образования и науки Российской Федерации, Санкт-Петербургский государственный архитектурно-строительный университет.

Gössling, S., 2014. *Planning sustainable transport, by Barry Hutton.* Journal of Sustainable Tourism: 22(8), pp. 1268-1269.

Goulias Konstadinos G., 2002. *Transportation Systems Planning: Methods and Applications.* ISBN 9780849302732 - CAT# 0273: CRC Press.

Green Paper, 2007. *Green Paper The European Research Area: New Perspectives.* Brussels: COMMISSION OF THE EUROPEAN COMMUNITIES.

Gulhan G., Ceylan Huseyin, Özuysal M., Ceylan Halim, 2013. *Impact of utility-based accessibility measures on urban public transportation planning: A case study of Denizli, Turkey.* Cities 32, 102–112: https://doi.org/10.1016/j.cities.2013.04.001.

Hack, J. S., 1976. *Land use transport interaction – a new approach to accessibility.* London: Development Plans Regional Strategies 2 Division, Department of the Environment, Working Note No 151.

Hagerstrand, T., 1970. *What about people in regional science?.* People of the Regional Science Association 24: 7–21.

Handy S.L., Niemeier D.A., 1997. *Measuring accessibility: an exploration of issues and alternatives.* Environment and Planning A 29: 1175–1194.

Handy, S., 2002. *Accessibility- vs. mobility-enhancing strategies for addressing automobile dependence in the US.* Paris: Paper presented at the Europen conference of Ministers of Transport (ECMT).

Hansen, W., 1959. *How Accessibility Shapes Land Use.* J. Am. Inst. Plan. 2: 5, 73–76.

Hawas Y.E., Hassan M.N., Abulibdeh A., 2016. *A multi-criteria approach of assessing public transport accessibility at a strategic level.* Journal of Transport Geography 57, 19–34: https://doi.org/10.1016/j.jtrangeo.2016.09.011.

Heddebaute O., Palmer D., 2014. *Multimodal city-hubs and their impact on local economy and land use.* Transport Research Arena 2014, Paris: https://hal.archives-ouvertes.fr/hal-01073030.

Hillman R., Pool R., 1997. *GIS-based innovations for modelling public transport accessibility.* Traffic Engineering & Control, 38(10): pp. 554-559.

Hoeverna F., Egmondb P., Speka S., Nesa A. Créc I., Berendsd B., Hoogendoorne C., 2014. *New tools for design and operation of urban transport interchange facilities, zones and development areas.* TRA2014: Proceedings of the 5th Transport Research Arena.

Huang, S. S. A., 2009. A novel forecasting approach inspired by human memory: The example of short-term traffic volume forecasting. *Transportation Research Part C: Emerging Technologies,* 17/5(Pergamon), pp. 510-525.

Inrosoftware.com., 2019. *INRO | Emme Desktop.* Canada: Available at: http://www.inrosoftware.com/en/products/emme/emme-desktop/ [Accessed 3 Mar. 2019].

Intelligent Energy Europe, 2010-2013. *SEGmented Marketing for ENergy efficient Transport: Intelligent Energy Europe.* EU: https://ec.europa.eu/energy/intelligent/projects/en/projects/segment.

Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., Blodniece I., Nathanail Ef., Adamos G., 2019. *A Cross-Case Analysis of Riga Interchanges' Information Services and Technologies.* 17-

20 October 2018. Riga, Latvia: The 18h International Multidisciplinary Conference Reliability and Statistics in Transportation and Communication (RelStat-2018).

Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., Gromule V., 2017c. *Accessibility to Riga Public Transport Services for transit passengers.* Vilnius, Procedia Engineering (ISSN:1877-7058), Vol.187, pp.82-88 DOI: 10.1016/j.proeng.2017.04.353. (Scopus).

Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., 2017a. *A Comprehensive Analysis of the Planned Multimodal Public Transportation HUB.* Transportation Research Procedia (ISSN: 2352-1465): Vol. 24, pp. 50-57 (2017) DOI: 10.1016/j.trpro,2017.05.067 (Scopus).

Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., 2017b. *Evaluating Riga Transport System Accessibility.* Procedia Engineering (ISSN: 1877-7058), Vol. 178, pp. 480–490 (2017) DOI: 10.1016/j.proeng.2017.01.091 (Scopus).

Yatskiv (Jackiva) I., Budilovich (Budiloviča) E. (2019b) Decision-support Framework for the Urban Public Transport System Sustainable Planning: Riga Case Study. The 11th International Scientific Conference Transbaltica 2019: Transportation Science and Technology, 4-5 May 2019, Vilnius, Lithuania, Springer (In print)

Yatskiv I., Gromule V., Pticina I., 2015. *Analysis of Different Aspects of Infomobility for Public Transport in Latvia.* Proceedings of the Tenth International Conference on Dependability and Complex Systems DepCoS-RELCOMEX: W. Zamojski, J. Mazurkiewicz, J. Sugier, T. Walkowiak and J. Kacprzyk eds.Sugier, T. Walkowiak and J. Kacprzyk eds.

Janić, M., 2014. *Advanced transport system. Analysis, Modeling, and Evaluation of Performances.* ISBN 978-1-4471-6287-2: Springer.

Janssen P., Heuberger P., 1995. *Calibration of process-oriented models.* Ecological Modelling 83: 55–56.

Järv O., Tenkanen H., Salonen M., Ahas R., Toivonen T., 2018. *Dynamic cities: Location-based accessibility modelling as a function of time.* ISSN 0143-6228: Applied Geography, Volume 95, Pages 101-110.

Jeon C., Amekudzi A., 2005. *Addressing sustainability in transportation systems: definitions.* Indic. Metrics: 11, 31–50.

Kenworthy, J., 2006. *The eco-city: ten key transport and planning dimensions for sustainable city development.* Environment and Urbanization: 18(1), pp.67-85.

Kittelson and Associates, 2003b. *Transit Capacity and Quality of Service Manual.* 2nd ed.:: TCRP Report 100, Transportation Research Board.

Koenig, J., 1980. *Indicators of urban accessibility: theory and applications.* Transportation 9: 145–172.

Koopmans C., Groot W., Warffemius P., Annema J.A., Hoogendoorn-Lanser S., 2013. *Measuring generalised transport costs as an indicator of accessibility changes over time.* Transport Policy 29, 154–159: https://doi.org/10.1016/j.tranpol.2013.05.005.

Krygsman S., Dijst M., Arentze T., 2004. *Multimodal public transport: an analysis of travel time elements and the interconnectivity ratio.* Transport Policy: 11(3), 265–275.

Kumar, A., 2014. *Design and Applications of Decision Trees.* International Journal of Computer Science Trends and Technology: 2(4): 94-98.

Kwan, M.-P., 1998. *Space–time and integral measures of individual accessibility: a comparative analysis using a point-based framework.* Geographical Analysis 30 (3): 191–216.

Lama W.H.K., Sumaleea A., 2013. *Introduction: Modeling for Sustainable Urban Transportation.* International Journal of Sustainable Transportation, 7(3): pp. 167-169.

Lamíquiz Patxi J., Carpio-Pinedo J., García-Pastor A., 2014. *Transport Interchange and Local Urban Environment Integration.* Procedia: Social and Behavioral Sciences 160.

Latvijas autoceļi, 2019. [Accessed: 13- Jan- 2019]: Lv.wikipedia.org, 2017. [Online]. Available: https://lv.wikipedia.org/wiki/Latvijas_autoce%C4%BCi.

Leonardi, G., 1978. *Optimum facility location by accessibility maximising.* Environment and Planning A, 10: pp. 1287-1305.

Lia Z.-C., Lia Z.-K., Lambc W.H.K., 2014. *An integrated design of sustainable land use and transportation system with uncertainty in future population.* Transportmetrica A: Transport Science, 10(2): pp. 160-185.

Litman, T., 2012. *Evaluating Accessibility for Transport Planning. Measuring People's Ability to Reach Desired Goods and Activities.* http://www.vtpi.org/access.pdf ed. Victoria Transport Policy Institute: http://www.vtpi.org/access.pdf.

Litman, T., 2013. *The New Transportation Planning Paradigm.* ITE Journal, 83, 20-28: www.vtpi.org/paradigm.pdf..

Litman, T., 2014. *Introduction to Multi-modal Transport Planning, Principles and Practices.* Victoria Transport Policy Institute: www.vtpi.org/comp_evaluation.pdf.

Litman, T., 2015. *Well Measured. Developing Indicators for Sustainable and Livable Transport Planning.* Victoria Transport Policy Institute: http://www.vtpi.org/wellmeas.pdf.

Litman, T., 2016. *Accessibility for Transportation Planning.* Victoria Transport Policy Institute: http://www.vtpi.org/access.pdf.

Lopes-Lambas, M. &. M. A., 2010. *Private funding and management for public interchanges in Madrid.*. Research in Transportation Economics: 29(1), 323-328.

LR Administratīvais likums, 2010. *Latvian Administrative Violations Code.* Saeima: https://likumi.lv/ta/en/id/89648-latvian-administrative-violations-code.

LR Saeima, 2010. *National: Sustainable Development Strategy of Latvia until 2030.* SAEIMA: REPUBLIC OF LATVIA.

Magginas V., Nathanail Ef., Adamos G, Tsami M., Yatskiv (Jackiva) I., Budilovich (Budiloviča) E., 2018. *Environmental Friendly Transport Interchanges: Active Travel Accessibility and Policy.* Riga, Latvia: The 18h International Multidisciplinary Conference Reliability and Statistics in Transportation and Communication (RelStat-2018). 17-20 October 2018.

Maya, A., 2013. *Urban Transport and Sustainability: The Key Challenges.* International Journal of Sustainable Transportation: 7(3), pp. 170-185.

Mamun M., Lownes N., 2011. *A Composite Index of Public Transit Accessibility.* Journal of Public Transportation 14(2): 69-87.

Manaugh K., El-Geneidy A., 2012. *Who benefits from new transportation infrastructure? Using accessibility measures to evaluate social equity in transit provision.* In: Geurs, K., Krizek, K., Reggiani, A. (Eds.), Accessibility and Transport Planning: Challenges for Europe and North America: Edward Elgar, London, UK, pp. 211–227.

Mattsson, C., 2006. *Sustainable Urban Mobility Plans - A Comparison of the Implementation in Spain and Sweden.* Luleå: Luleå University of Technology.

McLeod Sam, 2017. *Urban Public Transport: Planning Principles and Emerging Practice.* Journal of Planning Literature 32(3): 223–239 – via SAGE.

Mega V., Pedersen J., 1998. *Urban Sustainability Indicators, European Foundation For The Improvement Of Living And Working Conditions (http://eurofound.europa.eu).* s.l.:https://www.eurofound.europa.eu/sites/default/files/ef_files/pubdocs/1998/07/en/1/ef9807en.pdf.

Mid-term review of White Paper, 2006. *KEEP EUROPE MOVING. Sustainable mobility for our continent.* Luxembourg: Office for Official Publications of the European Communities.

