RETHINKING EVERYDAY MOBILITY

Results and lessons learned from the CIVITAS-ELAN project

Edited by Franc Trček & Drago Kos

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PREFACE

The massive automobilization of the second half of the 20th century has made traffic in the cities into a chronic problem. The traffic issue has started to endanger the "raison d'être" of cities. Together with the expansion and suburbanisation of the cities, forcing the inhabitants of "dispersed cities" to make longer trips to work, study, or for errands, the traffic problems accumulated over decades have become hardly manageable. Though there are a few exceptions worth imitating, we may generalise that the traffic issue is an identity feature of contemporary cities and urban regions. Moreover, the massive production and use of cars has affected the nature of contemporary societies to an extent that we may rightly refer to them as "system of automobility", i.e. societies adapted to massive car use. The fact that the adapted system is inevitably never finished, and that it constantly requires new interventions and infrastructure investments, is highly convenient for the expansive interests of the powerful automobile complex, which in addition to car producers comprises numerous interest groups from the cluster of the car ideology. In the early stages of automobilization, the most eminent representative of the branch, the eloquent Henry Ford, exclaimed: "We shall solve the city problem by leaving the city."

His prediction has largely come true. In the second half of the twentieth century, the cities in the developed parts of the world succumbed to the intense attacks of automobilization. Suburbanization became the leading trend, cities expanded, and numerous metropolitan regions and conurbations emerged. This urban development suited the growing middle classes, which could afford two basic goods: a detached family home and one, two or more cars. In the consumer society of high modernity, formally and legally founded on the individual, the patterns of urban mobility have become increasingly diverse, temporally and spatially dispersed, and consequently perplex and less predictable. The long-term projection of these trends leads to a radical transformation of the urban areas and, logically, of the rural areas as well.

As long as automobilism suited the basic features of contemporary consumer culture or until it turned into an obstacle to ensure accelerated flows of goods and people, alternative proposals were marginalised. Only constant traffic congestions and the consequent deterioration of the environment – which sensitised many users – led to broader views and reflections on the absurd and irrational domination of automobilism. However, introducing environmentally friendlier forms of mobility for people and goods, and asserting alternative traffic models, is far from simple, especially because of the relatively low operational capacity to legitimately introduce changes to the complex systems into which modern cities and urban regions have turned. These changes indeed have to meet economic, organisational, technical, political, social, cultural, and other criteria. This means, in other words, that it is very difficult to legitimately change traffic systems because it interferes with a strongly rooted system of interests, and at the same time directly affects the common routines of everyday life. Nevertheless, the time is right for a shift and turn.

This monograph presents the conceptual reflections on possible alternatives within the Civitas Elan project, its successful concrete solutions, as well as obstacles to the introduction of changes. The project has provided evidence of both continuing acute traffic problems and the spreading awareness of the necessity of change. Nevertheless, "systemic resistance" was often so powerful that for most of the time radical shifts seemed unlikely, but with some of the project's measures they were achieved all the same. It is also clear that the traffic issue is a specific, socio-technical combination, which necessarily requires the cooperation of technicians, technologists, organisers, logisticians, administrators, and various groups of users; in our modernist world this, too, is quite difficult and requires innovative approaches.

CIVITAS ELAN, which is part of the Civitas (stands for CIty-VITAlity-Sustainability) Initiative of the European Commission, is a program coordinated by cities and simultaneously a program "of cities for cities". The initiative derives from the premise that cities are living laboratories for learning and evaluation, where political commitment is a basic requirement in the search for better alternatives, which will provide cleaner and better transport in the cities, while promoting and implementing sustainable, clean and (energy) efficient urban transport, and building up a critical mass and markets for innovation.

The cities joined in the project's consortiums endeavour to solve similar traffic challenges in the form of demonstration projects; in their common living laboratories much tacit knowledge is exchanged and new, better solutions are searched for within the eight Civitas policy fields (Alternative fuels and clean vehicles, Collective transport and intermodal integration, Demand management, Influencing travel behaviour, Safety, security, and health, Innovative mobility services, Energy efficient freight logistics, Transport telematics).

The CIVITAS ELAN project is a consortium of five cities (Brno, Ghent, Ljubljana, Porto, and Zagreb) that includes 39 partners from seven European countries. In spite of the starting differences in the level of development of socio-technical traffic infrastructures, organisational and political cultures, and the specific nature of developmental traffic-infrastructure challenges, a CIVITAS ELAN family emerged already during the preparation of the application for the project, and strengthened during its four-year course. This family combines a wide range of technical and sociological experts in the fields of traffic, mobility, urban and regional (infrastructural) development, public administrators, representatives of civil society initiatives, and a very broad and diverse range of users. A part of our reflections and solutions is presented in this monograph, which is also the project's WD 11.4 Final Research Report.

To paraphrase Henry Ford, the project was essentially about action, i.e. how to solve traffic and related problems in the cities without leaving them. Though certainly a praiseworthy objective, it was also a very complex task. The experiences with our measures show that a "rescue operation" can succeed only if it manages - with the help of new "green" traffic, ITC supported, technologies and legitimately open decision-making processes - to convince the users that they may expect a higher quality of living in the cities. The postfordian city is an info-urban habitat that enables a high level of individual autonomy, including people's mobility. The CIVITAS ELAN project showed that massive car use in the cities is unnecessary and even outdated, that it lowers the quality of living, and that new approaches and technologies are capable of facilitating something that quite recently was thought impossible: to stop the prevailing suburbanisation trends and perhaps even trigger a new urbanisation trend, which will not deteriorate the environment and also prove to be economically efficient and generally, socially legitimate.

"Greening" city traffic is certainly a demanding task, but also a task with high added value for the quality of living in a city. Though such ambitious objectives undoubtedly cannot be achieved with a single project, it is possible to approximate them. The publication of the texts gathered in this monograph may contribute to spreading alternative views on the development of city traffic. And that is a very important task in modern reflexive societies, which face decision-making blockades precisely because of their reflexive nature. Given the automobility of contemporary societies, spreading ideas about new alternatives and improving old transport systems is important for their later legitimate introduction. This is the basic ambition and intention of the present scientific monograph. City traffic is beyond any doubt a technological issue, but it is an important shift to acknowledge that it is a social issue as well and that it therefore has to be addressed from sociological viewpoints as well. This opens the way to an operational definition of city traffic as a concrete socio-technical combination, which is not the simple sum or aggregate of its social and technical aspects. Rather, it is a new socio-technical entity, which cannot be taken apart simply into merely technical and merely sociological components.

The range of texts in this monograph is quite diverse, but some common points are easy to identify. The starting point of all the articles is the understanding that the means, ways, or technologies to "green" city traffic are known and actually available in our cities. However, many difficulties have to be overcome in the introduction of changes due to "systemic resistance". Surprisingly, these difficulties do not primarily depend on economic potential, but are rather caused by the necessary coordination of many institutionalised and non-institutionalised, even informal, interests and processes. It is important to identify this perplexity and to find ways how to coordinate and perhaps connect them synergistically.

The first part of the book includes texts dealing with the social circumstances of changing urban mobility and consequently with changing urban traffic systems and traffic policies. The second part presents some of the most successful methodological solutions that were used to analyze the changing, ever new forms of mobility. In the more extensive third part the articles present new techniques, technologies, solutions, approaches and products, which contribute to more efficient and environmentally friendlier city traffic. The monograph concludes with the reflections of the project's scientific coordinator about the cooperation in the RTD part of the project. It contains proposals which we hope will contribute to a better understanding of the project's achievements and stimulate further discussions on the objectives of the Civitas Initiative.

The published articles, of course, do not represent the entire research range of the CIVITAS ELAN project. It is rather a sample selection of texts illustrating the width and depth of "socio-technical" urban traffic combinations. The joint publication of these widely diverse articles also aims at transcending standard "specialist" treatment, because the increasing perplexity of modern urban mobility makes it more and more obvious that we are all – even if we are not particularly mobile – part of the problem as well participants in the creation of changes and alternative solutions.

To conclude this preface the editors would like to thank the authors of the articles and the reviewers, who responsibly and rigorously proposed many improvements to the texts. We also wish to sincerely thank Volker Hoffman, the project's official photographer, for the visual enrichment of the monograph, and the language editor Franc Smrke. We are particularly grateful to Ilija Stojanovič and Danijela Tamše, who thoroughly checked the texts and technically prepared them for publication, as well as to Jasmina Ploštajner, who designed the monograph.

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CIVITAS OR THE LEGITIMATION OF THE CITY MOBILITY CHANGES

Drago Kos

1 INTRODUCTION

There exists virtual consensus among policymakers, stakeholders and academics that public and stakeholder involvement in decision making processes can help to overcome the problems of trust, legitimacy and public acceptance encountered by past attempts to implement, for instance, solutions to city mobility. This belief is based upon growing evidence from several cases of progress towards solutions after years, sometimes decades, of controversy and deadlock. In a number of domains distrust of official actors is increasing, as is evident from public opinion polls or people's concrete behaviour. People's reactions to policy measures are increasingly influenced by distrust in the institutions that are responsible for providing information. In fact, the solutions of many urgent problems nowadays – at least in democratic societies - depend more on public acceptance than on technical possibilities. The reason is evident. The benefits of technical options are much more transparent while public acceptance depends on a number of known but also unknown, often quite enigmatic, factors. Nevertheless, the necessity to open the decision-making process to public participation instead of simply "educating" people is increasingly evident. This development is not unique to city mobility problems but reflects a wider trend in governance, in which the use of participation and consultation has become unavoidable and a credible way to achieve legitimation. The reasons for the legitimation crisis are paradoxically summarised as a consequence of modernist reflexivity, which „consists in the fact that social practices are constantly examined and reformed in the light of incoming information about those very practices, thus constitutively altering their character." (Giddens, 1990: 38)

At the general level three possible variants of legitimation procedures exist: 1. authoritative: legitimation through the legal state (municipality) authority; 2. the market: legitimation through market negotiation; 3. consensual: legitimation through a transparent information process and participatory decision-making. In practice all three options are combined, but due to the critical credibility of state and market institutions (Habermas, 1975; Offe, 1987) legitimation through participatory decision-making is probably the most plausible, i.e. politically and socially desirable solution to the legitimacy crisis. There is quite extensive evidence of such practices. Legitimation difficulties were already addressed by previous CIVITAS projects. Here are some quotations from different CIVITAS initiatives on participatory planning and promotion of sustainable mobility.

- *"... to go further down the path to a more participative management model in the field of mobility, which is one of the most complex issues faced by cities and towns today."*

- *"the general campaign will increase the knowledge of the population about the links between their behaviour and the quality of air and other environmental issues."*

- *"missing direct customer orientation in the phase of product launching often prevents customer's acceptance of innovative measures for cleaner and better transport in cities. Considerably improved knowledge about customers needs is necessary for a successful launch of these products."*

- *"the main purpose of this measure is to ensure sustainability and raise awareness of all the activities to increase citizens' support for environmental ways of travelling."*

- *"... the relevance of the planned measures and their level of impact on the mobility scenario require strong social consensus and public awareness."*

(The Civitas Initiative, 2012)

In fact, the difficulties encountered in previous CIVITAS projects have been one of the reasons for the CIVITAS ELAN project to deeply integrate a focus on citizen engagement in its work plan. Little systematic analysis has however been carried out on the limits and problems associated with such participation of individuals and interest groups. Success depends on the complex historical, cultural, political, and legal background that is incorporated in the carefully designed participation of all interested parties. Urban mobility is a special case in this respect. Besides general legitimation problems existing in contemporary modern societies, planning and changing mobility patterns in urban settlements is an extremely interesting and complex issue for two general reasons.

The first is the fact that urban mobility issues affect nearly all urban residents and visitors. In this respect, it is one of the most widespread issues and hardly any urban resident or visitor can possibly avoid it. Mobility is in fact the fundamental defining feature of the urban way of life. It provides access to people, institutions, businesses, spaces, events, etc. Mobility actually makes networking possible and effective.

The second reason is that the most popular and most commonly used technological means for achieving mobility, cars, are in constant conflict with the urban (city) way of life. The alternative solution, i.e. urban public transport, has been known long since but a more or less explicit confrontation between individual and public mobility practices continues to exist. Virtually uncountable sources deal with this chief urban problem. At a very general level, its persistence may be explained by the very powerful ideology of "automobility", which has a very strong impact on popular, modern ways of life. According to Urry, automobility is one of the principal socio-technical institutions of modernity. The ideology of automobility represents freedom, flexibility, efficiency, privacy, movement, speed, progress, autonomy (Urry, 2005).

But nevertheless the urban way of life is indeed a constant conflict with individual motorists. There is hardly a modern city where this conflict is not acute. Because the mobility issue in cities is so "ubiquitous" in the sense that it affects nearly everybody, and because automobility is such a popular ideology and practice, it is not difficult to conclude that the solution to the problems largely depends on legitimation procedures. From the opposite point of view (the other way round), it is obvious that any move, any change to urban mobility practices immediately causes legitimacy problems. Although urban mobility problems are widely acknowledged, they challenge the motivational ability of the entire urban population, meaning that they challenge cognitive as well as a value dimensions. In the implementation of changes to mobility it is therefore vital to: 1) structure and select the most accute problems and 2) reach a consensus about the dynamics of the introduction of measures that are as desirable as they are unpopular.

It is clear then that we are dealing with highly complex conditions. The task is demanding because we have to simultaneously deal with numerous individual components and their interdependence. The standard assignment of responsibilities between the numerous relevant disciplines and specialists is rather questionable in methodological terms. Simultaneous disciplinary specialization and integral treatment is one of the key conditions for an expert approach to mobility changes. This means that we have to simultaneously observe environmental, economic, political, legal, i.e. social aspects in their interdependence. Such an "integral methodology", however, first needs to be developed and asserted, because in spite of the in principle agreement on the necessity of interdisciplinary treatment, we are still in the embryonic state in this aspect too. In these circumstances, a promising approach would be to constantly confront expert reflection on individual issues with general social value contexts, which largely determine our capacity to act. From this viewpoint, it makes sense to observe urban mobility change at three levels: a) analytical, b) normative, and c) strategic (Becker et al., 1997).[1]

1.1 THE ANALYTICAL LEVEL

At the initial analytical level, we try to establish and empirically measure the traffic impact and social and environmental consequences of present mobility practices and proposed mobility changes. Basically, this is about an objective as possible selection of sustainable and non-sustainable urban mobility behaviours. An essential element is the assessment of the carrying capacity of the urban environment and a realistic prediction of possible (technological) innovations, which will bring about more social, economical and environment-friendly use of transport technologies. At first glance, it is obvious that the analytical level is above all related to the field of technical sciences and that, at least in principle the results of these analyses mainly depend on the capacity to carry out as accurate as possible empirical measurements and assessments of the effects of mobility practices. The analytical phase is thus mainly dedicated to the technical assessment of the impact on the urban environment caused by the operation of mobility technologies.

1 This approach was developed to deal with sustainable development, but it makes sense to use it in approaching other topics as well.

The gathered data should give us a clear idea how to timely introduce rational restrictions and even eliminate effects which will exceed the environment's carrying capacity.

