INNOAIR

INDEX: UIA05-202

Innovative demand responsive green public transportation for cleaner air in urban environment

Benefit Dependency Network on "Green measures to tackle air pollution and climate change"

Urban Innovative Actions, Les Arcuriales, 45D rue de Tournai, F59000 Lille, France

www.uia-initiative.eu

Authors

Stanimir Kabaivanov, Delyan Angelov, Stanislava Klisarova-Belcheva, Marin Bratkov, Ignat Ignatov, Margarita Ruseva

Key data

Benefit Dependency Network, smart cities, sustainable transport systems, business changes

Statement of originality

This o contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Table of Contents

List of figures

1.Introduction

Benefit Dependency Network (BDN) is a schematic summary of the motives and benefits of a project. For the construction of a logical causal chain of program results, system vision, as well as for their visual presentation, a map of the benefits is needed. This map shows the composition and relationship between the different results of the program: project motivation, project implementation, changes, operational results, and benefits. The formal benefit mapping process identifies gaps in knowledge and understanding that may not be apparent in an oral or email discussion. We can distinguish two types of benefit maps - those used to define the problem and the options for solving it, and those that outline the likely consequences of the initiative, project, or program for change. When used in combination, the presumption is that the benefits initiated by the project you choose to implement will be as relevant as possible to the problem we identified at the outset.[1]

1.1 General definitions

For the current project Sofia INNOAIR the map of benefits we offer is linked to the planned changes in the city, the attitude of city dwellers to cleaner air and a more environmentally friendly urban environment. It is divided into five sections: **ENABLERS (activators) → ENABLING CHANGES (primary changes) → BUSINESS CHANGES → BUSINESS & SOCIAL BENEFITS (intermediate benefits) → STRATEGIC OBJECTIVES (end benefits) and DRIVERS** (Fig. 1).

Firstly, what is the problem (or opportunity) that makes us consider a new investment? Is the benefit large enough in terms of value to be worth the planned investment?

Approximately 23% of the country's population lives in the capital city of Bulgaria; it increases by 10% per decade, mainly through internal migration; 25% of cars are over 20 years old; 51% of PM2.5 emissions are generated by road traffic. Transport is responsible for nearly 30% of the EU's total CO2 emissions, of which 72% comes from road transportation. As part of efforts to reduce CO2 emissions, the EU has set a goal of reducing emissions from transport by 60% by 2050 compared to 1990 levels.[2]

[1] https://www.linkedin.com/pulse/why-map-benefits-other-uses-dependency-network-hugo

[2]https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

The city is growing rapidly in terms of population and new residential and office neighborhoods. The number of registered vehicles in Sofia is growing every day. There are 550-600 cars per 1000 inhabitants. Bulgarians drive some of the oldest cars in the EU: in 2017, a quarter of all vehicles were over 20 years old and another 60% - between 10 and 20 years old. Traffic in Sofia has the greatest impact on air pollution.

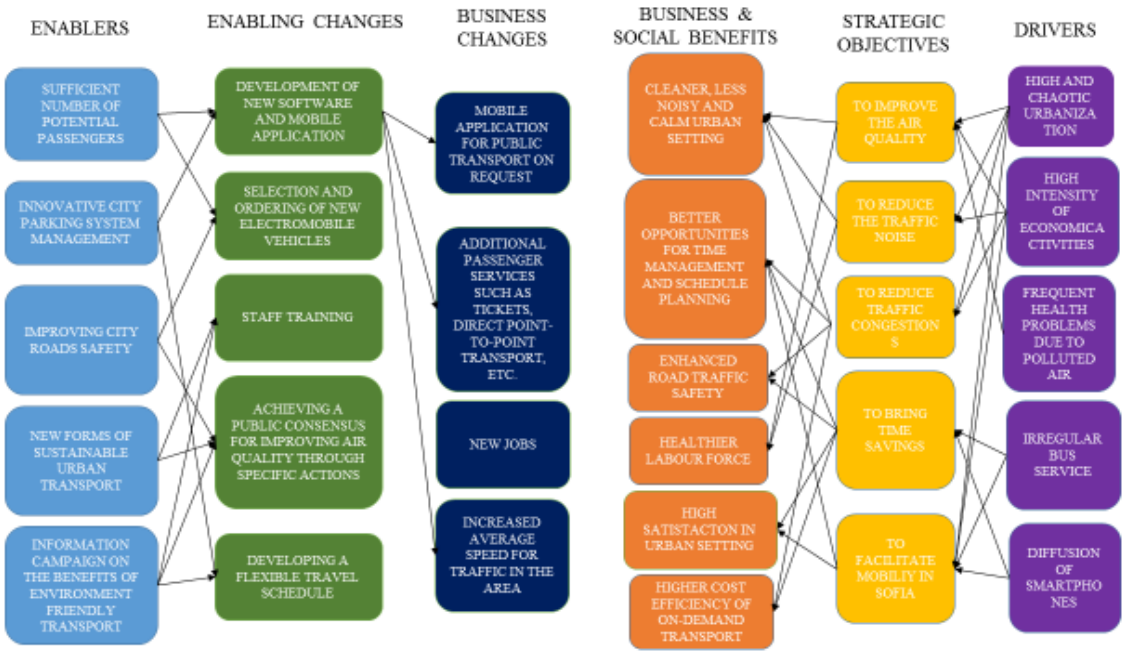

Fig. 1 Benefit Dependency Network of INNOAIR Project

These are the reasons that make us undertake a project that will significantly contribute to the reduction of PM10-PM2.5 emissions, as well as reduce noise and normalize traffic. It will involve a larger number of city dwellers as active participants in an environmental initiative, especially adolescents who have experience working with mobile applications. It will encourage older people to save on their personal cars by using them less often.