Ministry of Transport LR, 2016. *Satiksmes Ministrija - Rail Baltica.* Latvia: http://www.sam.gov.lv/sm/content/?cat=467.

Min, W. W. L., 2011. Realtime road traffic prediction with spatiotemporal correlations. *Transportation Research Part C: Emerging Technologies,* 19/4(Pergamon), pp. 606-616.

Mobility plan, 2011. *Riga and Pieriga mobility plan.* Riga: Ministry of transport the Republic of Latvia. [Online] Available at: http://www.sam.gov.lv.

Monzon, A. C. F., 2016. *City-HUBs Sustainable and efficient urban transport interchanges.* KSCE J Civ Eng (2016) 20: 1066: https://doi.org/10.1007/s12205-016-0685-0.

Morris J.M., Dumble P.L., Wigan M.R., 1979. *Accessibility Indicators for Transport Planning.* Transp. Res. A 13A: 91–109.

MOST, 1999. *Moving on Sustainable Transportation.* Transport Canada: http://www.tc.gc.ca.

MoTiv, 2018. *Mobility and travel time report.* University of Žilina, Slovakia: http://motivproject.eu/fileadmin/user_upload/deliverables/UNIZA_D2.2_Mobility_and_Travel_Time_Report_submitted.pdf.

Nathanail Ef., Adamos G., Tsami M., 2017. *Green urban interchanges: stakeholder and user perspectives.* September 2018Transport and Telecommunication 19(3): To appear in Special Issue of the Fresenius Environmental Bulletin Journal.

Niedzielski M., Boschmann E., 2014. *Travel time and distance as relative accessibility in the journey to work.* Ann. Assoc. Am. Geogr. 104 (6): 1156–1182.

Niemeier, D., 1997. *Accessibility: an evaluation using consumer welfare.* Transportation 24: 377–396.

OECD, 1998. *Environmentally Sustainable Transport: Report on Phase II of the OECD Project: Volume 1 Synthesis Report Organization of Economic Coordination and Development.* EU: www.oecd.org.

Páez A., Mercado R., Farber S., Morency C., Roorda M., 2010. *Accessibility to health care facilities in Montreal Island: an application of relative accessibility indicators from the perspective of senior and non-senior residents.* Int. J. Health Geogr. 9 (52): 1–15.

Páez A., Scott D.M., Morency C., 2012. *Measuring accessibility: positive and normative implementations of various accessibility indicators.* Journal of Transport Geography 25, 141–153: https://doi.org/10.1016/j.jtrangeo.2012.03.016.

Pirie, G., 1979. *Measuring accessibility: a review and proposal.* Environment and Planning A 11: 299–312.

Pitsiava-Latinopoulou, M. and P. Iordanopoulos, 2012. *Intermodal passengers terminals: Design standards for better level of service.* Procedia-Social and Behavioral Sciences: Transport Research Arena 2012 48: 3297–3306.

Polite-project.eu, 2018. *Policy learning in information tehnologies for public transport enhancement.* Intereg IVC: [online] Available at: http://www.polite-project.eu/ [Accessed 8 Dec. 2018].

Preston J., Raje F., 2007. *Accessibility, Mobility and Transport-related Social Exclusion.* Journal of Transport Geography 15: 151-160.

Project NODES, 2016. *Welcome to NODES.* EU: http://www.nodes-interchanges.eu/.

Pticina, I., 2015. *Promocijas darbs. Pilsētas sabiedriskā transporta sistēmas kvalitātes integrāls novērtējums no lietotāja kvalitātes integrāls novērtējums no lietotāja viedokļa.* Riga: TSI.

publictransportaion.org, 2018. *Where public transportation goes community grows.* [Online] Available at: https://www.publictransportation.org/Pages/default.aspx [Accessed 2018].

PV, 2018. *AS Pasažieru vilciens.* https://www.pv.lv/lv/informacija-pasazieriem/vilciena-ar-velosipedu/: Last accessed 4 Oct 2018.

QUATTRO, 2017. *Transport research & inovation portal.* [Online] Available at: http://www.transport-research.info/project/quality-approach-tendering-urban-public-transport-operations

Quinlan, 1993. *C4.5: Programs for machine learning.* San Francisco: Morgan Kaufmann.

Railbaltica.info, 2014. *Rail Baltica project.* Latvija: http://railbaltica.info/en/.

RD PAD, 2005. *Rīgas ilgtermiņa attīstības stratēģija līdz 2025.* Riga: Available: http://www.rdpad.lv/wp-content/uploads/2014/12/Rigas_ilgtermina_attistibas_strategija_2025.g.pdf.

RD PAD, 2014. *Sustainable development strategy of Riga until 2030.* Riga: Riga city development department.

RD PAD, 2017. *Rīgas transporta sistēmas tematiskais plānojums.* Rīga: Rīgas attīstības departaments.

RD PAD, 2019. *Riga Transport System Sustainable Mobility Action Plan, Status Report.* Riga: RD.

Regulation 1315/2013, 2013. *Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU.* REGULATION (EU) No 1315/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on: Official Journal of the European Union.

Richardson, B., 1999. *Towards A Policy On A Sustainable Transportation System. System.* Transportation Research Record 1670: pp. 27-34.

Rigas Satiksme, 2016. *Rigass atiksme.* Riga: [online] Available at: https://www.rigassatiksme.lv/en/about-us/ [Accessed 29 Aug. 2016].

Road traffic law, 2015. *Ceļu satiksmes likums.* Latvija: https://likumi.lv/doc.php?id=45467.

Rodrigue, J., 2017. *The Geography of Transport Systems.* New York: Routledge, 440 pages. ISBN 978-1138669574.

Rules of the Roads N.571, 2015. *Ceļu satiksmes noteikumi.* MK noteikumi Nr.571: https://likumi.lv/doc.php?id=90585.

Schofer Joseph, L., 2018. *Mass transit.* UK: Encyclopedia Britannica.

Schoon J., McDonald M., Lee A., 1999. *Accessibility Indices: Pilot Study and Potential Use in Strategic Planning.* s.l.:Transportation Research Record: Journal of the Transportation Research Board, 1685, 29-38.

Sdoukopoulos et al., 2019. *Measuring progress towards transport sustainability.* s.l.:Transportation Research Part D 67 (2019) 316-333.

Sheikh Ariful Alam, 2013. *Evaluation of the potential locations for logistics hub: A case study for a logistics company (Degree project in Transport and Location Analysis).* s.l.:KTH Architecture and the built environment.

Silva C., Papa E., 2017. *Accessibility instruments in planning practice are bridging the implementation gap.* s.l.:s.n.

Sintropher, 2012. *Good practice in transport interchanges: A range of case studies from across the northwest Europe area examining public transport interchange design.* Project report: http://sintropher.eu/sites/default/files/images/editors/Project_Reports/Interchanges%20report%20web%20version%20editors/Project_Reports/Interchanges%20report%20web%20version%20.

Sivilevičius, H., 2011. *Modelling the interaction of transport system elements.* Vilnius: https://doi.org/10.3846/16484142.2011.560366.

Song, Y. L. Y., 2015. *Decision Tree Methods: Applications for Classification and Prediction.* Shanghai Archives of Psychiatry : 27(2): 130-135.

Song, S., 1996. *Some tests of alternative accessibility measures: a population density approach..* s.l.:Land Economics 72 (4), 474–482.

Spiess, H. F. M., 1989. *Optimal Strategies: A New Assignment Model For PT Networks.* s.l.:Transportation research B 2 (1989): 83-102.

Strategy 2030, 2014. *Riga Sustainable development strategy of Riga until 2030.* Rīga: Riga city development department: http://www.rdpad.lv/strategija/.

SUMBA, 2017. *SUSTAINABLE URBAN MOBILITY AND COMMUTING IN BALTIC CITIES.* EU: http://sumba.eu.

SUMMA, 2003. *Deliverable 2.* s.l.:http://www.tmleuven.be/project/summa/summa-d2.pdf.

Sustainability for all, 2018. *DO YOU KNOW WHEN SUSTAINABILITY FIRST APPEARED?.* [Online]
Available at: https://www.activesustainability.com/sustainable-development/do-you-know-when-sustainability-first-appeared/
[Accessed 1 May 2019].

Taylor D., Mahmassani H., 1996. *Analysis of stated preferences for intermodal bicycle-transit interfaces.* Transportation Research Record: Journal of the Transportation Research Board: 1556(1): 86–95.

Te Brömmelstroet M., Bertolini L., 2009. *Integrating land use and transport knowledge in strategy-making.* Transportation: 37(1), pp.85-104.

Thematic research summary on passenger transport, 2013. *Thematic Research Summary. Passenger Transport.* COMMUNICATING TRANSPORT RESEARCH AND INNOVATION: https://www.kowi.de/Portaldata/2/Resources/fp/trip-passenger-transport.pdf.

Tyrinopoulos Y., Antoniou C., 2008. *Public transit user satisfaction: variability and policy implications.* s.l.:Transport Policy, 15(4), pp. 260-272.

TRB, 1997. *Toward A Sustainable Future; Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology, Committee for a Study on Transportation and a Sustainable Environment.* National Academy Press: www.trb.org.

Tsami M., Adamos G., Nathanail E., 2013a. *Investigating the accessibility level for disabled users at urban transport interchanges.* Riga, Latvia: Proceedings of the 13th International Conference Reliability and Statistics in Transportation and Communication (RelStat'13), pp. 109–116.

Tsami M., Adamos G., Nathanail E., 2013b. *Sustainable development for the design for the transformation of the Thessaloniki railway station into a City Hub.* European Transport Conference (ETC) 2013, Frankfurt, Germany: http://abstracts.aetransport.org/paper/index/id/171/confid/1.

Tsami M., Adamos G., Nathanail Ef., Budilovich (Budiloviča) E., Yatskiv (Jackiva) I., Magginas V., 2018b. *A decision tree approach for achieving high customer satisfaction at urban interchanges.* Journal of Transport and Telecommunication: 2018, Vol.19 (3), pp.

Tsami M., Budilovich (Budiloviča) E., Magginas V., Adamos G., Yatskiv (Jackiva) I., 2018a. *Assessing the Design and Operation of Riga's International Coach Terminal.* Riga, Latvia: In: Kabashkin I., Yatskiv I., Prentkovskis O. (eds) Reliability and Statistics in Transportation and Communication. RelStat 2017. Lecture Notes in Networks and Systems, vol.36. Springer, 497-506.

Tsami M., Nathanail E., 2014. *A decision tree application in transit quality of service in the city of Volos.* s.l.:2nd Conference of Sustainable Urban Mobility, 05-06 May 2014, Volos, Greece.

T-TRANS, 2018. *T-TRANS upbringing ITS products and services to market.* s.l.:Available at: http://www.ttransnetwork.eu/ttrans/ [Accessed 8 Dec. 2018].

U.S. Department of Environment, 1996. *Policy and Procedure Guidelines.* USA: pp. 6.