Because of the complexity and interconnectedness of social and environmental effects and consequences, and because many cause-and-effect connections are still unknown, for instance the vague relation between network performance and perceived quality of service, the relatively clearly defined analytical task turns out to be quite demanding and cannot be entirely achieved as yet. This means that the information generated by expert systems is often not coordinated and transparent enough to have a mobilizing impact. The expert evaluation of environmental effects is a plural undertaking, and this means that expert assessments of one and the same effect often disagree. This issue, of course, belongs to a field that exceeds the sociological dimension of sustainable urban mobility. For the discussions on the implementation of urban sustainable mobility, these disagreements produce a highly important side effect – a decline in the credibility and social legitimacy of specialist assessments. The analytical level is thus expected to contribute as credible as possible information about what is the best possible sustainable urban mobility technology.

For the aforementioned reasons, CIVITAS ELAN has developed an ambitious plan for conducting the research and analytical activities in the initial, preparatory phase. The aim was to carefully examine the existing circumstances in the field (technical ones as well as those related to perception and preferences of the PT users), provide adequate scientific working methods and procedures for the consortium members, and plan and prepare all the measures before the demonstration phase had begun. For this purpose, the following activities have been included, as stated in the Description of work:

- Technical studies
- Financial & economical studies
- User needs assessment
- Negotiation & consultation processes
- Implementation planning
- Testing

As an example, a modal split analysis can be mentioned. It has been conducted simultaneously in all the cities of the consortium (respecting their specific historical development paths by introducing a tailor made design of the analysis for each of them) in order to determine the actual use of transportation and travel habits at urban and suburban level, test the quality of service satisfaction on public transport modes and help local measures to recognize important themes, issues, vulnerable groups and potential conflicts that may arise. Within this modal split analysis, in the city of Ljubljana two surveys have been conducted: “Changes in the public transport system of Ljubljana and the Ljubljana region” and “Travel habits of the respondents in the Ljubljana Urban Region”. Through these surveys data were collected on transport mode usually used for various activities, use of car pooling, frequency of public transport use, average travel times, transport mode in relation to distance/travel time etc. This contributed greatly to the final design of the measures to be implemented, and the control of their effects during the implementation.

1.2 THE NORMATIVE LEVEL

The simplest definition of the normative level would be that it is an assessment of the gap between analytical findings on sustainable urban mobility and the way actors respond to these findings. Because even the most developed (post)-modern societies often respond reflectively, we may theoretically expect a wide range of responses – from opposition and indifference to a major surge in the motivation for concrete changes from non-sustainable to sustainable behaviour. Though analytical methods can be used at the normative level too, so many diverse factors are involved that we do not have available accurate determinist forecasts at this level. What we can try to establish are concrete connections between the degree of economic development, social context, and the willingness to change.

Within the CIVITAS ELAN framework, much attention has been paid to citizens’ response to mobility management projects. Surveys were being conducted on a permanent basis in an attempt to get the adequate feedback to analytical findings. These surveys were to reveal the ways in which users of the PT system respond to them, thus showing to which extent theoretical conclusions are really applicable and effective from the point of view of the final beneficiaries. The city of Ljubljana has used such surveys, introducing them as a consultative instrument and a very useful mechanism for the inclusion of various stakeholders in the assessment of the changes to be implemented. The results were very indicative.[2] They have shown that the vast majority of the participants were very well aware of the problems related to the PT system, and that most of the proposed measures, aiming at a shift towards more sustainable transport solutions, received professed support. However, as much as these value-based considerations were in favour of measures foreseen, a big gap has been detected between professed attitudes and the actual willingness to change existing mobility practices. In the explanation of this obvious discrepancy, besides the individual cost-benefit analysis (as an apparent antithesis to value-based considerations, predominantly emphasizing the community benefit) a number of other factors have been taken into account, using socio-theoretical concepts to bridge the gap. Furthermore, the surveys have not only stressed the importance of the economic, social and political factors in the acceptance of changes in mobility practices, but also imposed the necessity to include a broadly defined range of stakeholders in the decision making processes on mobility issues, since they affect virtually everyone: residents, commercial entities, guests, and tourists equally.

Useful information for assessments of sustainable behaviour is which social groups are aware of the analytical findings and which are willing and capable to respond actively to these findings. Widely diverse responses are normal and to be expected. And this is of course a very important circumstance for the efforts for introducing sustainable urban mobility. The differences are also very big within relatively homogenous social groups. Even in such circumstances, there is a wide range of options - from indifference to energetic engagement; the key point is, of course, when awareness starts to motivate strongly enough to change questionable behaviour, and people become actively engaged. People's behaviour is obviously influenced by a wide variety of perceptions, interests, financial, cultural, psychological, and even accidental factors. A model that would take account of the connection between the degree of urban pollution and the willingness to change one's mobility behaviour would be highly reductionist. And this is what actually occurs when we observe the analytical level only, when we assume that by merely declaring expert findings on sustainable mobility practices we will bring about changes in behaviour. To introduce sustainable mobility principles to social practices, it is very important to assess why and how major or minor differences are generated between

2 For more detailed explanation, see in this book chapter "Public perception of changes in Ljubljana's traffic system – identifying key themes, barriers and relevant stakeholders" by Matjaž Uršič.

analytical findings and normative responses to them.

If we do not take account of essential contextual influences, our assessment may be totally wrong. One of the essential features of this concept is thus “calibration”, that is the assessment of mobility behaviour in view of concrete, economic, and cultural characteristics. The normative assessment of behaviour is therefore hard to standardize and this of course causes difficulties in comparisons. This is particularly true of isolated assessments of individual questionable behaviour. At the aggregate statistical level, the assessment is easier, but even there it is hard to avoid relativising.

1.3 THE STRATEGIC LEVEL

The differences between the analytical and normative levels make it very hard or nearly impossible to implement a uniform strategy to achieve sustainable urban mobility. The management, regulation, stimulation, and conduct of various policies – in order to achieve goals – must be adapted to the highly diverse conditions at all levels, from the local to regional, national, and even international level. To elaborate and legitimize policies of sustainable urban mobility is therefore a demanding task. Such a task is beyond the management skills, capacities, and motivation of project managers, because legitimation as a social and political process goes beyond expert competencies. It is a kind of action research where the main protagonists construct a communication forum, a kind of stakeholders’ arena. The strategic level of sustainable urban mobility can produce good quality results only if it is based on competently performed previous phases: that is analytical and normative assessments of the situation at hand, and if it is open to participation of so-called “civil societies”, i.e. all stakeholders. Key information for the construction and implementation of a successful strategy must certainly include an estimate of the gap between analytical findings and their evaluation by different social groups. And it is hardly less important to establish the reasons for differences in the evaluation of questionable practices of urban mobility. Only such diverse information will allow us to obtain a clear enough idea how to elaborate an operational strategy for sustainable urban mobility.

It is of paramount importance how the harmonization of the differences between the analytical and normative levels will take place. In theory and practice there are two rather different options: 1) instrumental action oriented toward success (one-way communication from analytical to normative level only), or 2) communicative action according to Habermas (1987/91) oriented toward understanding (two-way participative interactive communication from analytical to normative level and back). The difference between these two options is the difference between a reduced, instrumental PR legitimation campaign and communicative legitimation procedures which include a transparent information flow and is open to participation from the urban public in the decision-making process. It is likely that changes to city mobility practices will trigger so intensive responses that without the participation of civil society it will not be possible to achieve legitimacy. It is therefore essential to establish mechanisms which harmonise the differences between the analytical and normative levels. There are a number of possible mechanisms, but success decisively depends on the implementation of two-way communicative action oriented toward understanding.

From the very beginning CIVITAS ELAN has been oriented towards citizens. It is obvious from its mission statement, agreed at the initial phase between the representatives of the consortium cities: "To 'mobilise' our citizens by developing with their support clean mobility solutions for vital cities, ensuring health and access for all." The focus on citizen participation is a very important feature of the work plan, and it has an essential role in many measures, in evaluation, dissemination, and risk management. Putting the citizens first means an essential shift from perceiving them as a "problem" to their inclusion as the most important and constructive part of the solution. In that sense, CIVITAS ELAN has accepted the great responsibility of finding solutions which are, at the same time, sustainable for the PT systems and acceptable from the point of view of the citizens and their habits and personal preferences. In order to harmonize this strategic orientation and the structure of the project, several NGO's have been included in the project consortium, so that the voice of the civil society can be ever present during the implementation.

2 FRAMING THE URBAN MOBILITY QUESTION: A SYNTHESIS OF THE ANALYTICAL, NORMATIVE AND STRATEGIC LEVELS

Public understanding of an issue depends on how it is framed. Erving Goffman (1974: 21) defined frames as 'schemata of interpretation' which enable their users (individuals or groups) 'to locate, perceive, identify, and label' events and occurrences, thus rendering meaning, organising experiences, and guiding actions. Of the two types of frameworks he distinguishes, the natural and the social ones, the latter are of interest to us, as they provide 'background understanding for events that incorporate the will, aim, and controlling effort of intelligence'. To Michael Kosicki (2002: 66) framing is a perspective from which to approach the study of public consultation, the process of collective and open reasoning and discussing about the merits of public policy. Framing includes 'the discursive process of strategic actors utilizing symbolic resources to participate in collective sense-making about public issues' (ibid.: 66). Framing is part of the broader processes of selecting and structuring social problems. Actually, the frames are the changeable results of a perplexed and continuous "social construction" of social reality. The person who structures and selects is the person who has the power to determine what is more and what is less important, safe, dangerous, etc. In this respect, framing processes are an attempt at "invoking a particular image of an idea", for instance about urban mobility. It is quite obvious that these processes are open to a variety of interventions and therefore so complex and multileveled that precise management of the framing procedures is not possible. As a consequence, these elusive framing procedures are a persistent problem to the technocratic style of urban development management. It must also be understood that multiple frames exist in any given society, where particular frames may prevail with different groups holding on to them. Frames change in time and between groups. It is particularly interesting to analyze the dynamics between different framing clusters.

3 PARTICIPATORY PLANNING AND THE DECISION-MAKING PROCESS

In order to optimise the legitimation of urban mobility changes through an open information flow and participatory decision-making, it makes sense to incorporate the presented theoretical sketch in the project's outline. Ideally, deliberation and the inclusion of stakeholders is seen as a virtue for the reasons outlined above, all of which results from 'opening up' the decision-making process to the engagement of a wider range of interests. Since community tendencies exist to take an active role in decision-making, it makes sense to consider an institutional framework for the participation of interest groups. This could be a kind of local council, board, committee, local partnership, or some other way facilitating residents and users of the urban transport infrastructure to participate in the planning and implementation of changes to urban transport. Such an institution can contribute to the information flow, transfer of expertise, knowledge building, and especially trust building. Community engagement is consistent with the European requirement in the Aarhus Convention to provide access to information and public participation in decisions concerning the environment. However it is important to control the relations between the efficiency and legitimacy of policies.

Institutionalizing the framework for the inclusion of citizens in a decision making process regarding the changes that are to be applied (which also means gaining the necessary legitimacy) was a key issue in some of the measures implemented during the course of the project. Measure "2.9-GEN Participatory redevelopment of main station area" (CIVITAS ELAN, 2008: 332–336) is one of those, and probably the best example of such practice. The goal of the measure is to design and develop a participative communication policy and for this purpose different tools are being used: information letters to the people living in the station area; public fora; a periodical sent to all inhabitants of Ghent; press releases; website items (newsletters, audiovisual presentations, news items). Furthermore, a special digital 3D scale model has been designed as one of the major innovations delivered by the project, and several press releases were sent to different newspapers, broadcasting companies and local TV stations on a wide range of topics related to the works. In addition, reduced hindrance meetings were held on a weekly basis, functioning as a bridge between the project partners and the neighbourhood. As a final outcome there is a reconstructed station, designed in accordance with the needs and preferences of the people, along with verifying an apparently very successful practice of including the final beneficiaries in the essential phases of the project. An additional synergetic effect is the increased interest in the city's tourist offer as well as in future activities related to infrastructure facilities, signalizing that a specific culture of effective communication between stakeholders about mutually important issues has started to emerge.

As pointed out above, the institutional framework is not formed in a neutral environment. It is embedded in its particular local and national context and this will have an influence on its design, effectiveness, and legitimacy. When establishing a participatory framework, the contextual and specific characteristics of every case should therefore be considered. This context does not refer to the physical and social environment only, but also to cultural, economic, and historical evidence that should be considered. In this respect, past experiences and comparative practices in traffic management are of crucial importance. This means that the framework depends on the structure and definition of the problem. It is easier to construct and operate a framework if we are dealing with a single-issue problem. In city mobility changes, this is certainly not the case and the participation framework needs to be carefully designed.

In any case, the institutional participation framework should also provide a forum for community discussions on the organisation and improvement of the traffic issues of individual cities. It should gather and disseminate information, keep abreast with the scientific research performed by other actors, develop and deliberate on solutions to address the impact on the community of infrastructure and the operation of traffic, give recommendations to other actors, monitor their performance, and play a role in the decisions on the organisation of traffic and the changes to it. A further list of the participation of interest groups in an organised framework includes their cooperation in defining goals, defining roles and responsibility, ensuring early and inclusive participation, offering and discussing alternatives, ensuring that values and interests are weighed and balanced, providing a comprehensive and stepwise approach, ensuring flexibility and adaptability, making sure that early action does not make desirable action impossible, ensuring that the decision-making process is transparent and open, allowing sufficient time, sticking to the rules of the game, establishing control over the process, adapting the format to the task, allocating adequate resources, ensuring continuity of the structure and awareness, etc. Implementing a selection of these approaches may help to overcome the abovementioned gap between the analytical and normative levels of urban mobility.

A number of measures within the CIVITAS ELAN project have been dedicated to this issue. Just to mention some of their anticipated outputs:

- a sustainable congestion charging scheme for Ljubljana has been prepared in cooperation with actors at the national and agglomeration levels (3.1-LJU),
- an individualised mobility marketing campaign has been designed, based on social research on mobility needs (and a “traffic regime” in Ljubljana, based on citizens’ expectations, has been adopted) (4.1-LJU),
- a participatory “Sustainable Urban Transport Planning Process” for Ljubljana has been initiated (4.9-LJU),
- “mobility dialogues” with citizens have been established and

marketing campaigns have been carried out in Ghent, Zagreb, Brno (4.10-GEN, 4.11-ZAG, 4.12-BRN),

- an attractive “Integrated Mobility Centre” has been set up in Brno and a “Mobility Shop” in Porto (4.13-BRN, 4.14-OPO),
- “freight roundtables” of stakeholders about an integrated freight policy development in all the cities have been established (7.1-COM), etc.