The city of Sofia has a compact urban structure and mixed-use development, which does not always use land efficiently and does not protect the environment, biodiversity and suburban areas well enough for agriculture. This compact multifunctionality is not available in a few districts of Sofia, Malinova Dolina is one of them. It is entirely built up of residential buildings and it lacks a number

of important infrastructure sites such as large commercial sites, kindergartens, schools, clinics, hospitals and others. For this reason, residents of the neighborhood are forced to leave it often and mostly using their personal vehicles.

Determining the specific number of inhabitants in Sofia's districts and neighborhoods is difficult due to deficits in the capital's statistics. There is only indirect data that in the neighborhoods with newer construction live mostly younger people, young families. This is due to the fact that there is a deficit of real census, and only reporting of personal data. In 1985 the population of Sofia was 1,122,000 (NSI, 1986), and in 2021 it increased to 1,221,785 (NSI, 2021) [3] or 1,280,034 (at the current address, GRAO, 2020) [4], something that is not corresponds to the statistics for increase of the population of the capital by ten percent per decade after 1990. Fluctuations in the processes of natural and mechanical growth, typical for other regions of Bulgaria have little effect on the growth of the capital city, which is most preferred by domestic migration. flows and the younger population. Here we estimate that in the newer neighborhoods such as "Malinova dolina", "Students City" and neighborhoods with more residential buildings "new construction" live more young people.

Urban form, measured by urban density and centralization of jobs, has been found to have a very strong link with transport models, especially the level of road dependency and public transport efficiency. For example, if we compare urban density with the use of a private car, urban density explains 84% of the differences in car travel.

Increasing **the capacity of the transport system** to meet the transport demand arising during daily life and economic activity must be achieved through the implementation of a plan to improve the urban transport system. Improving mobility means making it possible for everyone to move quickly, safely and conveniently to their destination at any time at a low cost. When implementing the project, it is necessary to consider not only the impact of individual components (enablers) on the lives of citizens and the condition of buildings, such as noise, vibration and air pollution, but also the global impact on the environmental situation in the area.

[3] https://www.nsi.bg/bg/content/2981/%D0%BD%D0%B0%D1%81%D0%B5%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5-%D0%BF%D0%BE-%D0%B3%D1%80%D0%B0%D0%B4%D0%BE%D0%B2%D0%B5-%D0%B8-%D0%BF%D0%BE%D0%BB

[4] https://www.grao.bg/tna/t41nm-15-06-2020_2.txt

How much space a city requires to house its population and distribute its economic activities is crucial in determining its sustainability, especially its transport patterns and impacts. The shape and spatial structure of the city determine the basic framework in which everything else in the city must develop. These urban forms and factors are particularly important for the way the city relates to its bioregion, whether it uses it for urban development or whether the urban area is able to extract much of the food, materials and thus water requirements in within its own boundaries or environment minimizing the ecological footprint of the city.

From the point of view of managing **the city parking system**. The parking management system must be renovated to limit the total number of trips by car. The streets in the central part of the regions should also be used for parking, by expanding the parking spaces in the streets together by organizing off-road parking facilities. Despite the relatively high price, we must strive for the construction of underground parking lots.

Automated parking systems are car parks equipped with an automatic system controlling entry and exit, calculating the price of parking according to the current tariff and collecting the payment. Such a system makes parking convenient and safe for consumers, ensures the owner's control over cash flows and eliminates abuse by staff and customers. This is a complex of modern hardware and software that allows you to automate all processes of paid parking. The subject of automation can be both a small parking lot for 20-30 parking spaces and a large parking lot for several thousand places with high traffic intensity. System requirements depend on scale, location, traffic, average usage time, key users, and many other factors. How to automate one or another object, what equipment to choose and how to install it, how to organize the scheme of movement of the car. All these issues need to be addressed at the feasibility study stage and in the design process. The successful operation of automated paid parking in the future and its economic efficiency largely depend on the professional performance of these activities and the detailed study of the site.

According to the conditions in the surveyed areas to provide for the organization of a minimum of 6000 parking spaces on public roads, provided on a paid basis. For their organization to be developed a scheme for organizing the traffic in the area of paid city parking, to install appropriate road signs and to put markings indicating parking places.

The creation of paid city parking is an organizational measure for streamlining parking in the central part of the city, providing free organized parking spaces for short stays of vehicles and reducing the load on the road network.

Improving the road sector alone will not achieve the environmental goals set. A comparison is made between cases with and without parking restrictions as a measure to control traffic in the same condition road network and public transport systems. The alternative with parking restrictions has been shown to be more economically feasible in terms of the vision of increasing the use of public transport.

Safety of movement and staying in the waiting areas. To develop safety measures for pedestrians and transport. In particular, it is necessary to plan activities to ensure the safety of pedestrians and vehicles during the dark hours, by improving markings and street and sidewalk lighting.

Improving traffic safety. Develop safety measures for pedestrians and transport. Take into account the priorities for regular urban transport, road routes restricting the entry of goods vehicles.

The negative consequences of high-density urban development are present, as are the very serious criticisms of car cities and the impact of cities on the environment. The strong link revealed by many studies between a more compact urban form with mixed use and reduced car use is reflected in efforts around the world to reduce urban sprawl and create more transit-oriented communities. These efforts to achieve more connectivity and urban mobility are compact models of development suitable for people, with the possibility of walking, with the need to build a more efficient community in cities and create a much better urban public space that has a real sense of place and meaning for people.

From an ecological point of view, preconditions must be chosen that reduce the negative impact on air quality, the preservation of the historically existing landscape architecture of the city, the prevention of redevelopment and resettlement and the preservation of green areas.