UITP, 2009. *Europen department's activity report for the year 2009.* Europen Union: http://www.uitp.org/sites/default/files/cck-focus-papers-files/Activity%20Report%202009.pdf.

UN ESCAP, 2012. *Sustainable Urban Transportation Systems.* United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP): https://www.uncclearn.org/sites/default/files/inventory/unescap20_0.pdf.

UNECE, 2015. *Sustainable Urban Mobility and Public Transport in UNECE capitals.* This publication is part of the Transport Trends and Economics Series (WP.5): UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE, New York and Geneva.

United Nations, 2015. *Transforming our world: the 2030 Agenda for Sustainable Development.* General Assembly. Resolution adopted by the General Assembly on 25 September 2015: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

United Nations, 2015. *World Population Prospects: The 2015 Revision.* Available from: http://esa.un.org/unpd/wpp/.

UNWC, 1987. *Report of the World Commission on Environment and Development: Our Common Future.* Oxford: Oxford University Press: http://www.un-documents.net/our-common-future.pdf.

Urban Mobility Package, 2013. *Together towards competitive and resource-efficient urban mobility.* Brussels, 17.12.2013: https://ec.europa.eu/transport/sites/transport/files/themes/urban/doc/ump/com%282013%29913_en.pdf.

Valdes C., Monzon A., Benitez F.G., 2016. *Sustainable urban transportation strategies: Searching for synergies.* KSCE J Civ Eng (2016) 20: 1066: https://doi.org/10.1007/s12205-016-0685-0.

Van Wee, B., 2013. *Urban Form and Transport Accessibility.* Journal of Environmental Policy & Planning: 15(2), 323-324.

Velokoncepcija, 2015. *Rīgas pilsētas velosatiksmes attīstības koncepcija 2015.-2030.gadam.* s.l.:Riga city Trafic department.

Verseckiene A., Meskauskas V., Gusaroviene M., 2015. *Vilnius public transport development: towards the more sustainable system.* Vilnius: CASPT2015.

Verseckienė, A., 2016. *Public Transport Accessibility for People with Movement Disorders: The Case Study of Vilnius.* Urban. Vilnius: Procedia Engineering 134:48-56.

Vlahogianni, I., 2005. *Optimized and meta-optimized neural networks for short-term traffic flow prediction: A genetic approach.* Transportation Research Part C: Emerging Technologies: https://doi.org/10.1016/j.trc.2005.04.007.

Vlasov D.N., 2017. *Транспортно-пересадочные узлы.* Москва: Министерство образования и науки Российской Федерации. Национальный исследовательский московский государственный строительный университет.

Wachs, M., 1973. *Physical Accessibility as a Social Indicator.* Socio-Econ. Plan. Sci. 7: 437–456.

WCED, 1987. *Our Common Future, World Commission on Environment and Development.* Brundtland Commission: http://ringofpeace.org/environment/brundtland.html.

White Paper, 2001. *"European transport policy for 2010: Time to decide".* European Commission: CEC.

White Paper, 2011. *White Paper on transports.* Luxembourg: Publications Office of the European Union: https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf.

WHO, 2011. *Global Plan for the Decade of Action for Road Safety 2011-2020.* Geneva, Switzerland: World health organization (OSN).

Widener M., Farber S., Neutens T., Horner M., 2015. *Spatiotemporal accessibility to supermarkets using public transit: an interaction potential approach in Cincinnati Ohio.* s.l.:J. Transp. Geogr. 42, 72–83.

Wikipedia, 2018. *Transports HUB.* Available from: https://en.wikipedia.org/wiki/Transport_hub.

Wilson, E., 1998. *Consilience.* New York: Alfred Knopf.

Zhang W., Nian P., Lyu G., 2016. *A multimodal approach to assessing the accessibility of a high-speed railway station.* Journal of Transport Geography 54, 91–101: https://doi.org/10.1016/j.jtrangeo.2016.05.007.

ACKNOWLEDGEMENTS

The promotion work is based on the research and work that has been conducted in the framework of the ALLIANCE project (http://alliance-project.eu/), which has received funding from the European Union's Horizon 2020 Research and Innovation Programme. This study is part of an EU project that is surely carried out according to ethical policies. The authors would like to thank both the consortium of the project and the European Commission.

Also, I would like to say many thanks to my second supervisor from Greece to Dr Giannis Adamos for his intelligence and knowledge in our collaboration work. My co-authors and colleagues: Maria Tsami, Visarion Magginas, dr. Vaira Gromule and, of course, the professor Eftihia Natinael for the help in writing article.

I want to say thanks to the professor I.Kabashkin for his constructed and systematic advice during the research preparation.

Moreover, the work would not have been realised without the professor Irina Yatskiv, without her knowledge and belief that it is possible!

My special thanks go to Ilze Purmale (The deputy of the urban planning board in Riga Council Development Department) for approving to study and work.

APPENDIX

Appendix 1. The application for sustainable indicator definition

Source: Adapted by authors from SUMMA (2003), European Environment Agency (2005, Kennedy et al. (2005: 394)

	Criteria	Indicators	Score					
			1	2	3	4	5	
			worse	low	average	good	high	sum
1.1	Accessibility (average walking time between travel point, multimodal accessibility, accessibility by road)	**Access to public transport** (Piekļuve sabiedriskajam transport)						
1.2		**Access to basic services** (Piekļuve pamatpakalpojumiem)						
1.3		**Accessibility of origins and destinations** (Pieejamība sakumā punktam un galamērķi						
2.4	Health and safety vehicle accident rate, passenger accident rate, crime rate)	**Accident-related fatalities and serious injuries** (Nelaimes gadi jumi ar nāvi un nopietniem ievainojumiem)						
2.5		**Exposure to transport noise** (ietekme no transporta trokšņiem)						
2.6		**Exposure to air pollution** (ietekme no gaisa piesārņojuma)						
2.7		**Walking and cycling as transport means for short distances** (iešana ar kājām un braukšana ar velo tikai uz īsiem attālumiem)						
3.8	Cost-effectiveness	**Energy efficiency** (Energoefektivitāte)						
3.9		**Generation of non-recycled waste** (ražot nepārstrādājumus atkritumus)						
3.10		**Public subsidies** (Valsts subsīdijas)						
4.11	Impact on competitiveness and generation of wealth	**Gross value added** (PVN)						
4.12		**External transport costs** (transporta izmaksas)						
4.13		**Benefits of transport** (Ieguvumi no transporta)						
5.14	Consumption of natural capital	**Land take** (zemes aizņemšana)						
5.15		**Consumption of solid raw materials** (Cietu vielu patēriņš)						
5.16		**Damage to habitats and species** (Kaitējums dzīvotnēm un sugām						
6.17	Production of pollutants	**Emission of greenhouses gases** (gāzu emisija siltumnīcefekta palielināšanai)						
6.18		**Emission of air pollutants** (gaisa piesārņošana)						
6.19		**Runoff pollution from transport infrastructure** (Notece piesārņojums no transporta infrastruktūras)						
6.20		**Discharge of oil and waste at sea** (naftas un atkritumu noplūde jūrā)						

Appendix 2. The application for the traveller satisfaction survey

1. Jūsu brauciens. Ваша поездка. Your Trip.

1. Jūsu brauciena sākumpunkts (rajons, apkaime, adrese, pilsēta)
   Начало вашей поездки (район, микрорайон, адрес, город)
   Origin of your trip (district, address)

   ____

2. Jūsu brauciena galamērķis (rajons, apkaime, adrese, pilsēta)
   Пункт назначения (район, микрорайон, адрес, город)
   Destination of your trip (address, district)

   ____

3. Brīdī, kad piedalāties aptaujā jūs (atzīmējiet tikai vienu):
   Когда вы были приглашены участвовать в этом анкетном опросе, вы (отметить только одно):
   When you were invited to participate in this questionnaire, were you? **TICK ONE ONLY:**

❑	Gatavojaties braucienam Начали своё путешествие Starting your journey
❑	Pārsēžaties Пересаживались Transferring
❑	Esat atbraucis Конечная остановка Ending your journey

4. Kāds ir jūsu brauciena galvenais mērķis (atzīmēt tikai vienu)
   Какая главная цель вашей поездки сегодня (отметить только одно)
   What was the main purpose of your journey today? **TICK ONE ONLY**

❑	Darbs, komandējums Работа (поездка в работу и командировка) Work (trip to work and working trip)
❑	Mācības Образование Education
❑	Atpūta, tikšanās ar ģimeni vai draugiem Развлечение, встреча с семьёй или друзьями Leisure or visiting family and friends
❑	Cits Другое Other

5. Jūs braucāt….?
   Вы путешествуете…. ?
   Did you travel…?

❑	Viens Один Alone
❑	Kopā ar kādu Вдвоём With someone
❑	Ar bagāžu С багажом With luggage
❑	Ar vecāku cilvēku С пожилым человеком

	With older people
❑	Kopā ar pavadoni, piemēram, sakarā ar redzes vai pārvietošanās problēmām Сопровождение другого взрослого, например, из-за ослабленного зрения или подвижности Accompanying another adult requiring assistance, for example because of impaired vision or mobility

6. Vai jums ir invaliditāte?
Есть ли у вас какой-либо вид нетрудоспособности?
Do you have any kind of disability?

	Nē Нет No	❑	Uz laiku Временно Temporary	❑	Pastāvīgi Постоянно Permanent	❑	Nevēlos atbildēt Не хочу говорить Prefer not to say

7. Kāds ir jūsu brauciena kopējais laiks (no sākumpunkta līdz galamērķim/ no durvīm līdz durvīm) (minūtēs)?
Какое общее время вашей поездки (от начального пункта до пункта назначения/ от двери до двери) (в минутах)?
What was the overall duration of your trip (from origin to destination/ from door to door) (in minutes)?

____

8. Pārsēšanās daudzums ceļojumā laikā līdz(no) autoostai(s):
Количество пересадок, совершенное во время путешествия до(от) автовокзала:
Total number of transfers (changes in transport mode) in your trip to(from) RICT:

9. Ar kādu transporta veidu jūs brauksiet līdz(no) autoostai(s) (atzīmējiet visi transporta veidi, kas ir izmantoti braucienā)?
Какой вид транспорта вы используете для поездки до (от) автовокзала (отметьте все, которые Вы использовали в этой поездке)?
How did you travel to (from) RICT (please state your previous transport mode)?

❑	Vilciens. Поезд. Train.	❑	Motocikls. Мотоцикл/мопед. Motorcycle/Moped.
❑	Autobuss. Автобус. Bus.	❑	Divritenis. Велосипед. Bicycle.
❑	Taksometrs. Такси. Taxi.	❑	Gājējs. Пешком. Walking.
❑	Trolejbuss. Троллейбус. Trolleybus.	❑	Tramvajs. Трамвай. Tram
❑	Ar automašīnu kā vadītājs. На машине как водитель. Car as driver.	❑	Cits: Другое: Other, please state:
❑	Ar automašīnu kā pasažieris. На машине как пассажир. Car as passenger.		