However, some researchers (Fisher, 2000), have expressed concerns that such processes can also have the effect of ‘closing down’ deliberation. This can result when certain groups are excluded or where consensus building results in forced agreement, both of which can narrow down the range of possibilities considered. These and other concerns have led to questions that focus upon whether participatory processes are really ‘fit for purpose’; for example, in terms of their success in avoiding problems such as stakeholder fatigue, insufficient feedback, financial resources, time constraints, ensuring representativeness etc. In the planning and implementation of urban mobility changes, a problem of representativeness has been exposed. It is difficult to establish an operational institutional framework representing all the interested parties (residents, visitors, car users, public transport users, owners of real estate in the city, employees, and people with special mobility needs) in the city or even the whole metropolitan region. One option is to let the people themselves, not by the project leader or the administration, define the institutional framework facilitating participation. This of course presumes a quite high level of self-organisation and a highly developed urban civil society of the kind that was called CIVITAS in the ancient world.

REFERENCES

Becker, Egon, Thomas Jahn, Immanuel Stiess and Peter Wehling. 1997. *Sustainability: A Cross-Disciplinary Concept for Social Transformation*. Paris: UNESCO.

CIVITAS ELAN (2008): Description of Work, 332–336.

Earle, Timothy. C. and George Cvetkovich. 1999. Social Trust and Culture in Risk Management. In *Social Trust and the Management of Risk*, eds. George Cvetkovich and Ragnar Löfstedt, 9–21. London:

Earthscan.

Fischer, Frank. 2000. *Citizens, experts, and the environment: the politics of local knowledge*. Durham and London: Duke University Press.

Giddens, Anthony. 1990. *The Consequences of Modernity*. Stanford: California SUP.

Goffman, Ervin. 1974. *Frame analysis: An essay on the organization of experience*. Middlesex: Penguin Books.

Habermas, Juergen. 1975. *The Legitimation Crisis*. Boston: Beacon Press.

Habermas, Juergen. 1987/91. *The Theory of Communicative Action (I & II)*. Boston, Cambridge, Oxford: Bacon Press & Polity Press & Blackwell Publisher.

Inglehart, Ronald. 1997. *Modernization and Postmodernization: Cultural, Economic, and Political Change in 43 Societies*. Princeton, New Jersey: PUP.

Kasperson, Roger E. and Kirstin Dow. 1993. Hazard Perception in Geography. In *Behavior and Environment*, eds. Tommy Gärling and Reginald G. Golledge, 193–222. Amsterdam: North-Holland.

Kos, Drago, Matjaž Uršič, Franc Trček and Marjan Hočevar. 2006. *Diskurzivna analiza besedil o (ljubljanskem) urbanizmu. (Discourse analysis of text on Ljubljana's urbanism)*. Ljubljana: FDV.

Kos, Drago. 2002. *Praktična sociologija za načrtovalce in urejevalce prostora (Practical sociology for urban planners)*. Ljubljana: FDV.

Kos, Drago. 2004. *Tri ravni trajnostnega razvoja (Three levels of sustainable development)*. Teorija in praksa 41(1/2): 332–339.

Kos, Drago et al. 1994/97/02. *Socialno prostorski vplivi avtocest v Sloveniji (Socio-spatial aspects of highway construction in Slovenia)*. Ljubljana: FDV.

Kosicki, Gerald Michael. 2002. The Priming Effect: News Media and Considerations Affecting Political Judgements. In *The Persuasion Handbook: Developments in Theory and Prastice*, eds. James Price Dillard and Michael W. Pfau, 63–81. NJ: Lawrence Erlbaum Associates.

Marega, Milena in Drago Kos, eds. 2002. *Aarhuška konvencija v Sloveniji (The Aarhus convention in Slovenia)*. Ljubljana: REC.

Morgan, M. Granger, Baruch Fischoff, Ann Bostrom and Cynthia J. Atman. 2002. *Risk Communication: A Mental Models Approach*. Cambridge: Cambridge University Press.

Offe, Claus. 1987. *The Utopia of Zero-Option: Modernity and Modernization as Normative Political Criteria*. Praxis International 7(1): 1–24.

Plut, Dušan. 2007. *Ljubljana in izzivi sonaravnega razvoja (Ljubljana and challenges of sustainable development)*. Ljubljana: Faculty of Art.

Urry, John. 2005. *Automobilities*. London: Sage.

The Civitas Initiative. *Cleaner And Better Transport In Cities*. Available at: http://www.civitas-initiative.org/cms_pages.phtml?id=349&lan=en, 5. 1. 2012.

ELAN Youth Congress I To get to know better the different cultures and backgrounds of the ELAN cities, the students were divided into five groups, each with a representative from every city.

ELAN Youth Congress I The Mobility Treasure Hunt was not only a sightseeing tour, but also a game in which challenging riddles had to be solved.

ELAN Youth Congress | 40 students from all ELAN cities came to Brno to share new ideas on PT.

CONTEXTUAL MOBILITY AND THE NEW "MOBILITY PARADIGM": THE NATURE OF TRAVEL MODE CHOICES RECONSIDERED

Marjan Hočevar, Anže Zorman

1 INTRODUCTION: HOW TO GRASP THE COMPLEXITY OF THE MOBILITY ISSUE

In recent years, research into spatial mobility, as well as strategic mobility planning in practise, have not only intensified, but have taken into consideration new dimensions because of the issue's rapidly evolving complexity. There is an increasing amount of collaborative projects between transport researchers and sociologists, addressing the nature of mobility in modern life in relation to new forms of communication and the structure of social networks (Urry, 2007; Larsen, et al., 2005; Axhausen, 2003; Timo, 2006), with interdependent social, political, and spatial dynamics leading to completely new reflections on trans-sectoral and multilevel spatial conceptualisation and planning.

Because of the increased scope of movement in the physical (and virtual) space, an increasing portion of the built environment is dedicated to various forms of built mobility infrastructure: roads, airports, parking lots, crossroads, stations, rest areas, refuges, etc. Alongside the growing number of occasional and temporary structures occupying space, there is also the functional geography of wi-fi networks, mobile signal reach, satellite connections, etc. In general, we are witnessing many ways to ensure the simultaneous presence of people or actors, therefore implying a multiplication of the methods for travelling in time and space. New forms of mobility are emerging from the combination of physical and virtual mobility, leading to new, mixed forms of daily, residential, and travel mobility. These new forms of mobility have in common that they are largely based on the use of transportation systems, as well as the efficient appropriation of information and communication technologies (mobile phones, internet, etc.). They require actors to have a well-developed ability to appropriate technological systems and new tariff schemes for services (Flamm and Kaufmann, 2006: 168). In the face of mounting environmental costs these new mobilities are increasingly modelled in accordance with sustainable development principles. These call for consideration of the intersections and interactions between environmental, economic, and social systems, taking into account varying spatial scales (from local towards global ones) and temporal scales (from short-term towards long-term ones).

We observed that so far the discussion on how to improve mobility systems and the everyday life of individuals, institutions and businesses, has mainly focused on two obvious dimensions: space and time ("where" and "when"). Urban planners and transportation experts are consequently and primarily concerned with the technical issues of space consumption and the rationale of travel time budgets, regardless of specific personal, social, cultural, or even political contexts. Therefore, mobility is (on average) indeed increasingly freed from spatio-temporal and geographical constraints with the support of information and communication technologies (ICTs), and with the ever more sophisticated integration and diversification of transport modes, such as various modal-split options.

But in terms of broader social action and specifically of human interaction related to mobility, the issues of "why", "how", "by whom", "in which circumstances", as well as "under which considerations" these travels occur should be contextualised. In this paper we will advocate a contextual notion of mobility by arguing that being mobile or capable of being mobile is not just a rational matter of travelling (going somewhere and reaching one's destination) but that, more importantly, it is about the interaction individuals perform and the reflexive ways in which they interact with each other in their everyday lives (Kakihara and Sorensen, 2001). In other words: the contextuality in which the action occurs is of equal importance to organising human interaction as are the spatial and temporal premises, calculations of space consumption, and travel time budgets.

> *»...mobility research still focuses mainly on modal choice. Further aspects, such as realised distances, activity participation, or time structure of activities, are neglected. Nevertheless, these aspects remain important from an analytical as well as from an applied point of view with respect to sustainable transport planning:*

For instance, realised distances are connected to the consumption of resources and to the emissions of transport. Opportunities to participate in activities are highly relevant for older or mobility-restricted....« (Scheiner and Kasper, 2003: 323)

In a more practical way, some of these spatial, temporal, and contextual issues were addressed when conducting a public opinion survey on travel habits (choices) in the Ljubljana region, Slovenia, and while dealing with different measures of the CIVITAS ELAN project.

2 MOBILITY AS AN INSTRUMENTAL AND REFLEXIVE ACTION

Let us exercise a brief sociological explanation of the above introduced mobility complexity. On the one hand, we have the needs of the actors-users (individuals, families, organisations) for efficient, adaptable, interchangeable, and diversified temporal-spatial coordination. On the other hand, we have the strategists and operators of mobility services, who are presumably several steps behind in understanding temporal-spatial social dynamics and their effects on mobility. In the context of mobility, social dynamics reveal themselves in new relationships between individualism and reflective rationality. Individualism shows itself in the belief of individuals that it is their inalienable right to freely choose their ways and the extent of movement in space related to their life-style (e.g. opting for a car "at any price"), or limit it consciously by self-restraints as part of his/her social value orientation. Reflective rationality concerns the process of choosing and making decisions between different mobility options in the relationship between individual choices (wishes) and actual decisions based on other, "specific personal" circumstances (e.g. the use of public transport for reasons of ecological awareness). In terms of everyday life, this is basically the dilemma of mobility mode (more technically: modal split) discussions at the individual level as one of the measures we have been dealing with in the CIVITAS ELAN project. But this also means that measuring mobility, expressed with transport statistics in the sense of distance covered in time, can no longer be a key indicator explaining mobility motives, patterns, and potentials in modern societies. When conducting empirical research on mobility and life-style inter-relations, Scheiner and Kasper (ibid., 2003) analytically explained the broader socio-spatial context:

»...Decisions on mobility behaviour are reached within the context of certain space-time structures. These do not determine human activities (particularly with respect to opportunities for spatial mobility). Rather they have to be understood as dynamic and permeable resources. Space-time-structures are macrostructures that consist of global and national spatial and time regulations (e.g. spatial division of labour, EU regional planning policy, high-speed transport infrastructure) as well as settlement structures and time regimes on the scale of cities and neighbourhoods such as land use, quality of life in local communities, small-scale time-regimes (e.g. opening hours, time agreements), situation in the urban context and so forth. Interpretations have to be made with regard to economic, social, political and technical frame conditions (e.g. real estate market, fiscal housing grants, mobility-related taxes). Neither lifestyles nor mobility can be separated from macro-structural frameworks...« (Scheier and Kasper, 2003: 8–9)

Mainstream transport and spatial mobility statistics do not adequately consider the increasing degrees of freedom and functional ambiguity, nor the subjective rationales behind mobility decisions. Spatial mobility should no longer be understood merely as a means (of transportation) for arriving at a destination, but as a range of social activities, including travel as an aim in its own right. The time spent "on the move" (to work, holiday) is not necessarily identified as dead time which must be reduced. An increasing number of activities, associated with one's private interests or job obligations, i.e. with a fixed location, can be practiced while travelling. Clearly, these activities are likely associated with various modes of public and/or group transport (such as trains, buses, ships, or planes), giving our conceptual discussion an operational, meaningful public policy perspective (see illustration 1). Even if passive, the transition time can be experienced as a vehicle of functional transition between spheres of personal involvement; as such it can be even interpreted as non-existent in the new labour regimes of precarious, despatialised, and flexible arrangements.

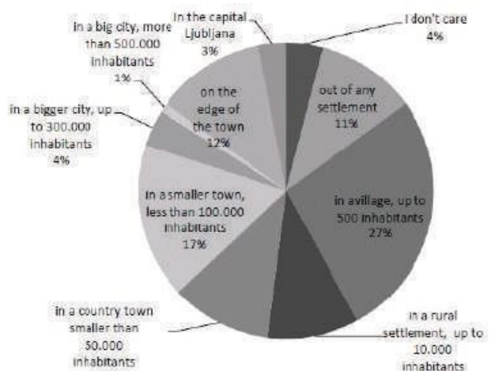


Illustration 1: Categories of activities conducted while on a train, grouped by types (leisure, business, commuting) of journey. Source: Lyons, Gleen et al., (n.d.).

In the same vein, a concept of “active travel” has emerged and has been actively promoted by government agencies and health institutions in recent years. The concept assumes walking and cycling for commuting purposes and other necessary trips (rather than leisure trips) for reasons of personal health and general well-being, thus embedding travel itself in the self-care paradigm. The rationale behind this can be judged from the large body of economic research on the subject, measuring cost-effectiveness or the cost benefits of introducing either structural or environmental measures to support these practices. Though the research findings seem to substantiate their economic viability, they betray a certain level of conceptual reductionism. Recent research (Anable et al., 2010) proposes active travel to be considered as a culturally and socially differentiated practice, with both socio-economic and cultural factors playing a decisive role alongside objective factors such as bicycle lanes, pedestrian areas, and the like. For example, according to the gathered data a) access to local shops and services and b) traffic congestion, both function as less significant explanatory factors for people opting to walk than their subjective sentiment or notion of environmental responsibility. Also, as the urge to get fit and healthy is one of the most significant factors explaining the frequency of walking or cycling, it is notable that residents of so-called deprived areas perceive fewer benefits from these practises, and that they are less common among people from the lowest income brackets and in poor health.

Still, the term's suggestive implications lead us to propose to place the concept in a wider framework. To us, active travel is thus a way of perceiving spatial transitions as a synchronised and intertwined set of social, cultural, symbolic, economic, psychological, and physical acts. While the physical mode of transition can already be embedded in these other actions, they can also be performed independently at the same time, as a set of meanings, decisions, or positions and, if taking into account various ICT effects, presences and flows. Deliberate or not, travel is always active.

Spaces, places, towns, or regions are no longer stable destination entities in a similar way as travelling should not be perceived merely as transitory. An already established way of discussing the modern interconnectedness of social and spatial dynamics and statics is the notion of networks and flows – the spaces of flows and the spaces of places - resulting from technological and telecommunication changes (Castells, 1996). The qualities of places, either as location points or area units in geographical space, do not suffice in any way to satisfactorily explain the activities of an individual, either in space or his daily travel patterns, e.g. in a town or between places. Administrative and geo-morphological urban areas are redefined in this context from spaces of production and collective consumption into points of functional interurban and supranational flows and networks. Carasco and Miller illustrate the development in these words:

> *"A spatial framework based on fixed points and distances among them are no longer adequate for understanding urban travel. Although people still move on transportation networks, the decisions and processes that lead to these movements are now much more complex"…. "Further, while land use still seems to be a useful predictor of aggregate trip patterns under the conventional zone-based framework, there is some evidence to suggest that the configuration and composition of people's social networks also play an important role in their propensity to undertake social activities and travel…"* (Carasco and Miller, 2006: 33)

Given that high-mobility societies are network societies, the movement of people, goods, and information assumes these social dynamics and the nature of socialising to have an ontological meaning. Alongside the "network paradigm", a parallel "mobility paradigm" is emerging (Wellman, 2001; Urry, 2004; Sheller and Urry, 2006), where travel is perceived as an integral part of social relations and processes, in the narrow sense of "social networking", and not merely as a refurbished concept of transport's useful calculability. Travel is not just a destination means but also the "glue" of human interactions, social networks and the strengthening of social and cultural capital. Dense, dispersed, and heterogeneous networks, which are at the same time highly selective, are one of the key features of modern societies. The above rule can be applied at all levels of social and spatio-temporal reality: in the family, among friends, between business partners and within towns, between towns, regions, and countries. The contextual relationship between travel and sociability is increasingly important because the geographical dispersion and remoteness included in social (business and other) networks is constantly growing. Spatial vicinity thus explains the steadily falling share of the operation of networks, especially in the complementary combination of physical co-presence and different forms of telecommunication connections between the actors in virtual networks. For example: We no longer enter the Internet, but carry it with us. We experience it while moving through physical spaces. Location-aware technology has thus made it possible to locate ourselves and be networked within multiple patterns of mobility.