Sofia is a monocentric city - it has a clearly defined center and periphery. The reason: the dominant part of the city was planned, built and developed in Soviet times: on the outskirts are the industrial zones, and around them - sleeping areas - suburbs, the so-called „dwelling complex (zh.k)“. Now the times of production in Sofia are in the past, the era of offices and sales is there. There is

now a "pendulum movement" of city dwellers: in the morning from work on the outskirts to the center and a business park, in the evening from work from the center to the outskirts. At this point, the road network is congested. In such a situation, it is important to find the optimal load regime, preferably not by hesitation, but in the laboratory. Indicators are taken for this. A model of road network functioning is created. Experts look at how relevant it is at the moment, change those parameters that impede the flow, find the optimum. By the way, in some cities, as a tool to solve the problem today, they practice the transfer of offices from the center to the districts and are generally actively involved in decentralization. In the capital, for example, there were plans to move parliament from the center to the outskirts. It is no secret that Sofia has a large administrative apparatus, equipped with both personal and municipality vehicles.

Improving vehicle accessibility. Access will be significantly improved if the proposed road network is implemented, which includes the construction of radial and ring roads, as well as missing plots. The radial and ring network model is also applicable to the rail transport system. The radial and ring road network will improve access to sites in the study area. Currently, the existing road network in the city does not meet the increased traffic in recent years. The main reason for the increased intervals in road transport is the congestion along the route of the connected routes, incl. with reconstruction of the outgoing highways of the city. This in turn reduces the quality of transport services for passengers, increases waiting times at stops and the duration of the trip. Unfortunately, congestion is random, unpredictable and difficult to predict.

The advertising mission of the project must be related to its presentation as a new public transport that sets new standards of service. This project does not fight with trams, trolleybuses and subways, but supports them. Calling the project an innovative public transport, we simultaneously increase the status of the usual urban transport and the requirements to it. We help to form in the urban population a quality new experience for moving in the city of Sofia.

Another significant factor is the **motorization rate of the population**. The trend is visible to the naked eye. According to statistics, the latest figure is close to three hundred cars per thousand populations. At rush hour, about 50,000 cars pass through the street and road network of the southern metropolitan areas. At the same time, the capacity of neighborhood roads is not elastic.

Many companies, organizations and employees have to anticipate and adjust the usual start of the working day an hour later.

All activities are formed in order to ensure transport and pedestrian connectivity of urban territorial units. Thanks to research work, the city receives annual funding to bring the road network in standard condition, more and more roads in the city are being transformed after a complete overhaul. Timely implementation of measures would prevent a situation in which every resident of the city, standing in traffic jams for many hours, feels the impact of the created factors, namely: insufficient road capacity, unattractiveness of public transport, lack of infrastructure for alternative modes of transport. transport, constantly increasing level of motorization of the population, low connectivity and growth of the city's neighborhoods, minimal maintenance of highways, chaotic parking lots of vehicles, not equipped with pockets for access to bus stops complexes. All these are the main reasons for the lost hours of our lives that we could spend with loved ones.

In general, the positive effects on urban transport models are higher density and more centralized land use are clear and are further developed in the following sections. Higher densities can bring greater protection to the natural environment and food growing areas in and around cities. Many European and Asian cities still accept significant local food production on farms and gardens within the city and its hinterland. This is possible only when the requirements of urban expansion do not consume the most developed land.

It is generally a misconception to make public investments in two competing transport infrastructures: private and public transport. The irrational policy of simultaneously increasing the capacity of urban roads - on the one hand, and stimulating the use of public transport (construction of new metro stations, distribution and construction of lines for buses and trolleybuses) - on the other, gives zero results. This situation in urban research practice is known as the paradox of Braes and the postulate of Louis and Mogridge, often used in the analysis of transport problems caused by private transport, such as congested roads in cities and highways.

2. Sustainable transport systems

Sustainable transport systems make a positive contribution to the environmental, social, and economic sustainability of the communities they serve. There are transport systems to provide social and economic connections, new opportunities offered through increased mobility, and urban households benefit greatly from low-carbon transport opportunities. The benefits of increased mobility must be weighed against the environmental, social and economic costs that transport systems represent. Short-term activity often promotes the gradual improvement of fuel efficiency and vehicle emission control, while long-term objectives include migrating transport fossil-based energy to other alternatives such as renewable energy and the use of other renewable resources. The entire life cycle of transport systems is subject to measurement and optimization of sustainability.

Sustainable urban transport has many social and economic benefits that can support the local transition to sustainable development. According to a series of reports by the Global Partnership for Low Emission Development Strategies (LEDS GP)[5], sustainable transport can help:

- job creation; to improve the safety of travelers;
- through investments in bicycle lanes and footpaths;
- provide access to employment and social opportunities;
- more affordable and effective.

It also offers a practical opportunity to save people time and household income, as well as government budgets, making investment in sustainable transport an alternative 'profitable' opportunity.

The impact of transport on the environment can be reduced by reducing the weight of vehicles, sustainable driving methods, reducing tire friction, promoting the use of electric and hybrid vehicles, improving walking and cycling conditions in cities, and by strengthening the role of public transport,

especially electric rolling stock. Green vehicles are designed to have less environmental impact than equivalent standard vehicles.

Electric vehicle technology has the potential to reduce CO2 emissions, depending on the energy used in the vehicle or power source.

Assuming that people prefer to get to their destination quickly, urban planning and zoning can affect whether schools, shops, public transport hubs and other destinations are within a reasonable walking distance of living areas. If the urban structure affects these problems, then compact, multifunctional urban areas encourage walking and cycling. Alternatively, the non-circular (i.e. linear) models of settlements with low density and one-sided functionality, typical of a scattered city, tend to discourage movement without personal transport. In 1990, the Netherlands adopted the ABC Urban Development Guidelines, promoting projects that are key attractive locations easily accessible to non-car users.