10. Cik ilgā laika jums aizņems brauciens ar sabiedrisko transportu Rīgā līdz(no) autoostai(s)?
Сколько времени займет ваша поездка на общественном транспорте в Риге от(до) автовокзала?
How long was your trip to (from) RICT by public transport in Riga?

Kopējais laiks: Общее время: TOTAL TIME. (minūtes, минуты)

11. Kādu biļeti jūs izmantosiet braucot ar sabiedrisko transportu:
Какой билет вы будете использовать для поездки на общественном транспорте:
Public transport ticket used for your trip:

❑	E-talons (dzeltenais) Э-талон (жёлтый)

	E-ticket (yellow)
❑	Rīdzinieka karte Карта рижанина Riga resident's card
❑	Cits Другое Other

12. Cik ilgu laiku jūs pavadījāt autoostā (pirms vai pēc brauciena)?
Сколько времени вы провели на автовокзале?
How much time did you spend within RICT station?

Kopējais laiks: Общее время: TOTAL TIME: (minutes, минуты)

13. Ko jūs darījāt savā brīvajā laikā autoostā. Lūdzu, izvēlieties aptuveno laiku (minūtes)
Чем вы занимались в свободное время на автовокзале. Пожалуйста, укажите приблизительное время.
How did this time break down (approximately)? Please provide your answer in minutes.

Pārsēšanās Пересадка TRANSFERRING MODES*	**Iekāpšanas gaidīšana Ожидание посадки QUEUING FOR BOARDING**	**Покупки Iepirkumi SHOPPING**	**Cits Другое OTHER ACTIVITIES****

**Pārsēšanās: Pastaiga līdz iekāpšanas vietai*
Пересадка: пешая прогулка до места посадки
TRANSFERRING MODES: Walking between different transport modes for boarding. E.g. transferring between train and bus stop.
***Citas: biļešu iegāde, uzturēšanās gaidīšanas zonā, u.c.*
Другое: покупка билетов, нахождение в зоне ожидания и др.
OTHER ACTIVITIES: buying tickets, seated in waiting areas, etc.

14. Cik bieži Jūs izmantojat autoostu? Atzīmēt tikai vienu atbildi
Как часто вы пользуетесь автовокзалом? Отметить только один вариант ответа
How often do you use this interchange? **TICK ONE ONLY**

❑	Katru dienu (vairāk nekā 4 dienas nedēļā) Ежедневно (более чем 4 дня в неделю) Daily (more than 4 days a week)
❑	3 vai 4 reizes nedēļā 3 или 4 раза в неделю 3 or 4 times a week
❑	1 vai 2 reizes nedēļā 1 или 2 раза в неделю Once or twice a week
❑	Pāris reizes mēnesī Пару раз в месяц Few times a month
❑	Retāk Не очень часто Less frequently

2. Pasažieru apmierinātības aptauja Rīgas starptautiskajā autoostā (RSA)
Опрос удовлетворённости пассажиров РА (Рижский автовокзал)
Travellers' satisfaction survey RICT (Riga international coach terminal)

15. Kāds ir jūsu apmierinātības līmenis attiecībā uz informāciju par braucienu?
Каков ваш уровень удовлетворения относительно **ИНФОРМАЦИИ** о поездке, обеспеченной РА?
What is your level of satisfaction concerning the **TRAVEL INFORMATION provided at RICT?**

Level of

Pieejama un ērta informācija (grafiki, reisi, kavēšanās) autoostā Доступность и простота использования информации (расписания, маршруты, задержки) на автовокзале Availability and ease of use of travel information (timetables, routes, delays) at the interchange (station)					
Informācijas pieejamība (grafiki, reisi, kavēšanās) pirms brauciena Доступность информации о поездке (расписания, маршруты, задержки) перед вашей поездкой Availability of travel information (timetables, routes, delays) before your trip					
Norādītas informācijas precizitāte un uzticamība autoostā Точность и надежность указанной информации о поездке для автобусов на автовокзале Accuracy and reliability of travel information displays for bus/trains/underground at the interchange					
Biļešu iegāde (biļešu kases, pašapkalpošanās biļešu tirdzniecības termināli, u.c.) Покупка билета (кассы, билетные автоматы, и т.д.) Ticket purchase (ticket offices, ticket machines, etc.)					

16. Kāds ir jūsu apmierinātības līmenis par informāciju un pieejamiem pakalpojumiem autoostas teritorijas apkārtnē?
Какой ваш уровень удовлетворения информацией, предоставленной РА об услугах и о возможности использования других транспортных средства возле автовокзала?
What is your level of satisfaction with the **information provided at RICT on how to find your way around the station and associated transport facilities**?

Level of

Informatīvas norādes par dažādiem pakalpojumiem (mazumtirdzniecības, sabiedriskās ēdināšanas vietām, uzgaidāmām telpām, tualetēm, u.c.) Указатели информации о различных удобствах и услуг (розничная продажа, места общепита, зоны ожидания, туалеты, и т.д.) Signposting to different facilities and services (retail, catering facilities, waiting areas, toilets, etc.)					
Informācija par iespēju pārsēsties uz citiem transporta veidiem (sabiedriskais transports, taksometri, divriteņu stāvvieta u.c.) Указатели информации о способах пересадки на другие виды транспорта (общественный транспорт, такси, стоянка для велосипедов и т.д.)					

Signposting to transfer between transport modes in all parts of the interchange. E.g. to buses, taxis, cycle parking, etc.					
Informācijas pietiekamība un autoostas personāla atbalsts (uzziņu dienests) Информирование и помощь обслуживающего персонала (справочная служба) Information and assistance provided by staff, e.g. at customer information points					

17. Kāds ir jūsu apmierinātības līmenis attiecībā pret LAIKU un KUSTĪBU autoostā?
Какой ваш уровень удовлетворения аспектом ВРЕМЯ&ДВИЖЕНИЯ на автовокзале?
What is your level of satisfaction concerning the following **TIME & MOVEMENT** aspects inside the interchange?

Level of

Pārsēšanās attālums starp dažādiem transporta veidiem. Piemēram, uz autobusiem, taksometriem, divriteņu stāvvietām u.c. Расстояние для пересадки между различными способами транспортировки. Например, к автобусам, такси, стоянке для велосипедов, и т.д. Transfer distances between different transports modes. E.g. to buses, taxis, cycle parking, etc.					
Dažādu transporta operatoru un transporta pakalpojumu savstarpēja sasaiste (piemēram, starp vilcieniem un autobusiem) Координация между различными компаниями-перевозчиками или транспортными услугами (например, между поездами и автобусами) Co-ordination between different transport operators or transport services (e.g. between trains and buses)					
Jūsu laika izmantošana (pārsēšanās un uzgaidīšana) autoostā Использование вашего времени (пересадка и ожидание) на автовокзале Use of your time (transferring & waiting) at the interchange					
Attālums līdz labierīcībām un citiem pakalpojumiem (mazumtirdzniecības, sabiedriskās ēdināšanas vietas, uzgaidāmās telpas, tualetes, u.c.) Расстояние до удобств и услуг (розничная торговля, места общепита, зоны ожидания, туалеты, и т.д.) Distance between the facilities and services (retail, catering facilities, waiting areas, toilets, etc.)					
Pārvietošanās brīvība autoostā lstreet cilvēku pieplūduma gadījumā Свобода передвижения из-за большого числа людей на автовокзале Ease of movement due to number of people inside the interchange					

18. Kāds ir jūsu apmierinātības līmenis attiecībā pret PIEEJAMĪBU autoostā?

Какой ваш уровень удовлетворения относительно ДОСТУПА?
What is your level of satisfaction concerning **ACCESS?**

Level of

			3		
Ērta vai vienkārša piekļuve autoostai Легкость и простота доступа до автовокзала Ease of access to the interchange					
Ērta vai vienkārša izkļūšana no autoostas Легкость и простота доступа из/от автовокзала Ease of access from the interchange					

19. Kāds ir jūsu apmierinātības līmenis attiecībā pret KOMFORTU un SERVISU autoostā?
Какой ваш уровень удовлетворения КОМФОРТОМ и УДОБСТВАМИ?
What is your level of satisfaction about **COMFORT & CONVENIENCE?**

Level of

Tīrība autoostā Общая чистота на автовокзале General cleanliness of the interchange					
Temperatūra, patvērums no lietus un vēja, ventilācija, gaisa kondicionēšana Температурный режим, укрытия от дождя и ветра, вентиляция, кондиционер Temperature, shelter from rain and wind, ventilation, air conditioning					
Kopējais trokšņa līmenis autoostā Общий уровень шума на автовокзале General level of noise of the interchange					
Gaisa kvalitāte, piesārņojums Качество воздуха, загрязнение. Например, выбросы транспортных средств Air quality, pollution. E.g. emissions from vehicles					
Veikalu daudzums Количество магазинов Number and variety of shops					
Kafejnīcu un restorānu daudzums Количество кафе и ресторанов Number and variety of coffee-shops and restaurants					
Bankomātu pieejamība Доступность банкоматов Availability of cash machines					
Sēdvietu pieejamība Доступность сидячих мест Availability of seating					
Mobilo sakaru un Wi-Fi pieejamība Доступность сигнала мобильного телефона и Wi-Fi Availability of mobile phone signal and Wi-Fi					
Informācijas ekrānu pieejamība Присутствие и комфортное расположение					

информационных экранов Comfort due to the presence of information screens					

20. Kāds ir jūsu apmierinātības līmenis attiecībā pret autoostas pievilcību un saistītā transporta iespējas?
Какой ваш уровень удовлетворения относительно привлекательности автовокзала и связанного транспорта?
What is your level of satisfaction concerning **the attractiveness of RICT and associated transport facilities?**

Level of

Apkārtne ir patīkama Окружающее пространство приятно The surrounding area is pleasant					
Iekštelpu dizains autoostā (izskats, pievilcība, u.c.) Внутренний дизайн автовокзала (общий вид, привлекательность, и т.д.) The internal design of the interchange (visual appearance, attractiveness, etc.)					
Ārējais autoostas dizains (izskats, pievilcība, u.c.) Внешний дизайн автовокзала (общий вид, привлекательность, и т.д.) The external design of the interchange (visual appearance, attractiveness, etc.)					