Seen from the social and spatial viewpoints, the co-existence (or co-presence) of different social groups and heterogeneous areas is the result and feature of new social configurations. The spatial distribution of co-presence has became more individualised and heterogeneous due to the contemporary ICT, which enables harmonising "among multiple flows of activity and the interplay of planned and improvised action" (Jain, 2003), making real-time modifications to schedules and timeframes, and thus further delimiting our notions of domestic, public and working spaces.

3 MOBILITIES AND MOVEMENTS »IN PLURAL«

As we already mentioned in the introduction, mobility has turned into one of the most widely discussed interdisciplinary and cross-disciplinary issues in different social contexts and at all levels of everyday socio-spatial reality (whether individual, local, national, or global) in the past decade. The ubiquity of research into the different forms, types, and complex combinations of the movement of people, buildings, objects, capital, culture, information, ideas, symbols, transport, etc., is directly related to science's response to intense social change. Compared to spatial mobility (travelling, moving, commuting, recreating, etc.) the share of social sedentarity (settled, static, unchangeable practices) is generally falling, and the accepted ideas on stable, territorially delimited socio-spatial entities have less and less explanatory or action power.

Dispersed, geographically unlimited, but selective and differentiated movement of people is one of the key characteristics of modern societies. The application of this rule concerns the entire variety of social relations: in the family, among friends, between business partners, within towns, and between towns, regions, and countries. The ratio between spatial mobility and sociability is increasingly important because the geographic dispersion and remoteness of the actors included in social (business and other) networks is constantly growing. Spatial vicinity is able to explain only the rapidly falling share of the operation of networks, especially in the complementary combination of physical co-presence and various forms of telecommunication connections between the actors in virtual networks. The level of proficiency in using movement options and managing the subsequent connections is thus a component of the so-called network capital that an individual or group possesses, being a function of and a supplement to his (its) social and cultural capital. The structure of one's personal networks and his positioning in them is a crucial determinant of his vertical social mobility capacity. Knowledge, skills, resources, and other attributes of the potentials one has can only be leveraged properly when combined with a network capital that effectively moves them towards ever fluid social relations.

Often, a dramatic designation is used, illustrating that not only people are constantly moving, but entire societies ("Societies on the move"). A commonly accepted image is that of spaces of flows, contrasting with traditional spaces of places. The complexity of mobility is expressed, on the one hand, through the (un)manageability of increasingly numerous infrastructural and social networks, intersections of (un)coordinated connections within mobility systems and between them and, on the other hand, through the increasing need of users for individualisation, customization, and accessibility of movement in space .

The emerging meta-paradigmatic framework of mobilities is an attempt at an integrated approach, combining all spatial disciplines and sub-disciplines, and is aimed at explaining, and later solving, one of the key features of modern societies. This approach sees the entire social structure as thoroughly embedded with (spatial, virtual, even imaginative) movements and the dynamics of people, information, machines, money, dangers, and image transitions. As Law (2006) points out, we are dealing with complex intersections of `endless regimes of flow', which move at different speeds, scales, and viscosities. Consequently, the paradigm suggests that we take into account these dimensions when considering the regular set of questions in individual social science disciplines. But it is also opening a new set of focal points altogether, shifting our attention to certain tools and immobile infrastructures which organise, enable, regulate, and limit these flows of (systematic or sporadic, deliberate or forced) movement. This broadly defined framework does not aim to posit itself as an affirmative approach towards mobility per se, but, on the contrary, functions as an apt criticism of so-called hypermobility, undesirable or forced mobility, confrontations with environmental restrictions and other risky forms of mobility, new-age nomadism as possible forms of social escape, the deterioration of collective and territorial identities, and the like.

Along with the mobilities paradigm, there are some other cross-disciplinary conceptual exercises, aimed at achieving an integrated approach to the highly complex body of mobility issues. For the sake of illustration, we will mention only one of these exercises and elaborate on it, because the attention of its proponents is clearly similar to the mobilities paradigm: the motility concept is defined as the "capacity of an actor to move socially and spatially", and "Mobility is not only about movement but also a system of potentials characterized by intentions, strategies and choices. Consequently, motility is how an individual or group endorses the field of movement possibilities and uses them" (Kaufmann, 2002; Canzler et al. eds., 2008) (see also illustration 2).

> *»...motility differs from accessibility by focusing on the logic of an actor's actions, in particular the reasons behind the choice of tools and localisations, without being concerned with an action's maximum utility. In this sense, motility concentrates more than accessibility on how an actor builds his/her relationship with space and less on the possibilities offered by a given territory...« (Flamm and Kaufmann, 2006: 168)*

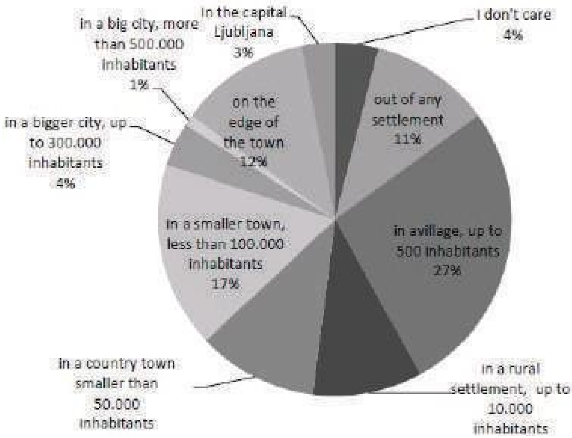


Illustration 2: Mobility, motility and movement.
Source: Canzler, Weert et al., 2008.

To use a conceptual frame of linguistics, motility then is a competence, whereas mobility is a performance.

4 SOCIAL STRATIFICATION AND MOBILITIES

In establishing a framework of scientific relevance for integrated mobility and to reconsider travel modes, sociology has – partly spontaneously and partly systematically – a coordinating and epistemological role, especially the sociology of space. Spatial constellations indeed inevitably depend on the existing social structure and cannot be managed or controlled merely with technical or technological innovations. In other words: the built environment and movement in it is a reflection of society, its stratification, organisation, and differentiation. Understanding vertical social mobility (climbing up or sliding down the social status scale) as an instrument for establishing stratification, inequality, hierarchies, and the dynamics of social relations, is of key importance for understanding spatial and other forms of horizontal mobility. The most general starting point for understanding social complexity is precisely the relationship between systems linking up (integration) and their internal divisions (differentiations).

Studying this relationship in the context of an integrated approach to mobility does not have, of course, a merely theoretical explanatory meaning:

- Do mobilities establish new social contradictions or eliminate old ones?
- Do they contribute to strengthening or reducing inequality in society?

The complex positioning of mobility within the broader context of social stratification can be easily neglected or narrowed down to questions of spatial accessibility and economic affordability. While these questions have a valid starting point, they can overlook the reciprocal relationship between patterns of social inequality and mobilities. Also, the "in plural" view extends to inequality as well, encompassing not only the differential distribution of (and access to) scarce, but desirable, goods or resources, and the disparity of opportunity to maintain or improve one's status. When taking into account the increasing variability of lifestyles, attitudes, life rhythms, and network positions, these vertical differentiations are also diffused with more complex inequality structures and expanded horizontally. Mobilities as the prevalent dynamic systems in modern societies can both function as the precursor of the existing differences in social position, status and power, or they can stand as an empowering factor in the social positioning of those with lesser means.

As outlined by Manderscheid (2009), a multi-dimensional perspective can be applied to the interconnections between social inequalities, spatial dispositions, and mobilities. At the first plane, the spatial structure is addressed in terms of accessibility and movement patterns, focusing on observable and measurable factors. The material environment, the technological constitution of spatial networks, and the dispersion and connectibility of the available nodes are directly linked to the levels of social inequality and operationalised as access to activities, resources, and goods. Geographical positioning can then allow or hinder job acquisition, access to healthcare and educational facilities, etc.

The second, less often discussed perspective is based on the aforementioned concept of motility as the ability to move - potential mobility. It is a three-component theoretical construct that encompasses access, competence, and appropriation. The elements were explained by Kaufmann et al. as follows:

> *"Access refers to the range of possible mobilities according to place, time and other contextual constraints, and may be*

influenced by networks and dynamics within territories. Access is constrained by options and conditions... Competence includes skills and abilities that may directly or indirectly relate to access and appropriation... Competence is multifaceted and interdependent with access and appropriation. Appropriation refers to how agents (including individuals, groups, networks, or institutions) interpret and act upon perceived or real access and skills. Appropriation is shaped by needs, plans, aspirations and understandings of agents, and it relates to strategies, motives, values and habits. Appropriation describes how agents consider, deem appropriate, and select specific options. It is also the means by which skills and decisions are evaluated." (Kaufmann et al., 2004: 750)

As such, motility can be viewed as a form of social inequality or a mechanism for its reproduction, where its composition either enables an individual or a group to participate and even imagine (desire) participation itself in the preferred sociocultural spheres, or prevents them from doing so.

The third view focuses on the social meaning of movement, taking into account representations and discourses, which are inherently based on power relations and as such infuse mobilities with corresponding symbolic meanings. Travel modes as a function of a symbolic transmission of dominance were the theme of a much cited article in the New York Times in 2009, which interpreted the unusually high number of vandalised Velib bikes (a bike-sharing system in Paris) as a response to the rampant patterns of social inequality and their spatial attributes, which reduced the options of contemporary mobilities for the (less well-off) residents of the peripheral areas. In a complementary way, the fourth perspective deals with questions of technologies as arbitrary, excluding, and stratifying phenomena, questioning the divergence between their in principle capacity and the actually existing priorities, needs, and sociocultural composition of individual societies. This perspective functions as a critique of the techno-deterministic concepts of mobilities, as technology itself is not an enabling force per se and is always socially appropriated and situated, functioning in accordance to what it means to different social groupings.

Though we touched upon the question of inequality only cursorily, it is of paramount importance that these perspectives should inform urban and transportation planning when decisions are taken at the systemic level. They show not only the extent of mobility complexity but also the wider responsibilities included in mobility management and its essential connections with social, cultural, economic, and political processes.

5 LEVELS OF MOBILITY GOVERNANCE AND ITS CHALLENGES

The difficulties of “translating” conceptual knowledge about the implications of general social trends into mobility systems in cities and regions, and applying this knowledge to integral and interchangeable transport networks with real “instruments” has accelerated the emergence of a specific scientific discipline - urban governance science. This discipline is to incorporate technical and sociological conceptualists and theoreticians, as well as practitioners from the fields of public opinion surveys and user (inhabitant) participation, and public relations consultants, who are to establish the framework for political (public) decision-making related to changing and introducing integrated mobility systems. We consider our research efforts, dealing with the broader issues of modal split within CIVITAS ELAN, as a tool for governance officials when making long-term decisions. All these profiles of experts are to operate in coordination at three levels of mobility governance:

- the strategic level should elaborate an ambitious and coherent mobility policy, adapted to the actual urban infrastructure, with means and goals that will meet be the collective needs of the users as closely as possible, while taking account of the long-term, broader social trends that are not exclusively connected with mobility (e.g. planning bicycle lanes or public transport corridors by reducing the roadway available to cars),
- the tactical level should strive to ensure – by combining techniques of inclusion and participation of the public, especially direct users, with education and consensual persuasion – that the strategic goals are in harmony with particular, individual, and community interests (and – to be honest - vice versa). In the context of education and persuasion it will be necessary to develop instruments for continuous, comprehensible, and convincing stimulation of users towards a reflective-rational understanding and values-based identification with the proposed forms of mobility (e.g. to abandon driving and take up cycling in connection with personal health and environment protection),

- at the operational level, strategy and tactics should be implemented in the execution of a mobility system from the viewpoint of transport in the narrow sense, with mobility in the general sense. Continuous monitoring of the execution by authorised operators will be necessary from the viewpoint of economics, social equity, maintenance, ecological criteria, and concrete usefulness to the users. Complementing, expanding, and changing the system to meet new, emerging circumstances will have to be monitored, especially from the standpoint of the timely detection of emerging new mobility patterns among the users.

The highly sensitive balance between the expectations of the users of mobility services in the city, and the capability of planners, operators, legislators, and regulators to meet these expectations, demands complex planning procedures. Dealing with questions of implementing sustainable urban development measures, Hanja Maksim (2012) notes that success predominantly depends on effective and efficient inter-sectorial coordination of urban and transport policies.

She also notes the impact of the large differences in practice, depending on the political culture, planning traditions, and local contexts of different European countries, because these define the particular modalities of tactical and operational consideration and execution. An additional circumstance in managing the modal split are the nationally specific and locally deep-rooted differences in the value orientations of the actors, which have a strong impact on existing mobility patterns and the ways and pace of changing them.

Consequently, when transferring and mirroring concepts and policy measures from the so-called demonstration cities (or urban laboratories) of the Civitas initiative, followers should first extensively elaborate the concrete local specifics of these generalised socio-spatial trends and perspectives. Briefly outlined, they are of course just the basis and generalised background of different real situations, helping us to reflect on how to research, substantiate, conceive, and finally operationally improve.

Based on researches and conceptual consideration, we can list a comprehensive selection of indicators to empirically measure integrated mobility in any national society or (city) region within the European territorial system. The potential range of the emerging integrated mobility paradigm can be divided analytically into several thematic subsets, whose validity we empirically tested (on some of them) by means of a public opinion survey on modal split and other surveys within the CIVITAS ELAN project:

- mobile spatiality and temporality,
- temporal-cost mobility matrices,
- environmentally sustainable and alternative forms of mobility,
- mobility rights and risks,
- new social networks and mobile media,
- immobility and social exclusion,
- hypermobility,
- access and availability of mobility networks,
- travelling (leisure) and commuting (daily, job-related) mobility,
- migrations and diasporas,
- transport and communication technology,
- transterritorial and transitive connectedness of mobility infrastructures,
- contemporary spatial management competences.