A city that strives to be more environmentally friendly will inevitably be concerned with providing access to green spaces. The city will remain controversial for many people, unless it can be seen in practice how can become truly „green“.

Concentrating more than half of the world's population in cities generates large amounts of energy used and increases pollution. The introduction of innovation requires the creation of "smart cities" that fight their main priorities for energy, air quality and transport problems. All these efforts require intensive analysis of data provided by various sources and devices from the IoT (Internet of Things). Among the main goals of the project are solutions leading to the improvement of the state of the urban environment, through research and monitoring of traffic and transport management.

The transport and pollution management platform in smart cities includes a set of software functions and modules that interact and exchange information with each other. A study of operating systems around the world can be summarized from the model presented in Fig. 2.

[5] https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf

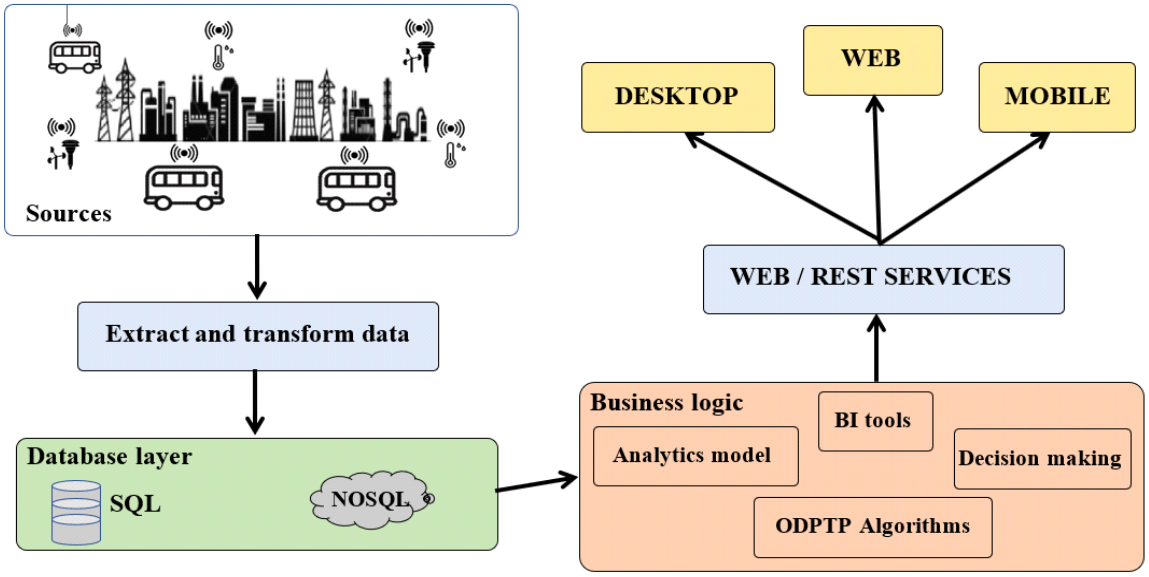

Fig. 2 Transport and pollution management model in smart cities

The control system includes many modules and technical means, but from an architectural point of view the layers of the platform are:

- Data sources - these are all technical means that are used to measure and collect useful information needed for the software system for traffic and pollution management. The sources include sensors for measuring PM2.5 pollution, temperature, humidity, precipitation and cameras for monitoring congestion and congestion of urban road infrastructure.

- Data integration - a module in the system that serves as an entry point for all kinds of data obtained from the Data Sources layer. The data formats can be quite different, as their purpose is to process and transmit to the data storage module in a suitable form according to the database management system.

- Data warehouse - this layer presents all the resources needed for physical or cloud data storage, which can be in a relational (SQL) database with clearly defined structures or in a NOSQL database storing information in an unstructured form (document, key-value, …)

- Business layer - contains tools and algorithms that are applied to the information that is stored in order to deliver information to relevant customers.

• Services - a layer for connection to various sources, offering a predefined API for connection to the software system

• GUI - contains developments for Desktops, Web and mobile applications that use the services provided by the system.

The following main elements are needed to solve the tasks set before the project:

• Development of new software and mobile application;

• Purchase of new electric vehicles;

• Staff training;

• Achieving public consensus to improve air quality through concrete actions;

• Development of a flexible travel schedule.

All these elements relate to improving the quality of public transport and reducing air pollution, which is one of the main goals of all smart cities around the world[6].

2.1 Development of new software and mobile solutions

The development of IoT (Internet of Thinks), the expansion of the communication network and the increase in the power of computers allows the development and use of software for real-time data analysis using BI tools and machine learning algorithms for self-learning. Achieving the goal of the project, which proposes the reduction of air pollution, requires a systematic approach and decision-making in the processing of multiple data coming from different and numerous sources. BI tools require the choice of many alternatives and criteria for the assessment, and the boards and assessments of basic criteria and key indicators will show the current situation. Due to the fact that the decision-making presupposes the satisfaction of the requirements of the stakeholders, the assessment of the qualitative attributes needs to be expanded by performing an impact and risk assessment. When developing the software architecture, it is necessary to emphasize the quality criteria and description of the trade-offs and opportunities that have been made for the respective

[6] H. Rajab, T. Cinkler, "IoT based Smart Cities", Conference: 2018 International Symposium on Networks, Computers and Communications (ISNCC), 2018

solution. This is a direct consequence of the main task of software that monitors and uses a constant flow of data.

For the approach in the current article, we derive the requirements of the needs for a large-scale software system in the field of intelligent urban management. A specific proposal is to use the integration of BI tools for assessing the current situation and tools including algorithms for decision making. The software system needs to be powered by data from different sources that can interact to work in a basic environment. The need for decision-making can have many possible applications, the most important of which is to deal with recurring situations in the analysis of decisions and proposals. Recurring situations can increase the quality and optimality, adjust the meaning and weight of the criteria, as well as add new ones. To achieve this goal, established architectural knowledge and solutions can be used[7], such as software models to meet all system requirements.