21. Kāds ir jūsu apmierinātības līmenis attiecībā pret drošību autoostā?
Какой ваш уровень удовлетворения относительно БЕЗОПАСНОСТИ на автовокзале?
What is your level of satisfaction concerning **SAFETY & SECURITY RICT?**

Level of

Pārsēšanās drošība no viena transportlīdzekļa uz citu Безопасность при пересадке с одного транспортного средства на другой Safety getting on and off the transport mode (train, bus, taxi, bicycle, etc.)					
Drošība autoostā Безопасность на автовокзале Safety whilst inside the interchange					
Drošības sajūta pārsēšanās un gaidīšanas zonās (dienas laikā) Чувство безопасности в трансфертных и зонах ожидания (в течение дня) Feeling secure in the transfer & waiting areas (during the day)					
Drošības sajūta pārsēšanās un gaidīšanas zonās (vakaros un naktī) Чувство безопасности в трансфертных и зонах ожидания (вечером/ночью) Feeling secure in the transfer & waiting areas (during the evening/night)					

Drošības sajūta autoostas apkārtnē Чувство безопасности на территории вокруг автовокзала Feeling secure in the surrounding area of the interchange					
Apgaismojums Освещение Lighting					

22. Kāds ir jūsu apmierinātības līmenis attiecībā pret ĀRKĀRTAS GADĪJUMIEM autoostā
Какой ваш уровень удовлетворения относительно ЭКСТРЕННЫХ МЕР?
What is your satisfaction concerning the **EMERGENCY PROCEDURES RICT?**

— **Level of** **+**

Informācija, lai uzlabotu jūsu drošības sajūtu Информация, чтобы улучшить ваше чувство защищенности Information to improve your sense of security					
Avārijas izejas zīmes Указатели запасных выходов Signposting to emergency exits					
Avārijas izeju atrašanās vietas ugunsgrēka gadījumā Расположение запасных выходов при пожаре Location of emergency exits in case of fire					

23. Lūdzu, sniedziet galīgo vispārējo novērtējumu par pakalpojumiem autoostā:
Пожалуйста, дайте заключительную общую оценку своего удовлетворения обслуживанием на автовокзале:
Please, give a final **overall value** for your satisfaction with the service at this interchange**:**

— **Level of satisfaction** **+**

1	2	3	4	5
❑	❑	❑	❑	❑

24. Noslēgumā, kādas ir trīs būtiskākās lietas autoostā?
В заключении, какие, по вашему мнению, 3 главные пункта для автовокзала?
Finally, which of the following are, in your opinion, the **three most important aspects** of an interchange?

	Atzīmēt tikai 3 **Отметить только 3** **Tick only 3**
Informācija: ceļojums un pārsēšanās Информация: поездка и пересадка Information: trip and interchange	
Uzgaidāmās zonas Зоны ожидания Waiting Areas	
Drošība Безопасность Safety & Security	
Pakalpojumi (tualetes, biļešu iegāde, bagāžas uzglabāšanas telpa u.c.) Услуги (туалеты, покупка билета, камера хранение	

багажа, и т.д.) Services (toilets, ticket purchase, luggage store, etc.)	
Veikali un kafejnīcas Магазины и кафе Shops and Cafes	
Pārsēšanās iespēja starp dažādiem transporta veidiem Возможность пересадки между транспортными средствами Transfer communication between transport modes	
Autoostas pieejamība Доступность автовокзала Access to the interchange	
Cits: Другие: Other: (Please specify): …………………………………….	

3. Jauns transporta mezgls /Новый транспортный узел /New multi-modal transport hub

2024.gadā Torņakalna apkaimē paredzēt izbūvēt multimodālo transporta mezglu, kura ietvaros plānota reģionālās autoostas izvietošana Kurzemes un Zemgales maršrutu apkalpošanai, automašīnu stāvvieta, dzelzceļa pieturvieta, kā arī sabiedriskā transporta savienojums.

2024 году планируется строительство нового транспортного узла в Торнякалнсе, который будет состоять из региональной автостанции (обслуживающей регионы Курземе и Земгале), автостоянки и новых маршрутов общественного транспорта.

By 2024 it is planned to build multi-modal transport hub in Tornakalns neighbourhood which will provide service for the regional bus station to Kurzeme and Zemgale destinations, car parking lot, railway stop and public transport links.

25. Vai dodoties uz Kurzemes un Zemgales virziena galamērķiem Jums būtu ērti izmantot autoostas pakalpojumus, ja reģionālās autoosta tiktu izvietota Torņakalna apkaimē?

Использовали бы вы новый мультимодальный вокзал в Торнякалнсе, как региональную автостанцию?

Would it be convenient to use bus station services for your trip to/from Kurzeme and Zemgale destinations if regional bus station will be located in Tornakalns neighbourhood?

	Jā Да Yes
	Nē Нет No
	Nezinu Не знаю Others

26. Kādus sabiedriskā transporta veidus un maršrutus vai privāto transportu Jums būtu nepieciešams izmantot, lai nokļūtu uz/no reģionālās autoostas Torņakalnā līdz/no galamērķim Rīgā?

Каким видом транспорта (общественный транспорт или легковая машина) вы бы предпочли начать/закончить свою поездку с/от автостанции?

What kind of public transport or private transport would you need to use to get to/from the regional bus station in Tornakalns neighbourhood to get to/from your destination in Riga?

❑	Vilciens. Поезд. Train.	❑	Motocikls. Мотоцикл/мопед. Motorcycle/Moped.
❑	Autobuss. Автобус. Bus.	❑	Divritenis. Велосипед. Bicycle.
❑	Taksometrs. Такси. Taxi.	❑	Gājējs. Пешком. Walking.
❑	Trolejbuss. Троллейбус. Trolleybus.	❑	Tramvajs. Трамвай. Tram
❑	Ar automašīnu kā vadītājs. На машине как водитель. Car as driver.	❑	Cits: Другое: Other, please state:
❑	Ar automašīnu kā pasažieris. На машине как пассажир. Car as passenger.		

27. Cita vieta, kur varētu būt izvietota autoosta, lai jums būtu ērtāk:

Другое местоположение автовокзала или мультимодального узла, которое было бы удобно для вас:

Other location of coach terminal or multimodal hub, which will be interesting for you:

	Maskavas foršate
	Jugla
	Skanste
	Centrs

4. Sociāli ekonomiskā informācija
Социально экономическая информация
Socioeconomic information

28. Dzimums: Пол: Gender:

	Vīrietis Мужчина Male		Sieviete Женщина Female

29. Vai jums ir ?
Есть ли у вас?
Do you have…?

❑	Vadītāja apliecība Водительские права A driving license
❑	Personīgā automašīna Свой автомобиль Access to own car
❑	Personīgais divritenis Свой велосипед Access to a bicycle

30. Jūsu vecums?
Ваш возраст?
How old are you?

	<17

	18 - 25
	26 - 40
	41 - 65
	>66
	Nevēlos atbildēt Отказываюсь говорить Would prefer not say

31. Izglītības līmenis
Уровень образования:
Education level achieved:

❑	Pamatizglītība Основное GCSEs or O-Levels
❑	Vidējā Среднее A-Levels
❑	Vidējā profesionālā Средне специальное
❑	Augstākā Высшее University degree

32. Nodarbošanās?
Социальный статус?
What is your employment status?

	Darbinieks/ strādnieks Работающий Employed
	Bezdarbnieks Безработный Unemployed
	Students Студент Student
	Cits Другое Other (specify)

33. Cilvēku skaits Jūsu mājsaimniecībā. Количество человек в вашем домохозяйстве. Number of people in your household.

---

34. Ienākumi Netto (pēc nodokļu nomaksas)
Ваш доход (ежемесячный, после уплаты налогов):
Personal Net-Income per month:

	≤200
	200-499
	500-799
	>800

Liels paldies par sadarbību un jūsu veltīto laiku!
Большое спасибо за Ваше сотрудничество и Ваше время!
Thank you very much for your kind cooperation and your time!

Appendix 3. The application for interviews with Practitioners

Date of interview:
Name of interviewer:
The organisation of interviewer:

Name of interviewee:
Type of stakeholder:
Position in and the name of the organisation:
Country:

Question 1: Which interchange are you describing? (Please state its name and briefly describe its location and its surrounding area).

Question 2: When was the interchange opened? When was it last refurbished/redeveloped? Please provide a brief explanation of the changes made.

Question 3: Which modes does the interchange cater for? (Please tick all that apply.)

□ Walking
□ Cycling (with cycle parking)
□ Cycle hire
□ Motorcycles/scooters/mopeds
□ Buses
□ Long-distance coaches

□ Light rail/ tram
□ Heavy rail
□ Private cars (with car parking)
□ Private cars (with drop-off)
□ Taxis
□ Other

If other, please provide details.

Question 4: Please describe the interchange's role/place in the overall transport network. For example, is the interchange for local, regional, national or international connections etc.

Question 5: Please can you provide some information on current passenger numbers? Including the total passengers by mode, the percentage split by mode, the approximate share of transfers between modes and spatial scale (please see table below) and the distribution between men and women travellers.

Approximate share of transfer between spatial scales: Percentage of passengers.

NB. Spatial scales may be different for each interchange, please, therefore, outline the basis used for your categories, e.g. local is up to 10 km, regional is up to 50 km, etc., or local covers all metro travel, regional covers travel on X bus route, national covers all X rail route.

From \ To	Local	Regional	National	International

Local				
Regional				
National				
International				

Please provide us with information on how you have defined the different spatial scales.

Local defined as:

Regional defined as:

National defined as:

International defined as:

Approximate share of transfer between modes: Percentage of passengers

Modes From/to	Train	Tram	Bus: Local Regional Interurban	Car	Cycling and walking	Other (specify)	Sum
Train							
Metro							
Tram							
Bus: -Local - Regional - Interurban							
Car							
Cycling and walking							
Other (specify)							
Sum							

Question 6: How many rail routes, bus routes, metro lines, and tramway lines use the interchange?

Rail routes =
Bus routes =
Tramway lines =

Question 7: What are the average frequencies (in minutes) for public transport arriving and departing at the terminal? What are the average frequencies (in minutes) for public transport arriving and departing during rush hour?

Rail =
Bus =
Tram =

Question 8: Please describe the connectivity provided between modes at the terminal, i.e. in terms of ease of transfer between modes and distance between modes (in metres).

Question 9: Are there regular delays with public transport that cause difficulties with transferring between modes (i.e. once a month or so)?

Question 10: Please describe the regulatory framework within which the interchange operates. For example, who regulates the different modes and/or the interchange itself? Please also describe any regulatory barriers to interchange between modes.

Question 11: What is the ownership structure of the interchange?
□ Public
□ Private
□ Joint Venture (Public and Private)
□ Other (Please provide details.)

Please describe the ownership structure. If a joint venture, please provide details of the proportion that is publicly/privately owned.

Question 12: Which organisation(s) is/ are responsible for the management of the interchange? (Please tick all who are involved and describe below.)
□ Central government or one of its agencies
□ Regional government or one of its agencies
□ Local transport authority
□ Rail/ LRT operator
□ Bus operator
□ Other (Please provide details.)

Please describe the management structure.

Question 13: Is there co-operation between the different operators for ensuring connectivity between modes? For example, relating to timetabling, ticketing or information etc... If yes, please describe. If no, is there a reason why not?

Question 14: Are there any factors that could facilitate co-operation between modes?