6 MODES OF TRAVEL AND THE SYSTEM OF SOCIAL VALUES IN SLOVENIAN SOCIETY: SELECTED RESEARCH ANALYSES AND FINDINGS

In the case of Slovenia, we will start from the following hypothesis: the Slovene territorial system is seemingly ideal from the viewpoint of approximating integrated mobility (in the movement of people as well as material and immaterial goods) because of its relatively small area. But this smallness, combined with dispersed settlement and local self-sufficiency, has a curbing effect on working and especially living sedentarity or settlement mobility. Now that the motorway network is nearly finished, accessibility has in general greatly increased, but the administrative territorial system has remained unchanged, and is accompanied by a tendency toward further fragmentation into (smaller) municipalities and even more dispersed settlement. These circumstances obstruct settlement and job mobility, which are at present among the lowest in the European Union. This is a serious structural problem because:

- it makes it impossible for social relationships to become flexible and modernized,
- obstructs the integral socio-spatial development of Slovenia,

- strengthens self-sufficient local interests and
- prevents processes of supranational (European and global) integration.

Rigid mobility reinforces traditional social networks of individuals and groups (e.g. kinship, where young people keep on living with their parents), and it does not accelerate the strengthening of individual autonomy and responsiveness to the turbulent demands for adaptation to dynamic social conditions.

Our previous research attempts at investigating value orientations, based on the country's historically rooted territorial development and the mobility patterns resulting from it, show that "anti-urban" value orientations, as we label them, constitute the essential characteristics and specific aspects of the perception of space in Slovenia, its symbolisation and symbolic representations. One of the essential spatio-demographic characteristics in Slovenia is that it is highly fragmented and diverse, compared to other territorial systems in Europe. According to Eurostat (2009), among the member states of the European Union Slovenia has the highest share of people living in detached houses – around 69% (followed by Hungary, Romania, Denmark and Norway), while the EU average is only half that percentage (34%). Along with a low (17%) and later stagnant population growth, the number of dwellings[1] in Slovenia increased by 72% between 1971 in 2007, and the share of detached houses increased sharply from 1960 onwards. In 2001, 92% of all housing units were privately owned in Slovenia (Statistični urad Republike Slovenije, 2002) and although the share dropped to around 88% in the past decade, it is still the third highest in the EU (behind Hungary and Romania).

In most Slovene towns the residential areas cover 2/3 of the urban space, but in Ljubljana, Maribor, Celje, Škofja Loka and the coastal towns individual housing construction consumes up to 15 times more land than multi-dwelling construction (Drug, 1999; Uršič and Hočevar, 2007). The average net size of residential area per capita in the urban environment is at least 15% lower than in the rural environment. The average entire (gross) area of consumed land (building lot) per single house is around 1000 m^2 in suburban settlements, with a total residential space between

1 We define dwelling as any structurally unified whole intended for residence, with one or more rooms, with or without appropriate utility spaces (kitchen, bathroom, toilet, anteroom, larder, etc.) and with at least one separate entrance. Account has been taken of all occupied and unoccupied dwellings and dwellings for occasional use (definition by the Statistical Office of the Republic of Slovenia). All premises that are intended for habitation in various buildings (apartment blocks, skyscrapers, detached houses, etc.) are included (see Hočevar, 2012).

200m² and 300m² (Rebernik, 2007). Nearly half the dwellings in Slovenia are outside the urban settlements. Of a total of around 6000 settlements, only 200 (or 3%) have the status of an urban settlement and about half the country's population lives in these 200 settlements. Around 90% of all settlements have less than 500 inhabitants and these are home to 35% of the population. The 15 urban settlements with over 10,000 inhabitants include less than 35% of the population. Areas of dispersed settlement with low population densities, prevailing freestanding single-family houses, and low spatial use are typical even of individual areas within the city of Ljubljana. In the case of Ljubljana, these were initially residential areas of unlicensed construction, later legalised, as well as "urbanised" rural settlements in the immediate vicinity of the central areas of the city of Ljubljana, which emerged through the gradual transformation of former rural villages. Like elsewhere in Slovenia, these areas developed unsystematically and without a uniform urbanist or morphological concept (Rebernik, 2007: 30).

The essential spatio-demographic characteristics outlined above position the development and mobility indicators in the value system of Slovene society concerning the population's settlement pattern and desired ways of living. The actual spatial dispersion of settlement in the Slovene territory and the use of space correspond with the anti-urban values of the population. These findings are supported by the interpretation of the public opinion survey "Spatial values, 2004", carried out on a representative sample of the Slovene population (See illustration 3) (Hočevar, 2000; 2004, Uršič and Hočevar, 2007).

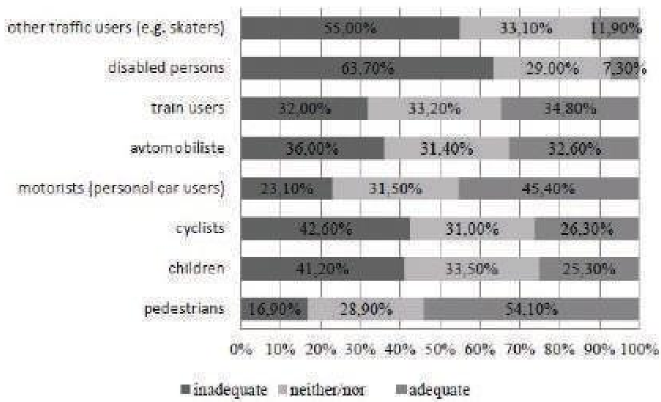


Illustration 3: Preferred modes of urban or rural settlement for living.
Source: Uršič, Matjaž and Marjan Hočevar, 2007.

The value system of the Slovenian population concerning spatial constellations is thus crucial for understanding the findings about the actual modal split situation, the value orientations of the actors, mobility patterns, motility externalities), the ways and pace of changing them with various governance actions, and how all these findings correlate with the objective morphological factors. These findings are:

- The geographic and urban configuration of Ljubljana requires a system of mobilities that is in principle compatible with the goals of the CIVITAS ELAN project. As such it figures as an enabling factor, which until recently has been overlooked, as has it capacity for more efficient, inclusive and diverse travel modes. Its densely concentrated historical city centre and the relatively short distances to be covered within the city's perimeter partly explain the survey's findings that the perceived conditions for pedestrians are very well arranged in terms of infrastructure (see illustration 4).

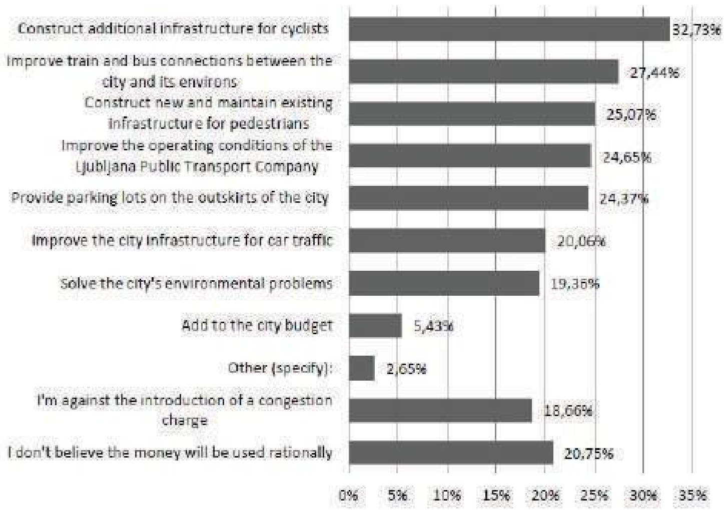


Illustration 4: The perceived adequacy of Ljubljana's traffic system for different user groups.
Source: Uršič et al., 2009.

This perception also results from the closure of the city centre to motor vehicles a few years ago. Despite their otherwise very automobile inclined perspective on urban questions, the respondents showed a marked inclination towards further pedestrianisation of certain city areas with distinct ambience and reflexive values, and we may interpret this as a kind of conscious self-limiting. Since the survey was applied, the city administration has actually excluded car traffic from additional areas, re-structuring the city's mobility in terms of a more differentiated and paradoxically even inclusive mode.

It should also be noted that this same pedestrian infrastructure is much less user friendly if we focus on the handicapped or some other traffic user groups: the urban accessibility factor has been additionally reduced for the already disadvantaged, showing that inclusiveness is very unevenly focused.

- The city space of Ljubljana is hypothetically well adapted to bicycles and its users favour them very much. As the city is relatively small, a proper adaptation of traffic spaces and further development of its cycling infrastructure (which was perceived as very problematic in 2009) would allow for a whole new mobility context; following the findings of a later survey (performed in 2011 and 2012), the city's residents consider bicycles to be the chief, and much appreciated, alternative for spatial movement. As an example we refer to the preferred use of the money collected with a hypothetical congestion charge (see illustration 5).

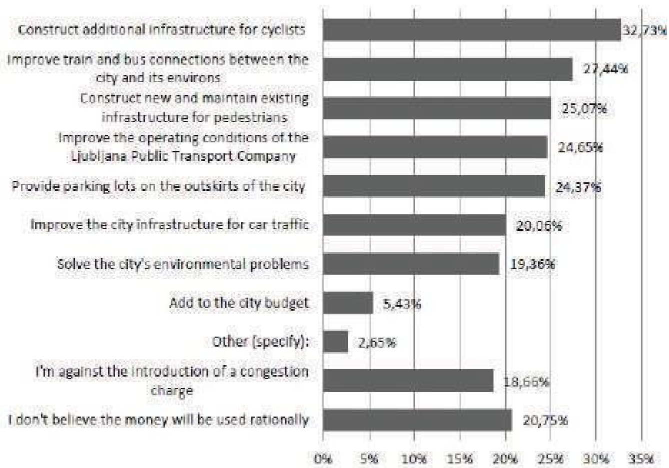


Illustration 5: Preferred ways of using money gathered with a hypothetical congestion charging scheme.
Source: Uršič et al., 2011.

However, this affinity for the use of bicycles curiously stems from the same logic that propels the use of automobiles in the first place – speed. Environmental sustainability, personal health and recreation do play a role, but they are all secondary to speed and a bicycle's supplementary benefit - no parking issues (see illustration 6). Cycling thus functions more as a negative definition in the interplay of the dominant mobility categories.

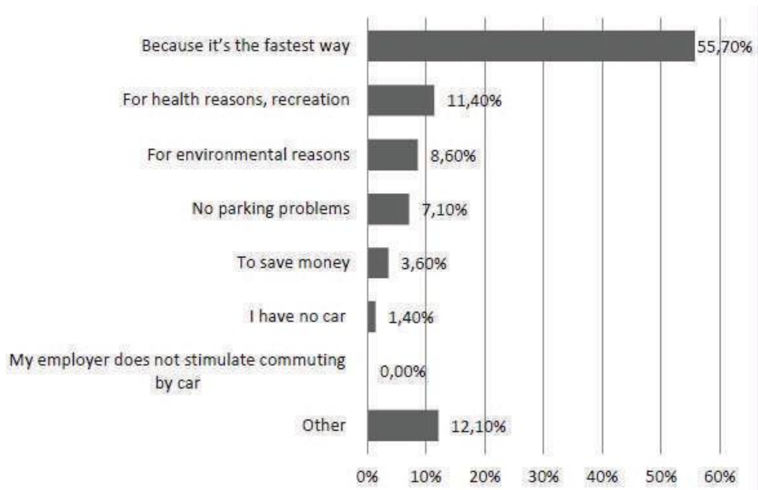


Illustration 6: Reasons for bicycle usage in the city.
Source: Uršič et al., 2009.

It should also be noted that the spatial distribution of public bicycle rental points follows a certain logic, which diverges from the principles of equal accessibility and inclusiveness, and actually worsens the existing uneven mobility options.

- Moving our focus to the means of public transport, a different picture emerges. Although there was a general consensus that the city bus infrastructure was appropriate, the actual use of public transport is relatively low, both at the urban and suburban levels, especially if look at the active population (excluding school-goers). As many as 40% of the population would never consider using a city bus and more than three quarters of the population do not use suburban buses or trains.

The respondents who used public transport were relatively and consistently satisfied with the aspects of the service that are "human factor based" (staff), and much more dissatisfied with "objectively based" ones (speed, schedules, frequency, ticket price, accessibility). The city's actual modal split is thus largely determined by the government's transportation policy, which prioritised building motorways instead of developing public transport.

Consequently, the use of public transport is largely determined by a person's position in the social stratification scheme, and its most frequent users are older, retired people or younger people, students, and, in addition to these two groups, the unemployed and people with lower education levels (see illustrations 7 and 8). They are the ones who cannot individualise themselves symbolically and must use collective means of transport - instead of the individualised, private, and perceivably freer mode of travelling by car. The fact that public transport fees are an often hotly debated issue shows that we are indeed talking about economically peripheral groups of users when discussing the current use of public transport in the region.

While the gathered data make it hard to draw conclusions about the potential of public transport as an enabling factor, we support the claim that its sociability dimension plays a significant role in it use by seniors.

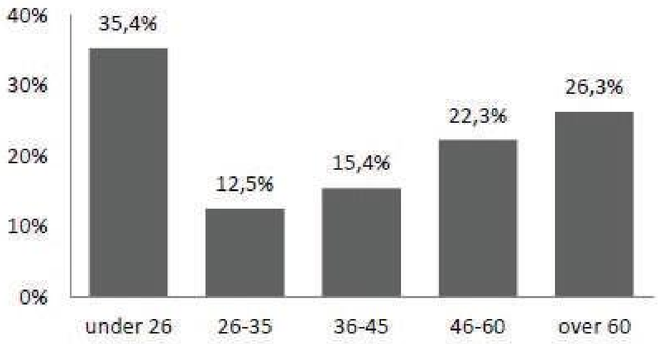


Illustration 7: Usage of public transport for work or school commuting, grouped by age. Source: Uršič et al., 2011.

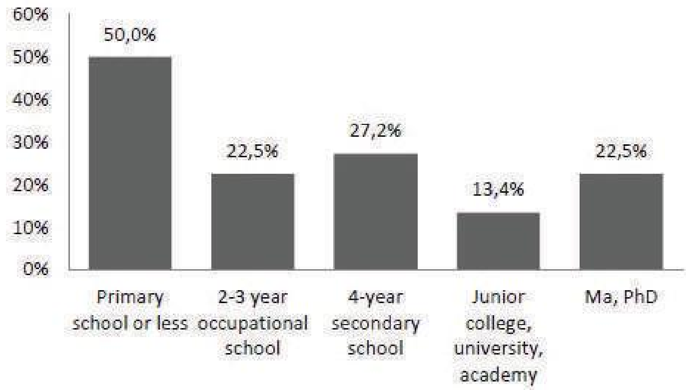


Illustration 8: Usage of public transport for work or school commuting, grouped by educational levels.
Source: Uršič et al., 2011.

- According to a number of surveys, traffic jams are always quoted first as the biggest problem in Ljubljana, followed closely by parking space issues. We may conclude that the urban configuration is not adapted to automobiles as the hugely dominant form of transport (see illustration 9).