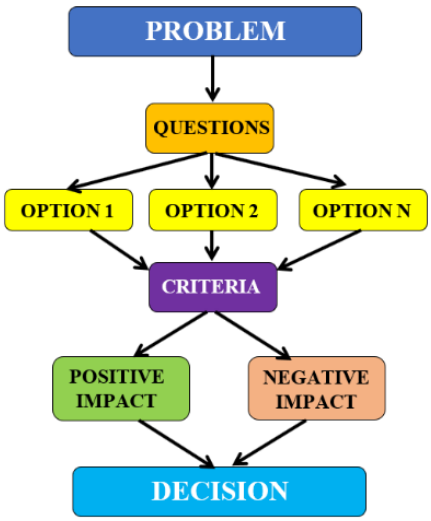

Fig. 3. Problem decision algorithm

When modeling and developing the software system, it is important to follow the approach of Problems, Questions, Options, Criteria, Positive and Negative Impacts (Fig. 3). The use of this approach can be applied to the architectural planning of the whole set of software tools, the interaction between them and the building of interconnections.

The software system will be based on a number of developed sub-products (tools), which must communicate through standardized interfaces, sharing resources, facts and solutions, as well as opportunities for expansion and balancing and communication of various external developers via API (Application Programming Interface).

[7] N. B. Harrison, P. Avgeriou, and U. Zdun, "Using Patterns to Capture Architectural Decisions," IEEE Software, vol. 24, no. 4, pp. 38–45, 2007.

2.2 Technical security

When developing the program for improvement of the urban environment and reduction of air pollution, it is necessary to perform an analysis in which to identify the largest sources of pollution and their respective alternatives for improvement. In order to establish the current situation, there is a need for constant monitoring. Devices for tracking air pollution, rainfall, temperature, humidity, traffic tracking cameras and passenger traffic are among the important data generators.

The traffic is as the main air pollutant indicated, Based on the available information (25%)[8]. A study on transport in Bangkok states that Buses (first) and trucks (second) cause most of the pollution. The study also calculates the energy savings of electric buses. The purchase of new electric buses and the use of a route-based route prediction system would have a major impact on improving air quality.

2.3 Training and support

Due to the constant development, the addition of new and the maintenance of the existing technical means imposes the need to increase the qualification and acquire new knowledge and skills in the implementation of the new platform. Staff training should be based on knowledge and good practices to be built and improved during and after the installation of the software product. The training will also form new attitudes in the staff to increase motivation and increase the quality level necessary for the efficiency of the whole organization.

2.4 Achieving public consensus

Poor air quality is among the main problems for Sofia Municipality, and surveys place the capital in 20th place[9] among all major cities in the world in terms of poor air quality from a Greenpeace survey for 2020. Through questionnaires and a survey conducted can be considered the main attitudes of the passengers in the public transport, recommendations and respectively to evaluate the main proposals in the INNOAIR project.

2.5 Development of a flexible schedule

The main module in the system is the optimization of transport, through routing algorithms depending on requests, road conditions, problems with vehicles and the respective passenger flow. This module will create a flexible schedule, and through tools for analysis, prediction and machine learning will be self-learning.

3. Business Changes

Business changes are permanent changes to working practices, processes, or relationships that will cause the benefits to be delivered. In the context of the project for “On-demand green public transport” business changes must be the fundamental of sustainability. The University of Plymouth Centre for Sustainable Transport [1] provides a widely accepted definition of a sustainable transportation system that states:

A sustainable transportation system is one that:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;

- is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy;

- limits emissions and waste within the planet’s ability to absorb them, minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

Such sustainability improvements around transportation may not be achieved quickly. However, using a framework to guide planning, policy decisions, and implementation can provide steps toward developing a sustainable outcome. When thinking about delivering transportation solutions and infrastructure in a more sustainable manner, agencies and companies are considering each of the bottom line elements:

• Economy – Support economic vitality while developing infrastructure in a cost-efficient manner. Costs of infrastructure must be within a society’s ability and willingness to pay. User costs, including private costs, need to be within the ability of people and households to pay for success.

[8] “Urban air pollution – what are the main sources across the world?”, The European Commission's science and knowledge service, https://ec.europa.eu/jrc/en/news/what-are-main-sources-urban-air-pollution

[9] World Air Quality Report, Region & City PM2.5 Ranking 2020, Greenpeace paper, https://www.greenpeace.org/static/planet4-romania-stateless/2021/03/d8050eab-2020-world_air_quality_report.pdf

• Social – Meet social needs by making transportation accessible, safe, and secure; include provision of mobility choices for all people (including people with economic disadvantages); and develop infrastructure that is an asset to communities.

• Environment – Create solutions that are compatible with - and that can be an enhancement to - the natural environment, reduce emissions and pollution from the transportation system, and reduce the material resources required to support transportation.

For greenhouse gas (GHG) emissions mitigation, there is a list of options but little consensus about how to prioritize certain practices and strategies over others.

Fuel/Energy efficiency – At the vehicle scale, vehicles must become more fuel- or energy efficient. National standards for passenger and other vehicles are the main overarching impetus here, but proactive or cost-driven fleet acquisitions by public agencies, corporate purchasers and households are likely to spur rising fleet efficiency.

Lower-carbon transportation energy sources – This need is likely to be met over time in large part with electrification of transportation. Alternative transportation modes and integration of land use and transportation – urban buses, light rail, intercity rail, and intercity bus are understood to have generally lower GHG emissions per passenger mile than conventional options and are therefore considered important emissions reduction strategies. The link between higher intensity land use and transit as well as other land use/transportation patterns are important mitigation techniques often employed through metropolitan planning organizations.