Question 15: Who bears the financial responsibility of the interchange (maintenance, investments, local charges)?
□ Public
□ Private
□ Joint Venture (Public-Private)
□ Other (Please provide details.)
Please describe the responsibilities…..
Question 16: Is the interchange financially profitable?
□ Yes
□ No
□ Don't know

Question 17: Are there any (financial) reports available?
□ Yes
□ No
□ Don't know

Question 18: Which organisation(s) was/were responsible for the design of the multimodal interchange (including any re-developments)? (Please tick all who are involved and describe below.)
□ Central government or one of its agencies
□ Regional government or one of its agencies

□ Local transport authority
□ Rail/ LRT operator
□ Bus operator
□ Private organisation
□ Other (Please provide details.)

Please describe who was responsible for the design and any re-developments which have subsequently occurred….

Question 19: Please now consider the capital costs involved with developing the interchange.

a) What was the financing model used to fund the development of the interchange?

b) What was the expected payback time of the investment?

c) Who were the main financiers?

Question 20: Is there a business model* developed for the interchange?
* By business model, we mean a strategic plan that outlines how to utilise the interchange facilities in a way that optimises the potential revenue from existing facilities and provides cost-effective maintenance services.
□ Yes
□ No
If yes, please could you provide a copy (This will be treated as confidential)?
If not, please describe how decisions on pricing and level of services are determined?

If no business model exists, do you think the interchange would benefit from having one?
□ Yes
□ No

Question 21 Was the public consulted during the design and/or re-development of the interchange?
□ Yes
□ No
If yes, please describe the process applied to involve the public….

Question 22: Is the public involved in any on-going engagement with regards to the operation of the interchange?
□ Yes
□ No

If yes, please describe the process applied to involve the public….

Question 23: Why is this interchange considered successful? (Please tick all that apply and describe below.)
□ Ownership/ management structure

□ Availability of interchange space
□ Quality of transfer between modes
□ Quality of waiting areas
□ The range of retail establishments
□ Security and safety
□ Facilities for the mobility impaired
□ Quality of journey planning and real-time information
□ Integrated ticketing arrangements
□ Other (Please provide details.)

Please describe…

Question 24: What were the key factors that influenced the design/redesign of the interchange?

1.
2.
3.

Question 25: Can you describe any specific methods that were used or provide guidelines that aided the coordination between modes at the multimodal interchange?

Question 26: Was energy efficiency considered in the interchange design and its operation?
□ Yes
□ No

If yes, please explain how energy efficiency was ensured in the interchange design and its operation? (e.g. energy use in the terminal).

If yes, regarding the operation, please explain how to monitor the energy use and carbon footprint (or CO_2 emissions) of the interchange? If applicable, is it possible to estimate the percentage of alternative energies used?

Question 27: Does the interchange analyse its impact on air quality? Is air pollution considered a problem for travellers at the interchange? Has the interchange implemented any measures to improve air quality (e.g. monitoring, ventilation systems, instructions to switch off engines while waiting)? Please describe.

Question 28: Are you satisfied with the information and intelligent systems in the interchange?

If not, how would you improve the quality, content or provided systems and services? Please tick a) the ones currently in use and b) what you think would be essential to implement.

In use	Needed	Intelligent System or Service in the Interchange Area
☐	☐	Journey planner for local public transport for pre-trip planning
☐	☐	Journey planner for long-distance public transport for pre-trip planning
☐	☐	Information for interchange facilities and layout available on the internet (or via call centre) for pre-trip planning (important especially for the disabled)
☐	☐	Smart ticketing [speeds up transfer]
☐	☐	Electronic departure time displays based on *timetables* (for multiple stops)
☐	☐	Electronic departure time displays based on *timetables* (at stops)
☐	☐	Electronic departure time displays based on *real-time information* (for multiple stops, incl. fleet monitoring systems)
☐	☐	Electronic departure time displays based on *real-time information* (at stops)
☐	☐	Departure times via audio calls
☐	☐	Real-time disturbance information provided via *displays*
☐	☐	Real-time disturbance information provided via *audio calls*
☐	☐	Multi-language information
☐	☐	Public access information kiosk/internet kiosk restricted for Public Transport information (not for open internet surfing)
☐	☐	Information centre with personal service
☐	☐	Audio Services for the visually impaired (e.g. a special dedicated information area with a push-button)
☐	☐	Guidance and warning surfaces for the visually impaired
☐	☐	Tactile maps of the interchange for the visually impaired
☐	☐	Information with hearing aids (e.g. "T-coil")
☐	☐	Matrix barcodes (e.g. QR-codes) for additional information with mobile phones (e.g. for departure times for a specific stop or platform)
☐	☐	Intelligent Indoor-Navigation System
☐	☐	Intelligent security systems (e.g. CCTV)
☐	☐	Area or terminal fleet management with the aid of cameras, in-vehicle systems, Variable Message Signs etc. for guiding buses, taxis, P&R etc.
☐	☐	Intelligently automated passenger or people counting (infrared, video, thermal etc.)

Please provide any additional comments

Question 29: What impact has the interchange had on employment?

a) Please describe any direct employment effects (i.e. staff needed to operate and maintain the interchange).

b) Please describe any indirect employment effects (i.e. supporting services created in the interchange)

c) Please describe an impact on the surrounding areas (i.e. new services generated in the proximity of the interchange (estimate, if no data available)?

Question 30: If possible, please provide an estimate of the typical cost of housing and retail units at the interchange, and near the interchange.

Question 31: Have there been any change in the number of new start-up businesses close to the interchange?

Question 32: Have there been any changes connected to the housing in close vicinity to interchange?

Question 33: Has any new housing been developed in/or near to the interchange? If possible, please provide the area (in m^2) and the type of housing.

Question 34: Please give an indication of the area (in m2) of commercial centres or retail in/or near to the interchange.

Question 35: Is there good access provided between the interchange and the commercial/retail centre?

Question 36: Have any new offices been developed in/or near to the interchange? If possible, please provide the area (in m^2) and the type of offices (e.g. headquarters, international or national offices).

Question 37: Can you estimate the number or percentage of these new housing, retail or office developments which are direct as a result of the interchange?

Question 38: Can you provide any other examples of successful multimodal interchanges in your country?

□ Yes

□ No

If yes, please provide details of the location, a brief description (e.g. modes of transport available) and explain in what ways the interchange is successful; any specific factors, e.g. information systems, accessibility, energy-efficient design/operation.

Question 39: Please describe any particular challenges that are commonly faced in the design of multimodal interchanges?

Many thanks for completing this questionnaire. If you would like any further details on the ALLIANCE project, please visit our website at http://alliance-project.eu/.

The ALLIANCE Partners.

Appendix 4. The application for stakeholder survey about Integration of information systems, ticketing and other ITS services

Information Provision

1. Are there regulations or guidelines on the requirements for the provision of information to travellers? If so, what is required and where (particularly for interchanges)?
2. How is information about interruptions and incidents (e.g. breakdowns) provided to travellers?
3. How is information about emergencies provided to travellers?
4. Can the same information displays be used for different purposes depending on the situation?

Yes	No	Purpose
		Timetables
		Departure / Arrival time
		Interruption information
		Emergency information
		Advertisement

Please provide any additional comments (e.g. how, or why not)

5. Do retailers or restaurants at or near the interchange provide transport information to their customers? What and how? (e.g. departure time displays)
6. How and what information is provided to travellers with disabilities? (e.g. impaired vision or mobility)

Information Integration and Uniformity

7. Do different operators share the same displays? (e.g. combined timetable info) If not, are different operators' information displays uniform in style?
8. What kinds of information services are there which integrate information from different operators? (e.g. mobile services with timetable data from multiple operators)

Ticketing

What kinds of ticket purchasing options are available?

9. Mobile solutions (e.g. text message ticket, NFC payment)
10. Traditional solutions (e.g. ticket machines, travel cards)
11. Please provide any additional comments (e.g. are new ticketing solutions being implemented or planned?)
12. Are tickets valid for multiple modes and operators? Are there plans for shared ticketing systems?

ITS Systems at the Interchange

13. Are you satisfied with the information and intelligent systems in the interchange?
14. If not, how would you improve the quality, content or provided systems and services?

Please tick a) the ones currently in use and b) what you think would be essential to implementing, and c) what systems are considered unimportant (e.g. system has been tried and found not necessary or worth costs).

In use	**Needed**	**Not needed**	**Intelligent System or Service in the Interchange Area**

In use	Needed	Not needed	Intelligent System or Service in the Interchange Area
			Journey planner for local public transport for pre-trip planning
			Journey planner for long-distance public transport for pre-trip planning
			Information for interchange facilities and layout available on the internet (or via call centre) for pre-trip planning (important especially for the disabled)
			Smart ticketing [speeds up transfer]
			Electronic departure time displays based on *timetables* (for multiple stops)
			Electronic departure time displays based on *timetables* (at stops)
			Electronic departure time displays based on *real-time information* (for multiple stops, incl. fleet monitoring systems)
			Electronic departure time displays based on *real-time information* (at stops)
			Departure times via audio calls
			Real-time disturbance information provided via *displays*
			Real-time disturbance information provided via *audio calls*
			Multi-language information
			Public access information kiosk/internet kiosk restricted for Public Transport information (not for open internet surfing)
			Information centre with personal service
			Audio services for the visually impaired (e.g. a special dedicated information area with a push-button)
			Guidance and warning surfaces for the visually impaired
			Tactile maps of the interchange for the visually impaired
			Information with hearing aids (e.g. "T-coil")
			Matrix barcodes (e.g. QR-codes) for additional information with mobile phones (e.g. for departure times for a specific stop or platform)
			Intelligent Indoor-Navigation System
			Intelligent security systems (e.g. CCTV)
			Area or terminal fleet management with the aid of cameras, in-vehicle systems, Variable Message Signs etc. for guiding buses, taxis, P&R etc.
			Intelligent automated passenger or people counting (infrared, video, thermal etc.)

Please provide any additional comments (e.g. more details, priorities, planned improvements)

THANK YOU VERY MUCH FOR YOUR CONTRIBUTION!

Servisa nodrošinātāju apmierinātības aptauja Rīgas starptautiskajā autoostā (RSA)

Опрос удовлетворённости РА (Рижский автовокзал)

Services providers' satisfaction survey RICT (Riga international coach terminal)

35. Kāds ir jūsu apmierinātības līmenis attiecībā uz informāciju par braucienu?
Каков ваш уровень удовлетворения относительно **ИНФОРМАЦИИ** о поездке, обеспеченной РА?
What is your level of satisfaction concerning the **TRAVEL INFORMATION provided at RICT?**

Level of

	1	2	3	4	5
Pieejama un ērta informācija (grafiki, reisi, kavēšanās) autoostā Доступность и простота использования информации (расписания, маршруты, задержки) на автовокзале Availability and ease of use of travel information (timetables, routes, delays) at the interchange (station)	❑	❑	❑	❑	❑
Informācijas pieejamība (grafiki, reisi, kavēšanās) pirms brauciena Доступность информации о поездке (расписания, маршруты, задержки) перед вашей поездкой Availability of travel information (timetables, routes, delays) before your trip	❑	❑	❑	❑	❑
Norādītas informācijas precizitāte un uzticamība autoostā Точность и надежность указанной информации о поездке для автобусов на автовокзале Accuracy and reliability of travel information displays for bus/trains/underground at the interchange	❑	❑	❑	❑	❑
Biļešu iegāde (biļešu kases, pašapkalpošanās biļešu tirdzniecības termināli, u.c.) Покупка билета (кассы, билетные автоматы, и т.д.) Ticket purchase (ticket offices, ticket machines, etc.)	❑	❑	❑	❑	❑

36. Kāds ir jūsu apmierinātības līmenis par informāciju un pieejamiem pakalpojumiem autoostas teritorijas apkārtnē?
Какой ваш уровень удовлетворения информацией, предоставленной РА об услугах и о возможности использования других транспортных средства возле автовокзала?
What is your level of satisfaction with the **information provided at RICT on how to find your way around the station and associated transport facilities**?