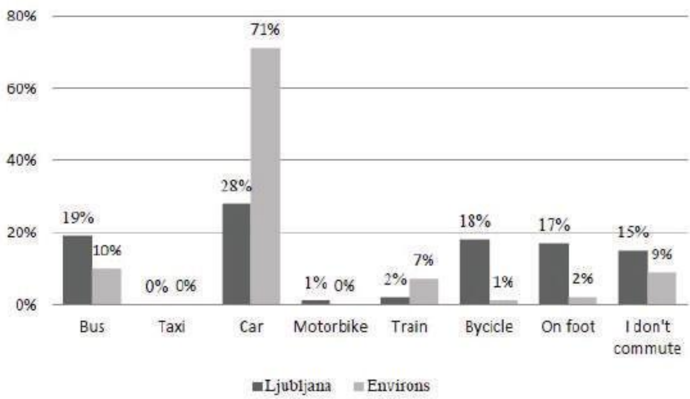


Illustration 9: The distribution of modes of transport for commuting to school or work.
Source: Uršič et al., 2011.

On the other hand, however, the data tells us that the average time spent on the move is actually relatively low (see illustration 10), especially when taking into account the distances the commuters from neighbouring towns – about half the respondents - have to cover. We may claim that Slovenia's specific sedentary culture affects our perception that the time consumption listed below is highly problematic.

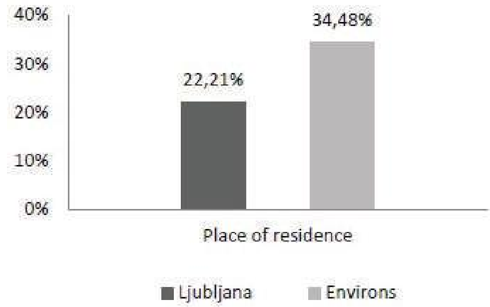


Illustration 10: Average time usage for one-way commuting to school or work.
Source: Uršič et al., 2011.

Automobile use functions as the core attitude and value orientation of mobility in Ljubljana and its wider regional hinterland. Although keeping a car is a considerable expense in almost any household, cars were owned by 88 % of respondents from the 2009 survey (85% in 2011) and they were – again at a considerable cost – more or less used by a single person per car for work or school related travels (see illustration 11). Further taking into account time management (since other means of transport can be cheaper and faster) and the relatively short distances the respondents had to cover, using a car is an increasingly irrational choice for many people, and as such must be rooted in hard to detect reasons.

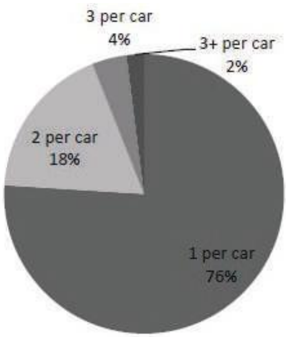


Illustration 11: Number of passengers by car when commuting to school or work.
Source: Uršič et al., 2011.

Respondents who used a car to drive to work or school dominated in the demographic groups of people between 25 to 45 years of age, and a slight majority of them were men; this corresponds with the stratification patterns established elsewhere.

- The presented "auto-mobility" paradigm is mirrored in the disregard of questions about environmental costs and sustainable traffic options. Certain discourses and themes have yet to become part of individual stances and public debates, and therefore have not been able to have an impact on mobility values, which still rest on speed, individualism, freedom from spatial constraints. We notice indifference towards collective agendas, rational and holistic consideration of one's personal well-being, income use, or other relevant contexts, and this may result from the relatively archaic patterns of the economy, lifestyles, and social networks of a considerable segment of the population.

In line with this, we also notice that the contemporary mobilities agenda is valued relatively higher by younger respondents, who live a less sedentary life with asymmetric rhythms of obligations and endorse more flexible means of transport, using different mobility modes, extending into the virtual world with the use of applications like, for instance, Google maps.

7 CONCLUSION

The article addresses contextual mobility, which is characterized by its focus on some important social aspects of travelling and people's movement in space in general, but in particular on the interconnections between mobility and sociability. Contextual mobility attempts to bring together different modern sociological and interdisciplinary concepts: the mobilities paradigm (Urry), the motility concept (Kaufmann) and the socio-spatial network theory (Castells). Mobility complexity is first explained through the interlacing instrumental and reflexive actions of individuals. The way people actually make use of the given mobility options, while taking account of objective limitations, is defined as their "network capital" and is part of the wider principle of "social capital". This is the individual's ability or competence level to create a mobility and social matrix of his own, based on his lifestyle or "philosophy of living“, and taking account of the objective circumstances. Lower and higher competence levels can also be understood in the sense that new forms of inequality are established in society, because mobility increasingly influences the life courses of individuals and groups. The article advances the thesis that the ordinary focus of travelling on spatial-temporal and cost budgets may explain merely the instrumental motives of mobility in the sense of "as fast and as cheap as possible", but not reflexive ones, which refer to the (e.g. environmental, social) value orientation of every individual in a given society. We established that people's reflexivity relates to the already asserted concept of "active travelling" (walking, cycling), which assumes either personal benefits (e.g. health benefits) or social benefits (environmental awareness). Someone may choose a longer or even more expensive route to his destination, e.g. from point A to Point B, if he considers the benefits contextually, as a component of social responsibility (e.g. environmental responsibility). But as we show in the article his decision on his travel mode or means of transport (e.g. train) may be connected with his wish to socialize or to spend time on different activities, e.g. work, reflecting, relaxing, or other activities. In these cases, reflexive mobility is not merely the domain of leisure travels, as is suggested by most literature on mobility, but it increasingly refers to daily, routinized movement in space and time. From the aspect of spatial planning, these movements should no longer be treated merely as instrumentally transitive, but as multi-purpose spaces, including social ones. Only then will such spaces be perceived and used as places. The article's conceptual sociological discourse is linked to the example of mobility patterns and travelling habits in Slovenia and it establishes the high importance of taking account of the specific value systems of individual societies, because these essentially influence the success or failure of mobility strategies. Within the CIVITAS ELAN project, major emphasis is given to civil engagement in mobility strategies and to mobility management; here, persistent specific values in people's mobility patterns (e.g. the extreme significance of automobility in Slovenia) play a key role in the dissemination of the project's measures and results to the inhabitants and traffic users. The article also briefly presents the challenges of mobility management at the strategic, tactical, and operational levels, and draws attention to a series of aspects that have to be taken into consideration.

In the light of the social values in Slovenia and other socio-spatial circumstances, including its dispersed settlement in small settlements, where most people live in individual houses, we examined the existing travelling habits of the inhabitants of the Ljubljana region. All these circumstances have a strong impact on people's travel habits and on the success/failure of implementing mobility strategies aimed at higher efficiency, inclusivity, and diversity of travelling modes. The data which formed the basis for our interpretation were partly acquired with public opinion surveys performed as part of the CIVITAS ELAN project, and partly stem from previous surveys and mobility patterns in the territory of Slovenia and especially in the Ljubljana region. One basic finding is that contextual mobility is not yet perceived as a mobility matrix in the Ljubljana region, and that is has not yet become part of the value patterns of the inhabitants. The role of cycling, for instance, has been increasing, but people continue to associate cycling mostly with efficiency (speed, cheapness), and quite less with health, socialising, environmental sustainability. Our analysis of the modes and frequency of using means of public (city and regional) transport show that one's lifestyle and consequently reflexive perception of contextual mobility is not significantly important to the users. The results reveal a classical stratification in the use of mobility modes, because public transport is often used by the lower classes, seniors, and the young, who do not have the option to use a car. Exceptions, suggesting at least in part a shift towards contextual mobility, are seniors who use their travels with public transport for socializing as well, and young people who attribute to cycling different, not exclusively transitive meanings. The findings of the empirical researches within the CIVITAS ELAN project and other researches reveal that automobility as a mobility mode remains deeply rooted in people's value system, where the individual freedom of mobility choices is perceived in a distinctly one-dimensional (instrumental) or traditionalist way. To understand contextual mobility it is essential that we differentiate between, on the one hand, the value systems of modern, progressive societies and communities, orientated toward combining people's individualised lifestyles with active participation in the long-term sustainability of social development and, on the other hand, the value systems of non-modern, regressive societies of atomised individuals. Mobility strategies and mobility management at the level of cities and regions cannot bear fruit unless the development paradigm of society as a whole changes radically, transforming society's value system. The mobility image of the Ljubljana region thus reflects its wider socio-spatial circumstances; the measures and activities of the CIVITAS ELAN project have, as we established, great mobilisation and demonstration importance for the reflexivity of the inhabitants; they in turn can influence change in the entire Slovene society with a changed perception of modern mobility principles.

REFERENCES

Anable, Jillian, Geertje Schuitema, Yusak Susilo, Paulus Aditjandra, Mark Beecroft and John Nelson. 2010. Walking, Cycling and socio-economic status in *Scotland: Analysis of statistical data and rapid review of the literature*. Edinburgh: NHS Health Scotland.

Canzler, Weert, Vincent Kaufmann and Sven Kesselring (eds.). 2008. *Tracing Mobilities. Towards a cosmopolitan perspective in mobility research*. Ashgate: Aldershot.

Carrasco, Juan Antonio and Eric J. Miller. 2006. Exploring the propensity to perform social activities: A social network approach. *Transportation* 33(5): 463–480.

Castells, Manuel. 1996. *The Rise of the Network Society. The Information Age: Economy, Society and Culture Vol. I.* Cambridge, MA: Oxford, Blackwell.

Elliott, Anthony and John Urry. 2010. *Mobile Lives*. London: Routledge.

Maksim, Hanja. 2012. Car-euphoria to Opening of the Borders: Trajectory and Coordination of Transport and Urban Planning Policy. *European Journal of Transport and Infrastructure Research* 12(2): 211–225.

Flamm, Michael and Vincent Kaufmann. 2006. Operationalizing the Concept of Motility: A Qualitative Study. *Mobilities* 1(2): 167–189.

Hočevar, Marjan. 2012. Dispersed settlement in detached houses: Attitudes over the residential space consumption in Slovenia. Sociologija 54(1): 123–152.

Hočevar, Marjan. 2004. Vrednote v prostoru: javnomnenjska raziskava. (Values in space: public opinion research). In *Prostor Slovenije 2020 – Zbirka raziskav s področja prostorskega načrtovanja*, ed.

Ministrstvo za okolje in prostor, 1–48. Ljubljana: MOP.

Jain, Juliet. 2006. Bypassing and WAPing: Reconfiguring Timetables for Real time mobility. In *Mobile Technologies of the City*, eds. Mimi Sheller and John Urry, 79–101. London: Routledge.

Kaufmann Vincent, Manfred Max Bergman and Dominique Joye. 2004. Motility: Mobility as capital. *International Journal of Urban and Regional Research* 28(4): 745–756.

Kaufmann, Vincent. 2002. *Re-thinking mobility: contemporary sociology*. Aldershot: Ashgate.

Larsen, Jonas, John Urry and Kay Axhausen. 2006. *Social networks and future mobilities. Report to the Horizons Programme of the UK Department for Transport*. Lancaster: The University of Lancaster, Department of Sociology and University of Lancaster and Zürich: Institut Für Verkersplanung und Transportsysteme and Eidgenössische Technische Hochschule.

Law, John. 2006. Disaster in agriculture: or foot and mouth mobilities. *Environment and Planning* A 38(2): 227–239.

Lyons, Glenn, Juliet Jain and David Holley. (n.d.) The use of travel time by rail passengers in Great Britain. Under revision for publication in *Transportation Research A: Policy and Practice*. Available at http://www.bne.uwe.ac.uk/traveltimeuse/downloads/lyonsjainholley_useoftraveltime.pdf, 17.10.2012.

Manderscheid, Katharina. 2009. Integrating Space and Mobilities into the Analysis of Social Inequality. *Distinktion* 18: 7–27.

Ohnmacht, Timo, Hanja Maksim and Manfred Max Bergman (eds.). 2009. *Mobilities and inequality*. Surrey: Ashgate Publishing Limited.

Ohnmacht, Timo, Hanja Maksim and Manfred Max Bergman. 2009. Mobilities and Inequality – Making Connections. In *Mobilities and Inequality*, eds. Timo Ohnmacht, Hanja Maxim and Manfred Max Bergman, 7–26. Surrey, Ashgate Publishing Limited.

Rebernik, Dejan. 2007. Trajnostni prostorski razvoj in novejši procesi v prostorskem razvoju Ljubljane (Sustainable Spatial

Development and new Trends in Urban Development in Ljubljana), *Dela* 27: 17–38.

Scheiner, Joachim and Birgit Kasper, 2003. Lifestyles, choice of housing location and daily mobility: the lifestyle approach in the context of spatial mobility and planning. *International Social Science Journal* 55(176): 319–332.

Sheller, Mimi and John Urry. 2006. The new mobilities paradigm. *Environment and Planning* A 38(2): 207–226.

Urry, John. 2007. *Mobilities*. Cambridge: Polity Press.

Uršič, Matjaž and Marjan Hočevar. 2007. *Protiurbanost kot način življenja*. (Anti-urbanism as a Way ofLife). Ljubljana: Faculty of Social Sciences.

Uršič, Matjaž, Simona Zavratnik, Franc Trček, Drago Kos, Marjan Hočevar and Anže Zorman. 2009. *Koncno poročilo o rezultatih 1. dela javnomnenjske raziskave: Spreminjanje ureditve javnega prometa v Ljubljani in ljubljanski regiji.* Ljubljana, Fakulteta za družbene vede.

Uršič, Matjaž, Simona Zavratnik, Drago Kos, Marjan Hočevar, Franc Trček and Anže Zorman. 2011. *Javnomnenjska raziskava o možnostih izboljšanja prometne ureditve v Ljubljani – analiza percepcije zgoščevalne takse*. Ljubljana, Fakulteta za družbene vede, Center za prostorsko sociologijo.

LJUBLJANA | Several riverbanks of the Ljubljanica have been renovated in the past few years.

LJUBLJANA I The city aims to reduce motorised traffic in the streets. Many areas have recently been turned into pedestrian zones.

LJUBLJANA I Two free-of-charge Kavalir electric vehicles operate in the pedestrian zones, based on a call-on-demand system, and their popularity is growing.

PUBLIC PERCEPTION OF CHANGES IN LJUBLJANA'S TRANSPORT AND MOBILITY SYSTEM - IDENTIFYING KEY THEMES, BARRIERS AND RELEVANT STAKEHOLDERS

Matjaž Uršič

1 INTRODUCTION - THE ROLE OF PUBLIC OPINION SURVEYS IN PLANNING TRANSPORT AND MOBILITY SYSTEMS

Planning transport and mobility systems is all too often regarded as a merely 'technical' undertaking that positions adequate systems and infrastructures, whose functions are determined on the basis of accurate measurements and instruments. Is it assumed in advance that spatial planning will follow in detail the procedures and selected objectives of urban policies, limiting negative spatial processes and favouring such that will work to the benefit of the entire community. However, only in very rare situations can spatial problems actually be solved with merely 'technical' or formalized measures; much more often, what is required is to connect population groups with planning practices that yield more 'informed decisions' on interventions into space. Placing transport infrastructure in an urban area is a very sensitive undertaking in terms of social and cultural values, and requires a great deal of qualitative data and long processes of coordination between different groups of stakeholders. Planning the mobility and transport system is in this context perceived as a form of consultation or interactive management, where the objective is to harmonize the interests of the different (political, class, ethnic, cultural, capital) socio-economic groups that are present in a given space (Healey, 2003; Wilson, 2006). These groups may have conflicting interests and differ not only in regard to aims and expectations but also according to the acceptance level, which may be translated into group power, i.e. influence when it comes to the decisions about interventions in space. Because of the sensitivity of organizing transport, spatial planners are to adapt as much as possible to multiple aims, expectations, acceptance levels and needs of different groups or users, while simultaneously adhering to the formal procedures and selected objectives of urban policies aimed at limiting harmful and favouring useful spatial processes that will benefit the entire community.