System efficiency/optimization – Optimizing the existing system. Techniques include technology – such as intelligent transportation system (ITS) technology, as well as policy regarding behavior – such as limits on vehicle, truck or ship idling, or encouragement of eco-driving (reducing carbon dioxide emissions through changing driver behavior or adjusting maintenance techniques). Such behavior changes include avoiding quick starts, planning trips (linking trips), avoiding idling, driving the speed limit, or using windows rather than air conditioning in low speed situations.

Companies must start evolving the role they play in the new era of electric mobility [2]. This evolution goes beyond simply installing reliable EV charging stations for employees and guests.

Electric mobility will affect companies when it comes to fleet policies, awareness, and employee/commuter benefits.

Many businesses are already aware of the importance of sustainable mobility. A hidden driver behind the transition to electric mobility is increased awareness of sustainable practices. Almost every business will be required to develop and share sustainability practices with their shareholders and acknowledge sustainability as a critical KPI.

The social behavior of organizations is scrutinized from all corners of the marketplace – including by investors, employees, regulators, competitors, customers, and communities – and is factored into investment, business, purchasing, and employment decisions.

Stakeholders – including customers, shareholders, and governments – are paying more attention to sustainability and putting pressure on companies to act. Various policies and CO2 targets are being set to prompt companies to become more sustainable and contribute to how our planet and quality of living will evolve.

Setting sustainability goals and performance indicators as part of key business metrics will help businesses gain an edge on competitors. Explore sustainable mobility solutions for businesses – transportation will go beyond ownership. Businesses will have to diversify transportation offerings to incentivize the use of clean transport.

Businesses can help combat congestion by empowering employees to choose services beyond car ownership. Companies, such as Netflix and Uber, provide a travel budget for employees to use car or ride sharing services during their employment (including weekends), reducing the need for (large) car fleets.

Public transport is also improving across the world, providing businesses with yet another means of transportation to tap into while developing appealing ways for people to use public transport. As a business, this is an important aspect to take into consideration when adopting sustainable mobility as it helps accelerate the transition to a zero-emission world. There's more to electric mobility than just cars. On a broader level, electric mobility is about raising questions regarding sustainable practices, both on the business and individual level.

In general business changes have to include:

- Creation of personalized offers from customer demographic insights;
- Creation of proximity centric offers based on customer location;
- Tracking and optimizing campaign effectiveness using machine learning;
- More effective collaboration and coordination with partners;
- Faster creating and deploying marketing campaign materials.

In the context of the project business changes have to include:

- Improved communication;
- Mobile application development for “On-demand green public transport”;
- Development and provision of additional services such as travel cards, direct transport from point to point, etc.;
- New jobs;
- Traffic facilitate for business and citizens.

The benefits of *improved communication* can be seen from different perspectives:

- For the public – with the introduction of "On-demand green public transport" public transport becomes more convenient, accessible and understandable to all. The number of passengers using public transport would usually increase, and it will reduce citizen’s dependence on their cars with subsequent environmental benefits.

- For each individual – the quality of life of people with reduced mobility, as well as those who live in areas that in the past were not connected to the public transport network, will improve. Demographic trends in European countries in recent years clearly show that the number of older people will increase. Making public transport more accessible to this group of citizens is one of the most important challenges for the social development of European cities.

- For companies – if public transport companies improve the quality of service, the image of this form of transport will be improved and it will increase the number of passengers.

To make the services of public transport more attractive and thus to reduce the use of cars, cities and public companies transport should try to provide a high quality of service in the public transport system. One of measures that can also apply is introduction of a *mobile application.* Through the application every citizen will be able to request a bus at a specific place and at a specific

time. Instead of driving on pre-defined routes, the new e-buses will create route map based on citizen demand submitted via mobile application. The app will leverage machine learning and advanced data analytics to create the most efficient path for each ride, collecting as much passengers as possible.

The image, as well as the quality of urban public transport can also be increased by providing *additional services* such as innovative systems for pricing in public transport (e.g. smart card payment systems) and point to point transport for a fare. The benefits for consumers are the absence of the need to switch between different vehicles to reach the desired end point, as well as a fair travel fare. Public transport system is more likely to be perceived by the public if the offered services are at reasonable prices. For promotional purposes in the initial phase, free tickets (free fare public transport) can be distributed to citizens or discounts can be provided for encouraging new categories of users.

New jobs creation related to the maintenance of the new public transport system should also be noted as part of the public benefits from this project. One of the great benefits for business and citizens as a result of the implementation of this project is the *facilitation of traffic* – as a result of the use of public transport instead of private cars.

Demand-responsive transport scheme provides transport 'on demand' from passengers using fleets of vehicles scheduled to pick up and drop off people in accordance with their needs[10]. This type of transport has been seen as an intermediate form of public transport, somewhere between a regular service route that uses small low floor buses and variably routed highly personalised transport services offered by taxis[11]. The need of an on-demand public transportation platform (ODPTP) is justified by various current problems and possibilities in Sofia which reflect demographic and technological developments, environmental conditions and ongoing inefficiencies of the current public transport. Therefore, Innoair strives to alleviate these problems and capture the technological benefits so that the public transport in the city of Sofia fully meets up to the social expectations of

[10] Mageean, J. & Nelson, J.D. (2003). The evaluation of demand responsive transport services in Europe. Journal of Transport Geography 11: 255-270.

[11] Brake, J., Nelson, J.D. & Wright, S. (2004). Demand responsive transport: Towards the emergence of a new market segment. Journal of Transport Geography 12: 323-337.

an efficient and environment-friendly public transport. Such objective is feasible. Coutinho et al.[12] investigated the impact of a demand-responsive transport pilot program that replaced the regular bus service in low-density areas of Amsterdam, the Netherlands. They concluded that the reduced mileage, restricted greenhouse gas emissions and operating time-frame contributed to a better overall efficiency of the on-demand system, when compared to the previous fixed service, despite the drop in the ridership.