Level of

	1	2	3	4	5
Informatīvas norādes par dažādiem pakalpojumiem (mazumtirdzniecības, sabiedriskās ēdināšanas vietām, uzgaidāmām telpām, tualetēm, u.c.) Указатели информации о различных удобствах и услуг (розничная продажа, места общепита, зоны ожидания, туалеты, и т.д.)	❑	❑	❑	❑	❑

Signposting to different facilities and services (retail, catering facilities, waiting areas, toilets, etc.)					
Informācija par iespēju pārsēsties uz citiem transporta veidiem (sabiedriskais transports, taksometri, divriteņu stāvvieta u.c.) Указатели информации о способах пересадки на другие виды транспорта (общественный транспорт, такси, стоянка для велосипедов и т.д.) Signposting to transfer between transport modes in all parts of the interchange. E.g. to buses, taxis, cycle parking, etc.	❑	❑	❑	❑	❑
Informācijas pietiekamība un autoostas personāla atbalsts (uzziņu dienests) Информирование и помощь обслуживающего персонала (справочная служба) Information and assistance provided by staff, e.g. at customer information points	❑	❑	❑	❑	❑

37. Kāds ir jūsu apmierinātības līmenis attiecībā pret LAIKU un KUSTĪBU autoostā?
Какой ваш уровень удовлетворения аспектом ВРЕМЯ&ДВИЖЕНИЯ на автовокзале?
What is your level of satisfaction concerning the following **TIME & MOVEMENT** aspects inside the interchange?

Level of

	1	2	3	4	5
Pārsēšanās attālums starp dažādiem transporta veidiem. Piemēram, uz autobusiem, taksometriem, divriteņu stāvvietām u.c. Расстояние для пересадки между различными способами транспортировки. Например, к автобусам, такси, стоянке для велосипедов, и т.д. Transfer distances between different transports modes. E.g. to buses, taxis, cycle parking, etc.	❑	❑	❑	❑	❑
Dažādu transporta operatoru un transporta pakalpojumu savstarpēja sasaiste (piemēram, starp vilcieniem un autobusiem) Координация между различными компаниями-перевозчиками или транспортными услугами (например, между поездами и автобусами) Co-ordination between different transport operators or transport services (e.g. between trains and buses)	❑	❑	❑	❑	❑
Jūsu laika izmantošana (pārsēšanās un uzgaidīšana) autoostā Использование вашего времени (пересадка и ожидание) на автовокзале Use of your time (transferring & waiting) at the interchange	❑	❑	❑	❑	❑
Attālums līdz labierīcībām un citiem pakalpojumiem (mazumtirdzniecības, sabiedriskās ēdināšanas vietas, uzgaidāmās telpas, tualetes, u.c.) Расстояние до удобств и услуг (розничная торговля, места общепита, зоны ожидания, туалеты, и т.д.) Distance between the facilities and services (retail, catering facilities, waiting areas, toilets, etc.)	❑	❑	❑	❑	❑

Pārvietošanās brīvība autoostā lstreet cilvēku pieplūduma gadījumā Свобода передвижения из-за большого числа людей на автовокзале Ease of movement due to number of people inside the interchange	❑	❑	❑	❑	❑

38. Kāds ir jūsu apmierinātības līmenis attiecībā pret PIEEJAMĪBU autoostā?
Какой ваш уровень удовлетворения относительно ДОСТУПА?
What is your level of satisfaction concerning **ACCESS?**

Level of

	1	2	3	4	5
Ērta vai vienkārša piekļuve autoostai Легкость и простота доступа до автовокзала Ease of access to the interchange	❑	❑	❑	❑	❑
Ērta vai vienkārša izkļūšana no autoostas Легкость и простота доступа из/от автовокзала Ease of access from the interchange	❑	❑	❑	❑	❑

39. Kāds ir jūsu apmierinātības līmenis attiecībā pret KOMFORTU un SERVISU autoostā?
Какой ваш уровень удовлетворения КОМФОРТОМ и УДОБСТВАМИ?
What is your level of satisfaction about **COMFORT & CONVENIENCE?**

Level of

	1	2	3	4	5
Tīrība autoostā Общая чистота на автовокзале General cleanliness of the interchange	❑	❑	❑	❑	❑
Temperatūra, patvērums no lietus un vēja, ventilācija, gaisa kondicionēšana Температурный режим, укрытия от дождя и ветра, вентиляция, кондиционер Temperature, shelter from rain and wind, ventilation, air conditioning	❑	❑	❑	❑	❑
Kopējais trokšņa līmenis autoostā Общий уровень шума на автовокзале General level of noise of the interchange	❑	❑	❑	❑	❑
Gaisa kvalitāte, piesārņojums Качество воздуха, загрязнение. Например, выбросы транспортных средств Air quality, pollution. E.g. emissions from vehicles	❑	❑	❑	❑	❑
Veikalu daudzums Количество магазинов Number and variety of shops	❑	❑	❑	❑	❑
Kafejnīcu un restorānu daudzums Количество кафе и ресторанов Number and variety of coffee-shops and restaurants	❑	❑	❑	❑	❑
Bankomātu pieejamība Доступность банкоматов Availability of cash machines	❑	❑	❑	❑	❑

Sēdvietu pieejamība Доступность сидячих мест Availability of seating	❑	❑	❑	❑	❑
Mobilo sakaru un Wi-Fi pieejamība Доступность сигнала мобильного телефона и Wi-Fi Availability of mobile phone signal and Wi-Fi	❑	❑	❑	❑	❑
Informācijas ekrānu pieejamība Присутствие и комфортное расположение информационных экранов Comfort due to the presence of information screens	❑	❑	❑	❑	❑

40. Kāds ir jūsu apmierinātības līmenis attiecībā pret autoostas pievilcību un saistītā transporta iespējas?
Какой ваш уровень удовлетворения относительно привлекательности автовокзала и связанного транспорта?
What is your level of satisfaction concerning **the attractiveness of RICT and associated transport facilities?**

Level of

	1	2	3	4	5
Apkārtne ir patīkama Окружающее пространство приятно The surrounding area is pleasant	❑	❑	❑	❑	❑
Iekštelpu dizains autoostā (izskats, pievilcība, u.c.) Внутренний дизайн автовокзала (общий вид, привлекательность, и т.д.) The internal design of the interchange (visual appearance, attractiveness, etc.)	❑	❑	❑	❑	❑
Ārējais autoostas dizains (izskats, pievilcība, u.c.) Внешний дизайн автовокзала (общий вид, привлекательность, и т.д.) The external design of the interchange (visual appearance, attractiveness, etc.)	❑	❑	❑	❑	❑

41. Kāds ir jūsu apmierinātības līmenis attiecībā pret drošību autoostā?
Какой ваш уровень удовлетворения относительно БЕЗОПАСНОСТИ на автовокзале?
What is your level of satisfaction concerning **SAFETY & SECURITY RICT?**

Level of

	1	2	3	4	5
Pārsēšanās drošība no viena transportlīdzekļa uz citu Безопасность при пересадке с одного транспортного средства на другой Safety getting on and off the transport mode (train, bus, taxi, bicycle, etc.)	❑	❑	❑	❑	❑
Drošība autoostā Безопасность на автовокзале Safety whilst inside the interchange	❑	❑	❑	❑	❑
Drošības sajūta pārsēšanās un gaidīšanas zonās (dienas laikā) Чувство безопасности в трансфертных и зонах ожидания	❑	❑	❑	❑	❑

(в течение дня) Feeling secure in the transfer & waiting areas (during the day)					
Drošības sajūta pārsēšanās un gaidīšanas zonās (vakaros un naktī) Чувство безопасности в трансфертных и зонах ожидания (вечером/ночью) Feeling secure in the transfer & waiting areas (during the evening/night)	❑	❑	❑	❑	❑
Drošības sajūta autoostas apkārtnē Чувство безопасности на территории вокруг автовокзала Feeling secure in the surrounding area of the interchange	❑	❑	❑	❑	❑
Apgaismojums Освещение Lighting	❑	❑	❑	❑	❑

42. Kāds ir jūsu apmierinātības līmenis attiecībā pret ĀRKĀRTAS GADĪJUMIEM autoostā
Какой ваш уровень удовлетворения относительно ЭКСТРЕННЫХ МЕР?
What is your satisfaction concerning the **EMERGENCY PROCEDURES RICT?**

– **Level of** +

	1	2	3	4	5
Informācija, lai uzlabotu jūsu drošības sajūtu Информация, чтобы улучшить ваше чувство защищенности Information to improve your sense of security	❑	❑	❑	❑	❑
Avārijas izejas zīmes Указатели запасных выходов Signposting to emergency exits	❑	❑	❑	❑	❑
Avārijas izeju atrašanās vietas ugunsgrēka gadījumā Расположение запасных выходов при пожаре Location of emergency exits in case of fire	❑	❑	❑	❑	❑

43. Lūdzu, sniedziet galīgo vispārējo novērtējumu par pakalpojumiem autoostā:
Пожалуйста, дайте заключительную общую оценку своего удовлетворения обслуживанием на автовокзале:
Please, give a final **overall value** for your satisfaction with the service at this interchange**:**

– **Level of satisfaction** +

1	2	3	4	5
❑	❑	❑	❑	❑

44. Noslēgumā, kādas ir trīs būtiskākās lietas autoostā?
В заключении, какие, по вашему мнению, 3 главные пункта для автовокзала?
Finally, which of the following are, in your opinion, the **three most important aspects** of an interchange?

	Atzīmēt tikai 3 **Отметить только 3** **Tick only 3**
Informācija: ceļojums un pārsēšanās Информация: поездка и пересадка Information: trip and interchange	
Uzgaidāmās zonas Зоны ожидания	

Waiting Areas	
Drošība Безопасность Safety & Security	
Pakalpojumi (tualetes, biļešu iegāde, bagāžas uzglabāšanas telpa u.c.) Услуги (туалеты, покупка билета, камера хранение багажа, и т.д.) Services (toilets, ticket purchase, luggage store, etc.)	
Veikali un kafejnīcas Магазины и кафе Shops and Cafes	
Pārsēšanās iespēja starp dažādiem transporta veidiem Возможность пересадки между транспортными средствами Transfer communication between transport modes	
Autoostas pieejamība Доступность автовокзала Access to the interchange	
Cits: Другие: Other: (Please specify): …………………………………….	