Public opinion surveys as a consultative mechanism can constitute an important instrument for ensuring a higher degree of inclusivity of the public in joint planning of mobility and determining transport development priorities. By identifying the interests, needs, expectations, power relations between various groups of stakeholders, public opinion surveys can give orientations on how to prepare the processes of planning for transport solutions and give voice to deprivileged groups, i.e. assure sufficient participation of different users / the public. Despite the fact that the information gathered by public opinion surveys indicates a range of clear opinions and attitudes to the ways of organizing transport, they also reveal certain seemingly paradoxical situations, where the respondents both accept and reject certain transport development orientations. One of these seemingly paradoxical situations, registered in the public opinion surveys carried out for the needs of the CIVITAS ELAN project, is the high professed support for measures related to sustainable mobility and transport development, combined with the simultaneous rejection of the implementation of these measures at the practical level, i.e. in attempts which try to transfer sustainable transport practices into the population's everyday life.

The article presents in which way and, especially, why public opinion surveys on the theme of organizing mobility and transport in Ljubljana region often reveal apparent discrepancies in the attitudes of respondents when considering desirable changes to the transport system and mobility practices. We must however emphasize that in the case of professed support that is combined with simultaneous rejection of the practical implementation of sustainable mobility and transport solutions, the discrepancies in the respondents' answers are not surprising. The opinions of respondents are contradictory only at a first glance and can be explained with socio-theoretical concepts, like for instance professed (vs actual) opinions or so-called "passive activism" (Gladwell, 2010; 2011).

In the case of people's professed opinions or passive activism, what we see is apparent social engagement that is not realised in practice. It is a form of support to certain trends that is 'based on words but not on actions'. Similarly, elements of self-organisation and self-action, which are often connected with the activism of civil social movements, are absent in this case, and people's expectations about the successful implementation of changes in the environment are low. From passive activism 'not much is expected', because it is based merely on the professed wish to change the conditions in the environment. In this context we can delimit passive activism from activism on the basis of the principle which points put that 'wishing' to change something is different from 'wanting' to change it and becoming actively engaged in the processes of changing one's local environment. This difference in the degree of social engagement is well illustrated by public opinion surveys when they reveal specific value orientations, ideas, concepts that are not always in harmony with the respondents' actual expectations. It is often difficult to figure out how strongly someone really wants changes in his or her environment; for a variety of reasons (distrust, wishing anonymity, self-satisfaction, local conditions, etc.) respondents will voice only part of their actual opinions or orientations about a given theme.

In a more detailed explanation of professed opinions in selected surveys we will draw on individual cost and benefit analyse regarding the usage of various transport modes. In the context of Slovenia, we will show which elements and mobility features constitute the key factors for favouring the most frequent means of transport – cars. Last but not least, the findings deriving from the analysis of professed opinions in public opinion surveys about mobility and transport issues attempt to reveal not only possible barriers and potential conflicts in the implementation of the principles of sustainable transport systems, but also provide guidelines for solving these issues and suggest which instruments and mechanisms would be worth using among the population of Ljubljana and the Ljubljana region.

2 PROFESSED SUPPORT FOR SUSTAINABLE MOBILITY MEASURES IN THE CITY

In public opinion surveys respondents sometimes express opinions about an issue or attribute major importance to sustainable development themes that are in conflict with their responses at the practical level. During the attempts to translate expressed attitudes into practice substantial modifications and changes occur, indicating that their actual decisions are influenced by hidden factors, veiled ideas, and tacit information, which they do not reveal publicly or explicitly.

These cases reveal the differences between expressing apparent, professed support and the actual, legitimating power of decisions, which would lead to changes in mobility and transport systems. Why are people not willing to accept (legitimate) practical measures that would lead to a more sustainable transport system in spite of their professed support for these measures at the general, conceptual level? To understand the issue, it is essential to correctly define the differences between the categories of 'professed' and 'legitimating' statements, which are often confused or even erroneously linked in public opinion analyses. Although it appears that high professed support for sustainable transport development facilitates the implementation of practical measures, it soon becomes clear that this is not a sufficient condition for their implementation in the field. If professed arguments would suffice to implement more sustainable transport solutions, there would be no conflicts in spatial planning nor stagnation in implementing such solutions.

The reactions and opposition of different social groups to interventions into space suggest that many decisions, taken at the level of professed opinions about interventions into space, cannot be implemented due to the low level of legitimacy, feeble support, or overt/covert opposition from important stakeholders (local stakeholders, opinion leaders, interest groups) in specific urban areas.[1] In these events "it is quite clear that the lack of legitimacy does not abolish nor reduce the project's legality" (Kos, 2002: 22–25), but only prevents the adoption or implementation of certain professed decisions. Seen from this angle, it is possible that individual professed decisions on more sustainable mobility and transport solutions in Ljubljana may be correct and that their implementation would contribute to better development and a higher quality of life in the area, but their realisation is blocked by a specific, informal socio-cultural system that is not willing to change traditional, routine patterns of living, based on preferring transport by car. In this constellation of social conditions, every little change towards developing more sustainable forms of transport is perceived as an illegitimate measure or potential danger that will cause unpredictable consequences for the local community.

1 The differences between professed acceptance of and legitimating interventions into space are most evident in the NIMBY syndrome, where locating certain social, economic or cultural activities in a given area triggers strong opposition from the local community (e.g. locating waste dumps, rehabilitation centres for drug addicts, mosques, etc.). In these cases, the "civil sphere" prevents the implementation of formal, systemic spatial decisions: they are given only professed support, not the required legitimacy for physical implementation (see more in Kos, 2002).

2.1 THE PROBLEMS OF IMPLEMENTING MEASURES FOR A SUSTAINABLE MOBILITY AND TRANSPORT SYSTEM IN LJUBLJANA AND THE LJUBLJANA REGION – EXAMPLES FROM THE PUBLIC OPINION SURVEYS IN THE CIVITAS ELAN PROJECT

The respondents in the surveys on the subject of mobility and transport, carried out as part of the CIVITAS ELAN project (2008, 2009, 2011) are seemingly strongly in favour of more ecological and sustainable patterns of mobility (Table 1), which would reduce the use of cars. They positively judge and support most of the measures of sustainable mobility and transport solutions, which would be executed as part of the CIVITAS ELAN project (Table 2) and which they consider to improve Ljubljana's transport system. In this context, the data indicate[2] that the respondents are aware of the mobility and transport problems in Ljubljana and are thus in favour of certain changes to alleviate the present condition.

	I totally disagree	I disagree	I neither agree nor disagree	I agree	I totally agree
1. In transport solutions efficiency must have priority over environment protection	24.6	37.9	19.2	13.0	5.3
2. Bicycles and public transport must have priority over other means of transport	1.4	6.6	13.9	40.1	38.0
3. A transition from cars to public transport would reduce the traffic burden in the city centre	0.9	2.2	8.2	47.4	41.4
4. The construction of new lines of public transport is too costly, it would be better to use the funds for new parking lots	21.5	32.4	28.4	13.4	4.3
5. Employers should encourage their employees to use public transport with financial incentives.	2.3	6.9	14.8	42.1	33.9

Table 1: Please state to what extent you agree/disagree with the following statements. Source: Civitas Ljubljana, 2009.

2 The survey was carried out on a sample of 1069 persons (N=1069) living in Ljubljana or the Ljubljana region.

	I totally oppose	I don't support	I neither support nor oppose	I support	I strongly support
1. Construction of additional P&R (Park & Ride) facilities	0.8	2.9	13.0	40.9	42.3
2. Introduction of Car Sharing	4.7	17.7	36.4	29.2	11.9
3. Introduction of Car pooling	4.2	15.9	34.9	30.8	14.2
4. Introduction of vignettes for entering the city centre	21.6	29.4	18.3	19.4	11.3
5. Introduction of payable access to the city centre by car (Congestion Charging)	22.8	31.2	18.9	17.2	9.9
6. Introduction of universal tickets for trains and buses	2.4	5.6	14.8	41.0	36.2
7. Additional reduction of traffic speed in certain zones (e.g. to 30 km/hr)	7.3	17.3	25.6	33.3	16.5
8. Introduction of a system of one-way roads in the city centre	5.6	18.8	29.9	32.3	13.5
9. Introduction of traffic obstacles (road bumps)	11.7	22.6	25.9	29.5	10.3
10. Introduction of a special "yellow lane" for public transport	1.0	4.9	11.7	41.6	40.8
11. Introduction of non-stop public transport (24 hrs/day).	0.9	5.0	20.0	38.8	35.3
12. Electronic information displays showing the time of arrival of buses at the bus stops	1.1	3.8	14.8	41.4	38.9
13. Environment-friendly buses (hybrid vehicles, electric vehicles)	0.5	1.3	7.0	31.1	60.1

Table 2: Which measures would you support/oppose in Ljubljana?
Source: Civitas Ljubljana, 2009.

In favouring changes to Ljubljana's transport system the respondents were rather unselective and generally supported most of the measures proposed by the CIVITAS ELAN project. Unselective or general support for measures related to sustainable transport mobility suggests that the respondents maybe wish a different transport system, but at the same time their answers reflect that the level of conformity offered by car transport prevails over the wishes to implement the changes in practice. We must mention here that unselective or professed support for measures related to sustainable transport system is most pronounced with the more 'gentle' measures, including improvements of public transport, the construction of P&R (Park and Ride) facilities and the introduction of car-sharing and car-pooling systems. Much less support or even opposition is drawn for concrete or 'hard', restrictive measures, like a "congestion charging fee", which means the introduction of various forms of payment (vignettes, tickets, road tolls) for accessing the city centre by car.

The absence of clear opinions, ideas or orientation points, which would form the basis for the respondents to better differentiate between the effects, role, temporal feasibility and suitability of the introduction of sustainable mobility and transport solutions in Ljubljana indicates that the respondents wish changes in the transport arrangement. Nevertheless, the even bigger question is at what cost are they actually willing to accept transport measures that interfere with their daily routines. How substantial is the legitimating support for measures related to change in the mobility and transport system is revealed by the so-called 'control questions', which refer to the transfer of proposed mobility and transport solutions into practice. The control questions reveal that the majority of users are not willing to incur additional financial burdens (e.g. questions 4 and 5 in table 2), and are even willing to tolerate a higher degree of negative impacts from the increased use of cars (Table 3).

	I totally disagree	I disagree	I neither agree not disagree	I agree	I totally agree
1. I'd rather pay for access to the city centre than stop driving there	33,1	30,9	21,4	11,6	2,9
2. Crowds and noise are inherent to life in city centres	13,9	26,6	20,7	31,4	7,6
3. The city's existing four-lane access roads should be widened into six-lane roads	11,6	19,7	28,3	24,9	15,5
4. The existing transport conditions in Ljubljana make me consider to move out of the city	37,9	30,9	18,9	8,4	3,9

Table 3: Please state to what extent you agree or disagree with the following statements. Source: Civitas Ljubljana, 2009.

When answering control questions, which queried the respondents about concrete measures that would reduce car dependence, a majority favoured changes that would cause as little as possible economic costs and consequently even increase car traffic flows. The respondents particularly rejected measures involving increased payment for car traffic in the city centre, even though this might in the long-term bring about certain positive effects for the quality of life (less air pollution, less noise, etc.). Although in principle supportive of other measures to reduce car traffic flows in the city (e.g. reduction of the speed limit to 30 km/h), the respondents categorically rejected all measures that would mean a higher financial burden to them. At this point, it should be taken into account that the reasons why respondents chose such pattern of answers may be divided into two groups. First, the reluctance of citizens toward the practical implementation of more sustainable transport solutions could be explained as a lack of convincing alternatives. In other words – the use of very concrete 'sticks' (e.g. reducing the number of driving lanes, congestion charging fee) prevails in comparison to relatively uncertain 'carrots' (e.g. excellent public transport and accompanying services) that should offer reciprocal solutions to the comfort, travel time and economic benefits provided by cars. Secondly, the resistance of citizens against the implementation of a more efficient and sustainable transport system may be explained by the anticipated reluctance toward any attempts that try to change the daily routine of everyday life and would disrupt the existent socio-cultural relations. Strong beliefs in the benefits of the use of cars are inherently connected to specific value orientations and rooted into the wider cultural system and process of socialisation (Urry, 1999). In this sense, we may add that the categorical rejection of measures involving increased economic costs for transport users is a strongly present element also in other public opinion surveys (e.g. Hočevar, 2004). Such inclination toward rejecting any additional transport cost is particularly indicative for the respondents with a strong materialist value orientation[3], not only in the area of Ljubljana and the Ljubljana region, but in Slovenia as a whole.

3 In his analyses of values in European countries, Inglehart (1997) mentions that in some East-European countries a shift is noticeable towards "post-materialist" values (typically, these values put a higher emphasis on features like self-expressiveness, the quality of living, and social affiliation), but "materialist" value orientations (based on features like the value of goods, survival and individuality) continue to dominate.

The respondents' answers draw attention to a deep-rooted "car culture"[4] and a value system and lifestyles that strongly depend on the use of cars. Besides fearing 'money sanctions', the severe dependence on cars as the principal means of transport is a crucial reason for the phenomenon of passive activism and the low level of willingness to accept the introduction of more sustainable mobility and transport solutions in Ljubljana. Take for instance the question "What annoys you most about the traffic in Ljubljana?" where most respondents mention problems related to providing smooth traffic flow (congestion, crowded roads, and the lack of parking lots) (Table 4). Another element worth noticing is that over 40% of respondents adapt their daily activities and spatial-temporal rhythms or daily routines to using a car, while 15% of respondents would stop travelling in the city if the use of cars were to be limited.

Rang	Traffic annoyances	%
1	Congestions, crowded roads	63.6
2	Lack of parking lots	45.9
3	Dangerous driving by other transport users	28.0
4	Poorly laid-out cycle lanes	26.1
5	Inefficient public transport	22.3
6	Air pollution	21.3
7	Excessive parking rates	20.4
8	Infrequent bus schedule	17.5
9	Excessive public transport fees	16.4
10	Noise	9.8
11	Poorly connected city bus lines	9.6
12	Poorly adapted public transport for the disabled	8.7

4 Urry (1999: 1) refers to the Western civil societies as "societies of automobility" because of their dependence on cars; the increasing degree of automobilization is indeed closely linked with the origin of social patterns of behaviours that are based on automobility. Automobility changes our perception of spatial-temporal dimensions and enables the emergence of new social spaces, which builds up the flows of people on certain roads and motorways.