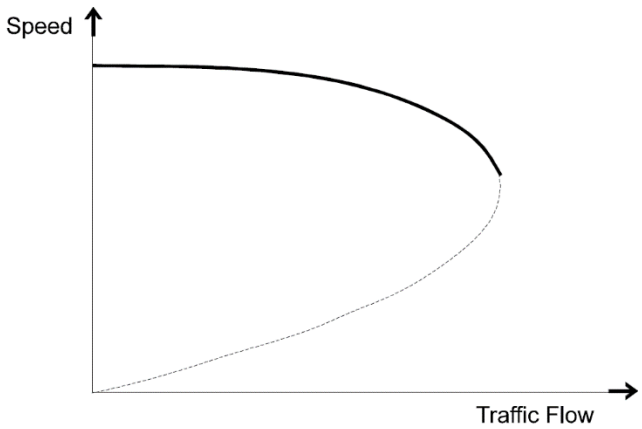

Fig. 4. Speed-flow relationship

Source: Dargay and Goodwin (1999)

In effect, the drivers of the whole project include:

– the continuing urbanization to Sofia – the urban sprawl challenges the city planners to attend to the public interest for environment-friendly urban setting and efficient public transport.

– the higher intensity of economic activities resulting from the greater urban population raises concerns not only about the provision of basic public services in certain areas but also about the quality of the air. This process might contribute to the worsening of the urban environment because it induces excess of carbon emissions, more frequent traffic congestions and insufficient provision

[12] Coutinho, F, Oort, N., Christoforou, Z. Alonso-González, M., Cats, O. & Hoogendoorn, S. (2020). Impacts of replacing a fixed public transport line by a demand responsive transport system: Case study of a rural area in Amsterdam. Research in Transportation Economics, Vo. 83,100910, https://doi.org/10.1016/j.retrec.2020.100910.

of public goods. According to Dargay and Goodwin[13] congestion is the impedance vehicles impose on each other, due to the speed-flow relationship (depicted in fig. 4), in conditions where the use of a transport system approaches its capacity.

The definition indicates that the underlying cause of congestion does not consist of the transient and immediate triggers which drivers notice when they are in a traffic queue, such as roadworks or taxis or accidents: the cause is because traffic flows are too close to capacity, when any of these transient incidents will have a disproportionate effect.

As a matter of fact, the higher occurrence of traffic congestions directly prevents workers from getting to work in time regardless they use personal or public transport and slows down the deliveries of products by firms within the city. As a whole the traffic congestions affect all people who have chosen the 'shorter' way through the city center by taking longer time than usual to reach a given destination. Eventually, the excessively longer trips in an urban setting consume greater time, leading to road aggression and less satisfaction[14].

The insufficient number of kindergartens has long been a problem for the Sofia municipality. Some newer areas in Sofia suffer from irregular bus service, restricting the overall urban mobility.

– the higher air pollution directly impacts the people through increased probability of respiratory problems and indirectly affects the firms through the urgency of some workers to miss job due to health issues. These developments also use up more public resources than it seems since the health problems entail health services that could have been provided for the prevention of other health conditions. Besides, the frequent absence from work warrants more social expenditures by employers.

As a whole, the inability of the urban authorities to keep pace with the urbanization and the economic processes negatively impacts not only the public but also the businesses in the city of Sofia.

[13] Dargay, J. & Goodwin, P. (1999). Traffic congestion in Europe. in Road Table Report 110, European Conference of Ministers of Transport, Paris

[14] De Vos, J., Ettema, D. & Witlox, F. (2019). Effects of changing travel patterns on travel satisfaction. Travel Behav. Soc. 16, 42–49. https://doi.org/10.1016/j. tbs.2019.04.001.

The ceaseless development of newer technologies provides an opportunity for implementation of flexible public transport solutions. Such novelty is the widespread use of smart devices which could justify the development of a mobile app and a software in support of the on-demand public transport platform.

The factors which misalign the characteristics of the urban environment with the public interest provide guidelines for the strategic objectives of the initiative.

– to improve the air quality – the high urbanization and the high intensity of the economic activities inherent to the city of Sofia as well as the frequent health problems due to polluted air underlie this objective

– to reduce the noise – the greater population concentrating within the city and the realization of the ongoing business relations make the urban environment rather noisy[15] thereby impacting the public health negatively

– to reduce traffic congestions – this objective follows from the chaotic urbanization taking place in Sofia and the thriving urban economy. It is highly likely that better urban planning of the traffic and reallocation of the vehicular flow might attenuate this problem.

– to bring time savings – the service provided by irregular public buses is costly for consumers and workers. This reason provides for the objective to economize on time by using the available mobile technologies. Such economies of time could well be elicited if the on-demand public transport platform (ODPTP) is successful, that is, it succeeds in serving low-density and dispersed settled areas, where regular public transport is usually not feasible on financial grounds. Given this circumstance the demand-responsive transport is a possible solution, helping the population to satisfy their mobility needs[16,17]

– to facilitate the mobility in Sofia – this goal follows from the rising urbanization, the dense urban economy and the need for more regular bus service. The wide mobile-phone diffusion eases

[15] McAlexander, T., Gershon, R. & Neitzel, R. (2015). Street-level noise in an urban setting: assessment and contribution to personal exposure. Environmental Health 14, Article number: 18. https://doi.org/10.1186/s12940-015-0006-y

[16] Ellis, E. & McCollom, B. (2009). TCRP report 136: Guidebook for rural demand-Response transportation: Measuring, Assessing, and improving performance. Transportation Research Board.