Akciju sabiedrība "Rīgas starptautiskā autoosta"

Reģ.Nr.LV40003361404, Prāgas iela 1, Rīga, LV-1050, Latvija
Tālrunis:+371 6750 3646, fakss: +371 6750 7009, e-pasts: autoosta@autoosta.lv, www.autoosta.lv

Rīgā, 2019.gada 30.augustā

Nr. 2-4 / 56

ATSAUKSME

Par promocijas darbu

"Ilgtspējīgas attīstības koncepcijas transporta plānošanā un lēmumu pieņemšanā multimodālā sabiedriskā transporta sistēmas ieviešanas gadījumā Rīgas pilsētas piemērā"

Iepazīstoties ar Evelīnas Budilovičas promocijas darbu "Ilgtspējīgas attīstības koncepcijas transporta plānošanā un lēmumu pieņemšanā multimodālā sabiedriskā transporta sistēmas ieviešanas gadījumā Rīgas pilsētas piemērā", vispirms jāatzīmē tā aktualitāte un novitāte piedāvājumam Rīgas sabiedriskā transporta ilgtspējīgas attīstības plānošanā un lēmumu pieņemšanā. Līdz ar jaunu multimodālu transporta terminālu izveidi Rīgā un tās apkārtnē saistībā ar "Rail Baltica" līnijas izbūvi, jaunu tehnoloģiju ieviešanu sabiedriskajā transportā un terminālos, iedzīvotāju mobilitātes paradumu maiņu, ir ļoti būtiski kompleksi izpētīt un attīstīt multimodālu sabiedriskā transporta sistēmu.

Promocijas darbā veiktā zinātniskā izpēte aprobēta analizējot Rīgas sabiedriskā transporta sistēmas, pasažieru terminālu un ar mobilitāti saistīto pakalpojumu atbilstību ilgtspējīgas attīstības koncepcijai un lietotāju velmēm, kā arī izstrādāti būtiski priekšlikumi kā pilnveidot lēmumu pieņemšanas atbalsta instrumentus gan veidojot politiku un attīstības programmas politiskā līmenī, gan arī praktiski piemērojot atsevišķos terminālos, pakalpojumu uzlabošanā klientiem.

Promocijas darba secinājumi un rekomendācijas attiecībā uz Rīgas sabiedriskā transporta sistēmas attīstību un konkrēti uz Rīgas starptautiskās autoostas darbību ir lietderīgi un ieviešami termināla pārvaldības praksē.

AS "Rīgas starptautiskā autoosta"
Valdes priekšsēdētāja V.Gromule

Valdes loceklis J.Briedītis

Appendix 7. Documentation for spatial transport planning in Latvia

EU regulations

Nr.	Nosaukums	Izdošanas datums
1.	BALTĀ GRĀMATA; Ceļvedis uz Eiropas vienoto transporta telpu — virzība uz konkurētspējīgu un resursefektīvu transporta sistēmu	28.03.2011.
2.	ZAĻĀ GRĀMATA; Klimata un enerģētikas politikas satvars 2030. gadam	27.03.2013.
3.	ZAĻĀ GRĀMATA; Ceļā uz jaunu pilsētu mobilitātes kultūru	25.09.2007.
4.	ES Enerģētikas un transporta komisijas ziņojums „Ilgtspējīga nākotne transportam — ceļā uz integrētu, uz tehnoloģijām balstītu un ērti izmantojamu sistēmu”	17.06.2009.
5.	Eiropas Parlamenta un Padomes Regula (EK) Nr. 1370/2007 par sabiedriskā pasažieru transporta pakalpojumiem, izmantojot dzelzceļu un autoceļus	23.10.2007.
6.	Eiropas parlamenta un padomes direktīva 2003/30/EK „Par biodegvielas un citu atjaunojamo veidu degvielas izmantošanas veicināšanu transportā”	08.05.2008.
7.	MEMO/10/343 Briselē, „Ceļu satiksmes drošības programma 2011.–2020.gadam: sīks pasākumu izklāsts”	20.07.2010.

State planning regulations and laws

Nr.	Nosaukums	Izdošanas datums
1.	Latvijas ilgtspējīgas attīstības stratēģija līdz 2030. gadam	10.06.2010.
2.	Latvijas Nacionālais attīstības plāns 2014. – 2020. gadam	20.12.2012.
3.	Reģionālās politikas pamatnostādnes 2013.-2019.gadam	29.10.2013.
4.	Transporta attīstības pamatnostādnes 2014.-2020.gadam	16.04.2013.
5.	Enerģētikas attīstības pamatnostādnes 2016.–2020. gadam	09.02.2016.
6.	Elektromobiltiātes attīstības plāns 2014. – 2016. gadam	26.03.2014.
7.	Ceļu satiksmes drošības plāns 2017.-2020.gadam	26.10.2016.
8.	Vides politikas pamatnostādnes 2014.–2020. gadam	26.03.2014.
9.	Metodiskie ieteikumi attīstības programmu izstrādei reģionālā un vietējā līmenī - VARAM	07.10.2014.
10.	Nozaru politiku vadlīnijas pašvaldībām - VARAM	07.10.2014.

Regional regulations

Nr.	Nosaukums	Izdošanas datums
	Pašvaldības funkciju tiesiskais regulējums	
1.	Valsts pārvaldes iekārtas likums	06.06.2002.
2.	Likums par pašvaldībām	19.05.1994.
	Teritorijas plānošanas tiesiskais regulējums	
1.	Attīstības plānošanas sistēmas likums	08.05.2008.
2.	Reģionālās attīstības likums	21.03.2002.
3.	Teritorijas attīstības plānošanas likums	13.10.2011.
	Autoceļu un autopārvadājumu tiesiskā regulējums	

1.	Likums par autoceļiem	11.03.1992.
2.	Autopārvadājumu likums	23.08.1995.
3.	Ceļu satiksmes likums	01.10.1997.
4.	MK noteikumi „Ceļu satiksmes noteikumi”	02.06.2015.
	Sabiedriskā transporta pakalpojuma tiesiskais regulējums	
1.	Sabiedriskā transporta pakalpojumu likums	14.06.2007.
2.	Ministru kabineta noteikumi Nr.634. Rīgā 2010.gada 13.jūlijā (prot. Nr.36 47.§). Sabiedriskā transporta pakalpojumu organizēšanas kārtība maršrutu tīklā	13.07.2010.
3.	Ministru kabineta noteikumi Nr.599. Rīgā 2012.gada 28.augustā (prot. Nr.49 9.§). Sabiedriskā transporta pakalpojumu sniegšanas un izmantošanas kārtība	28.08.2012.

Municipality planning regulations

Nr.	Nosaukums	Izdošanas datums
1.	Rīgas ilgtspējīgas attīstības stratēģija līdz 2030.gadam	27.05.2014.
2.	Rīgas attīstības programma 2014.-2020.gadam	27.05.2014.
3.	Rīgas attīstības programmas Rīcības plāns 2017.-2019.	04.07.2017.
4.	Rīgas attīstības programmas Investīciju plāns 2017.-2019.gadam	04.07.2017.
5.	Rīgas un Pierīgas mobilitātes plāns	18.10.2010.
6.	Rīgas pilsētas satiksmes drošības Baltā grāmata (2010. - 2014.g.)	2010.gads
7.	Rīgas teritorijas plānojums 2006.-2018.gadam (ar grozījumiem)	2010.gads
8.	Rīgas pilsētas velosatiksmes attīstības koncepcija 2015.-2030.gadam	2015. gada jūnijs
9.	Rīgas pilsētas sabiedriskā transporta attīstības koncepcija 2005.-2018.gadam	2004.gads
10.	Rīgas pilsētas elektrotransporta attīstības koncepcija 2004.-2018.gadam	2003.gads
11.	Ilgtspējīgas enerģētikas rīcības plāns viedai pilsētai 2014.-2020.gadam	2013./2014.gads
12.	Rīgas pašvaldības SIA „Rīgas satiksme” ilgtermiņa stratēģija no 2012. gada līdz 2033. gadam.	2012
13.	Rīgas domes autonovietņu politikas un attīstības koncepcija. Stāvvietu infrastruktūras sadaļas attīstības plāns. Gala ziņojums	2015.gada jūnijs
14.	Rīgas domes autonovietņu politikas un attīstības koncepcija. Stāvparku sistēmas sadaļas attīstības plāns. Gala ziņojums	2015.gads
15.	Par rīcības plānu vides trokšņa samazināšanai Rīgas aglomerācijā no 2017.gada līdz 2022.gadam	2017.gads
16.	Stratēģiskais ietekmes uz vidi novērtējums	2014.gada maijs
17.	Rīgas pilsētas gaisa kvalitātes uzlabošanas rīcības programma 2016.-2020.gadam	2016.gada augusts
18.	Par Rīgas pilsētas pašvaldības politikas plānošanas dokumentu izstrādāšanas un reģistrēšanas kārtību	2014.gada maijs
19.	Iekšējie noteikumi Nr.19: Par Rīgas pilsētas pašvaldības attīstības plānošanas dokumentu izstrādes kārtību	2017.gada marts
20.	Transporta plūsmu izpēte kravas transporta novirzīšanai no Rīgas centra, Rīgas domes Satiksmes departaments.	2014. gads
21.	Rīgas teritorijas plānojuma līdz 2030. gadam izstrādes ietvaros apstiprinātie 11. tematiskie plānojumi.	2017.gads

Appendix 8. The script in Python for calculating the Closeness centrality index

```
impedance_attr = "@total_impedance"

_m = inro.modeller
modeller = _m.Modeller()

scenario = modeller.scenario
network = scenario.get_network()

# create impedance extra attribute
NAMESPACE = "inro.emme.data.extra_attribute.create_extra_attribute"
create_extra = modeller.tool(NAMESPACE)
create_extra(
    extra_attribute_type="NODE",
    extra_attribute_name=impedance_attr,
    extra_attribute_description="Total impedance to all reachable nodes",
    overwrite=True)

# find the auto mode
for m in network.modes():
    if m.type == "AUTO":
        auto_mode = m

# exclude links which do not have auto mode
excluded_links = []
for l in network.links():
    if auto_mode not in l.modes:
        excluded_links.append(l)

# calculate shortest path to all other nodes and output to extra attribute
for i in network.nodes():
    total_imp = 0
    # create shortest path tree from node i
    tree = network.shortest_path_tree(
        origin_node_id = i,
        link_costs = "auto_time",
        excluded_links = excluded_links,
        consider_turns = True,
        turn_costs = "auto_time")

    # sum total costs for all valid paths to all nodes
    for j in network.nodes():
        try:
            total_imp += tree.cost_to_node(j)
        except:
            pass

    # write total impedance to extra attribute
    i[impedance_attr] = total_imp

scenario.publish_network(network)
```