[17] MOG (Move on Green). (2014). Policy guidelines for sustainable mobility in rural and mountain areas.

the on-demand transport in Sofia. The urban mobility could also be eased by optimizing the schedule of the public vehicles. Additional measures that are also desirable include the provision of various modes of transport. Thus, the public is free to choose how the destination within the city could be reached.

Provided that the set strategic objectives of the initiative are accomplished, then the public and the business are to benefit collectively:

– a benefit for firms and citizens is the cleaner, less noisy and calm urban surroundings – this benefit is achievable if the objectives for improvement of the air quality, reduction of the traffic noise and optimization of traffic are fulfilled. In such circumstances the outdoor activities will be desired and recommended because of the possibility to breathe cleaner air in a soothing environment, that is, there is a health benefit which could suppress any respiratory problems.

– another benefit for the firms and individuals is better opportunities for time management and schedule planning. This benefit stems from traffic reduction, attained time savings and facilitated urban mobility.

– enhanced traffic security – a benefit that arises thanks to relieved traffic and time savings. These circumstances provide for less traffic aggression and easier access to a given destination.

– healthier labor force – this benefit is thanks to the cleaner air and reduced traffic noise. In an environment with less CO_2 emissions the individuals on average enjoy better health and motivation to work. As a result of this the workers may be more productive.

– high satisfaction in urban setting – the public and the businesses benefit from facilitated mobility, times savings and higher transport punctuality. This inference is supported by Hook et al. who argues that the improvement of transportation mode availability enhances the satisfaction with commute time regardless of the level of residential urban density and corrects travel captivity[18].

– higher cost efficiency of on-demand transport – the optimized algorithms for the choice of routes makes the on-demand public transportation platform (ODPTP) more cost-efficient than conventional transport. Therefore, the demand-responsive transport is likely to set lower price for the consumers, which has a beneficial social effect. This line of reasoning is in line with the

[18] Hook, H., De Vos, J., Van Acker V. & Witlox, F. (2021). Do travel options influence how commute time satisfaction relates to the residential built environment?. Journal of Transport Geography, vol. 92

conclusions of Laws et al.[19] who conclude that demand-responsive schemes are often designed to tackle social problems caused by poor accessibility.

References

[1] Brake, J., Nelson, J.D. & Wright, S. (2004). Demand responsive transport: Towards the emergence of a new market segment. Journal of Transport Geography 12: 323-337.

[2] Coutinho, F, Oort, N., Christoforou, Z. Alonso-González, M., Cats, O. & Hoogendoorn, S. (2020).

[3] Impacts of replacing a fixed public transport line by a demand responsive transport system: Case study of a rural area in Amsterdam. Research in Transportation Economics, Vo. 83,100910, https://doi.org/10.1016/j.retrec.2020.100910.

[4] Dargay, J. & Goodwin, P. (1999). Traffic congestion in Europe. in Road Table Report 110, European Conference of Ministers of Transport, Paris

[5] De Vos, J., Ettema, D. & Witlox, F. (2019). Effects of changing travel patterns on travel satisfaction. Travel Behav. Soc. 16, 42–49. https://doi.org/10.1016/j. tbs.2019.04.001.

[6] Ellis, E. & McCollom, B. (2009). TCRP report 136: Guidebook for rural demand-Response transportation: Measuring, Assessing, and improving performance. Transportation Research Board.

[7] H. Rajab, T. Cinkler, "IoT based Smart Cities", Conference: 2018 International Symposium on Networks, Computers and Communications (ISNCC), 2018

[8] Hook, H., De Vos, J., Van Acker V. & Witlox, F. (2021). Do travel options influence how commute time satisfaction relates to the residential built environment?. Journal of Transport Geography, vol. 92

[19] Laws, R., Enoch, M. & Ison, S. (2009). Demand Responsive Transport: A Review of Schemes in England and Wales. Journal of Public Transportation, Vol. 12, No. 1

https://www.dot.ny.gov/programs/greenlites/repository/AASHTO%20Sustainability%20Briefing%20Paper.pdf.

[9] Laws, R., Enoch, M. & Ison, S. (2009). Demand Responsive Transport: A Review of Schemes in England and Wales. Journal of Public Transportation, Vol. 12, No. 1

[10] Mageean, J. & Nelson, J.D. (2003). The evaluation of demand responsive transport services in Europe. Journal of Transport Geography 11: 255-270.

[11] McAlexander, T., Gershon, R. & Neitzel, R. (2015). Street-level noise in an urban setting: assessment and contribution to personal exposure. Environmental Health 14, Article number: 18. https://doi.org/10.1186/s12940-015-0006-y

[12] MOG (Move on Green). (2014). Policy guidelines for sustainable mobility in rural and mountain areas.

[13] N. B. Harrison, P. Avgeriou, and U. Zdun, "Using Patterns to Capture Architectural Decisions," IEEE Software, vol. 24, no. 4, pp. 38–45, 2007.

[14] Pereira, H., 2019, *What businesses can do to advance sustainable mobility,* [online], [Accessed 10.11.2021], *https://blog.evbox.com/action-points-businesses-sustainable-mobility*.

[15] *Transportation and Sustainability. Best Practices Background*, prepared by CH2M HILL and Good Company for the Center for Environmental Excellence by AASHTO Transportation and Sustainability Peer Exchange May 27-29, 2009, Gallaudet University Kellogg Center, [online], [Accessed 9.11.2021]

[16] Urban air pollution – what are the main sources across the world?", The European Commission's science and knowledge service, https://ec.europa.eu/jrc/en/news/what-are-main-sources-urban-air-pollution

[17] World Air Quality Report, Region & City PM2.5 Ranking 2020, Greenpeace paper, https://www.greenpeace.org/static/planet4-romania-stateless/2021/03/d8050eab-2020-world_air_quality_report.pdf