13	The way irregular parking is fined	7.8
14	Too high fines for motorists	5.6
15	Poor traffic conditions for pedestrians	4.9
16	Too low fines for motorists	3.1

Table 4: What annoys you most about the traffic in Ljubljana?
Source: Civitas Ljubljana, 2009.

How strongly the use of cars is rooted among the respondents is among others indicated by cross-examining the answers to the questions about the introduction of vignettes and other money fees for entering the city centre with the answers of different groups of respondents, including both car users and public transport users (Table 5).

	I totally oppose	I oppose	I neither support not oppose	I support	I strongly support
Group of car users	25.6%	34.6%	15.9%	17.0%	6.9%
Other groups:					
1. Bicycle	17.7%	30.2%	19.8%	18.8%	13.5%
2. Bus	20.8%	28.7%	27.7%	11.9%	10.9%
3. Train	5.9%	47.1%	17.6%	11.8%	17.6%
4. I walk	26.1%	31.1%	16.0%	16.0%	10.9%
5. I equally use two or more means of transport	34.2%	20.5%	19.2%	13.7%	12.3%

Table 5: Support for the introduction of charges for access to the city centre by car - by groups of respondents.
Source: Civitas Ljubljana, 2009.

The analysis of the answers to the question about the introduction of vignettes or charges for access to the city centre shows that there are no major differences between the groups of respondents which use or do not use a car for travelling to work (school). Car users were somewhat more opposed to paying any charge for access to the city centre, but even among the groups that do not use car, the level of rejection of such measures was quite high. The high shares of rejection of money costs connected with using a car in the city centre among other groups can be explained either by a low level of information, the lack of information about the long-term effects of car transport on the living environment, or by the occasional use of a car by these groups. Though they do not use a car for travelling to work (school), many respondents occasionally use a car or use it for specific activities and reject money sanctions for this use.

2.2 PROFESSED ATTITUDES AS THE RESULT OF INDIVIDUAL COST AND BENEFIT ANALYSES BY CAR USERS

What attitude people adopt towards traffic changes likely to influence their living environment largely depends on the information they gather from different information networks. In addition to the information they receive from the media, experts, and other reference groups, other important information sources are undoubtedly the individual's own experiences or previous knowledge for processing the information from his environment. When considering which would be the most appropriate means of transport in a specific local context, individuals make up their own scale of priorities and adhere to it in the process of decision-making. They draw on their own cost and benefit analysis and decide to circumvent, sabotage, or openly oppose changes to their mobility patterns when and if they consider that unconditional acceptance of the novelties would cause them too high or unnecessary costs.

A cost and benefit analysis is based on elimination (tapering off) or, in our case, selecting the most adequate traffic infrastructure (service provision) that is available for daily travels to work, school, shops etc. Users thoroughly evaluate all possible features of the infrastructure that may bring them either benefits or loss. The benefits of using a specific infrastructure (service) taper off in line with increasing costs, measured in terms of time used, input of physical effort, (psychological) emotional reasons, or money spent.[5] The higher the

5 The scheme of cost calculation is not defined on a strictly rational basis but is formulated according to individuals' internal perception of the costs, i.e. his/her personality. In other words, what may for some individuals represent a huge cost, may be a benefit for other individuals. At the general level, some activities, e.g. the 'duration of daily commuting to and from work', 'daily waiting for transport' are perceived by a majority of people as costs. Some aspects of a cost-benefit analysis cannot be measured or it is impossible to define their exact influence on individuals, because they are related to intrinsic socio-cultural characteristics (e.g. tradition, social pressure, cultural patterns).

costs, the lower the benefit and this increases the possibility that the individual will choose another, more favourable infrastructure for his daily activities. Where the individual goes beyond the point of balance between benefits and loss, his costs continue to increase, and the balance point is therefore the ultimate moment for 'sobering up', i.e. the moment when the individual becomes aware that there are alternative and financially more favourable options of using means of transport. Any further investment of time, effort, or money would be pointless in view of the individual's subjective cost and benefit analysis. After going beyond the point of balance, when the costs prevail over the profit or benefits, the individual finds himself in an area of so-called "structural constraint" (Giddens, 1984) and chooses a different way of acting or decides to either circumvent, sabotage, or openly oppose changes or, as in our case, to opt for other means of transport for his daily activities. Structural constraint is a mild form of coercion in which individuals are not explicitly (by law) sanctioned if they choose to further ignore their own cost scheme. The individual acts within an environment that offers him different options to satisfy certain needs, but he always chooses or is gently coerced to choose the option which he thinks will bring him most individual benefits (Table 6).

Material constraint	(Negative) constraint	Structural constraint
Constraint deriving from the character of the material world and from the physical qualities of the body	Constraint deriving from punitive responses on the part of some agents toward others	Constraint deriving from the contextuality of action, i.e., from the 'given' character of structural properties vis-à-vis situated actors

Table 6: Three types of constraint which potentially limit an individual's behaviour. Source: Giddens, Anthony, 1984.

The concept of an individual's cost and benefit analysis is an important mechanism that explains apparently impractical or irrational behaviour. For example, in the context of Ljubljana and the Ljubljana region, where cars are the daily, i.e. most frequently used means of transport. From the viewpoint of sustainable mobility and transport development (e.g. air pollution, the problems of using up space for parking lots, the construction of additional roads in the city centre, traffic congestion, etc.), as well as in the long-term perspective, this may be irrational behaviour, but from the viewpoint of the average user's individual short-term cost and benefit analysis, it is quite rational and justified, because using his car means lower costs (in time, money, and effort) than using other means of transport, making it his most favourable means of transport. An individual's cost and benefit analysis works in two directions and to the wider community it brings either positive or negative consequences. On the one hand, the individual may establish that a certain kind of behaviour causes him loss in the sense of costs, but that the wider community as a whole will benefit from his behaviour and recognize the "altruistic surplus" (Faulkner and Tideswell, 1997) he sacrifices for the well-being of the community. On the other hand, there are situations where individual motivations direct people towards behaviour that is detrimental to the wider community. For instance, in the case of attempts to meet long-term objectives of transport policies, where the immediate effects of people's altruistic surplus are not immediately recognized by the wider community. This may lead to a so-called "people's tragedy", which Hardin (1968) describes as an autodestructive scenario. A good example are attempts to reduce the use of cars and consequently decrease the emission of greenhouse gases. In this case the change in a single individual's behaviour, i.e. when he stops using his car and opts for alternative options (bicycle, bus, train), does not yield any immediate benefits to the wider community; but at the same time the individual, who opts for altruistic behaviour, incurs higher costs in time, effort, and money. The result is that the scenario of altruistic surplus is abandoned, opening the way for the autodestructive scenario that leads to the exhaustion of common resources and gradual or long-term deterioration of the quality of life for the wider community and individuals.

It must be mentioned here that the concept of an individual's cost and benefit analysis may include, beside spatial or physical features, also various characteristics of the social environment. Other important characteristics in this context are social pressure, the demand to conform to cultural patterns, people's trust in institutions, and the options different groups of stakeholders have to be included in the planning process of mobility and transport solutions. In the formation of strategies for including users in planning mobility and transport solutions a basic dilemma often emerges, where the institutional structures must consider to what degree it is meaningful to include the users or the public in the planning procedures without endangering the objectives of transport planning. Arnstein's classification (1969) of the power relationships between the authorities or formalized systems and the users shows the variety of forms of (non-)cooperation between the actors in the process of spatial planning (Illustration 1).

8	Citizen control	Degrees of citizen power
7	Delegated power	Degrees of citizen power
6	Partnership	Degrees of citizen power
5	Placation	Degrees of tokenism
4	Consultation	Degrees of tokenism
3	Informing	Degrees of tokenism
2	Therapy	Non participation
1	Manipulation	Non participation

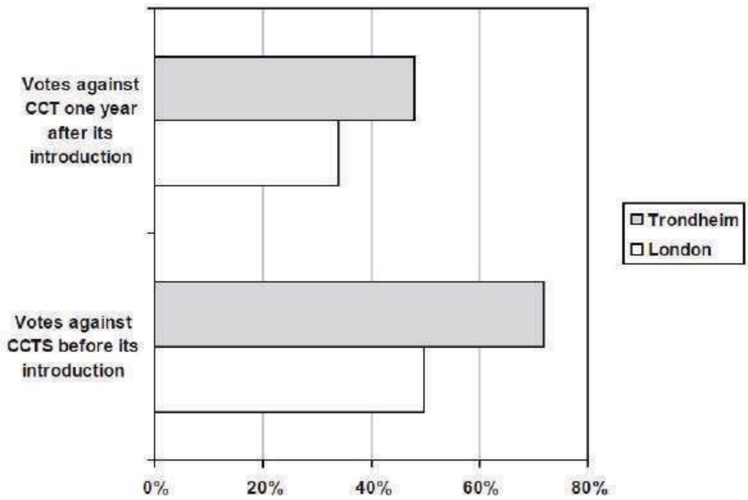
Illustration 1: Arnstein's ladder of user participation in spatial planning.
Source: Arnstein, Sherry, 1969.

The ladder of user participation in spatial planning is divided into eight degrees (rungs of the ladder) that can be divided into three wider categories. The first category is that of low citizen power or non-participation and includes the two lowest rungs on the ladder. The category of non-participation provides the users only with an illusion of power in the planning processes, because the levers of decision-making always remain firmly with the political and economic actors. The second category, that of symbolic power (tokenism), is based on a one-way strategy of informing the users in a 'top down' approach, using various techniques of informing, advising, negotiating with the users. The third category is the only one that grants the users full participation and ensures two-way communication between the actors, allowing also 'bottom up' influences in the different phases of spatial planning. The essential question then is how to coordinate the planning processes of traffic solutions to make sure that there is as little as possible tension between the producers, planners, authorities and users-consumers. If no suitable connections are established between the stakeholders and the formal system of spatial planning, this may lead to the autodestructive scenario, where individuals as part of their own cost and benefit analyses include the costs of reduced inclusion in the transport planning process, and this consequently reduces the options to change transport or mobility habits.

Taking into consideration people's cost and benefit analyses explains why respondents sometimes strongly voice professed opinions, which they perhaps hold at the principle level and consider being in harmony with their view of life and self-image. But their individual cost and benefit analysis, which they face at the practical level – as participants, users of traffic solutions that are being implemented – reveals their lack of actual willingness to change their mobility pattern in everyday life. This stage often reveals that they merely engage in passive activism, and that their professed opinions have no 'real substance' or have not sufficient legitimating potential, which would enable the physical implementation of changes in the real environment. People's personal analysis of the short-term costs and benefits deriving from envisaged changes to their daily living routines prevents car users from immediately accepting measures related to the development of more sustainable mobility and traffic solutions.

3 OVERCOMING PASSIVE ACTIVISM

The results from the public opinion surveys of the CIVITAS ELAN project show that deep-rooted automobility leads to the emergence of passive activism, which then blocks faster implementation of more sustainable transport solutions in Ljubljana and the Ljubljana region. This opens up the question in what ways it may be possible to overcome passive activism and facilitate the introduction of measures connected with sustainable transport solutions. Foreign examples of the introduction of a congestion charge show that in certain environments, where professed support for sustainable mobility and transport measures exists, it is possible to introduce, i.e. practically implement such measures in spite of the negative public opinion at the start of the implementation process. In spite of the high unpopularity and open opposition to the introduction of practical measures, which would reduce the car traffic burden in the city centre, the data show that the unpopularity of these measures dropped within a relative short period of time after their introduction (Graph 1).



Graph 1: Comparison of public opinion support before and after the introduction of a congestion charging fee (CCT) in London and Trondheim.
Sources: Trondheim Toll Scheme, 2011 and Transport for London, Congestion Charging, 2011.

Kos (2002: 30) explains that spatial planners present themselves largely as "spatial experts", even though in accordance with the above definition of spatial planning they should be "experts on space AND time". The physical nature of space is all too often pushed into the forefront, while the non-physical categories, related to time and social behaviour, are relegated to the background; their importance only emerges when "unexpected" events occur, upsetting the initially conceived plan of interventions into space. In the case of implementation of measures related to congestion charging in selected cities, we can confirm that a segment of the population that was initially opposed to them – because of the increased money burden in their individual cost and benefit analyses – was over a certain period indeed capable to recognize the long-term positive aspects and benefits of the new measures connected with more sustainable transport system.

In London, the congestion charging scheme was introduced by the mayor as part of his winning election programme and in spite of the initial opposition of most respondents. Similarly, Stockholm introduced a congestion fee after an initial trial period that was immediately followed by a referendum on the justification of the measure. Trondheim introduced its congestion fee with the aim of acquiring funds for the construction of urgently required bypass roads for the transit traffic passing through the city centre. In spite of the initial strong opposition, one year after its introduction the measure had gained major support as people recognized the advantages of the reduced car traffic burden on the city, and the share of respondents who opposed the introduction fell below 50 %. It has to be noted that in comparison to Ljubljana both London and Stockholm have excellent public transport networks. In spite of their different contextual characteristics the selected cities faced similar dilemmas when trying to implement specific sustainable mobility programs, indicating their sensitive nature and possible shifts in the public opinion's inclination.

During the process of spatial planning for mobility and transport solutions we must make sure that the interests of different (social, economic, political) groups are roughly equally represented, since incorrect distribution of the costs among the members of a single group would lead to conflicts and open opposition to the introduction of more sustainable transport solutions. Moreover, the process of spatial planning should include a component of long-term planning and "identify the externalities" (Tietenberg, 1994: 36), i.e. attempt to establish where problems and obstacles are likely to arise after a certain period. Furthermore, the findings based on experiences with the introduction of measures like a congestion charging fee in various European cities show that for the inhabitants to recognize the positive effects of initially unpopular measures, it is of extreme importance whether the implementers (spatial/transport planners, responsible institutions, economic/political representatives) provide them with sufficient information about the positive and negative effects of changes transport systems. This information must include a comprehensive approach to mobility and transport problems, which do not affect just local communities, but the quality of life in an entire urban region[6]. Only when the negative effects of 'car dependence' are identified by the majority of the population, greater support will follow for initially unpopular measures, which may at first increase the burden in the individual's cost and benefit analysis, but in the long term contribute to a higher quality of life for all population groups. The most illustrative example of the negative impact of car traffic on cities – which is simultaneously environmentally damaging – is an excessive

6 This involves both a higher level of inclusivity and participation of the inhabitants and traffic users in planning new sustainable transport solutions, as well as an illustrative presentation of the effects and consequences of the changes the new traffic system will bring about at different levels of everyday life.

level of pollution, which can affect all population groups. In Milan, for instance, the ECOPASS system (restricted access of cars to the city) was introduced when the level of pollution exceeded critical pollution levels for a longer period and a state of emergency was declared, including a stop to all motorised transport for several days (in the winter of 2005). What should be mentioned here is that a preventive presentation of the positive effects of introducing measures for a sustainable transport system, as was the case in Trondheim, can be equally efficient as the physical presentation of the negative or coercive effects, which by the way of threatening people's health trigger the implementation of adequate sustainable transport measures.

4 CONCLUSIONS – THE TRANSITION FROM PROFESSED ATTITUDES TO ACTIVE PARTICIPATION IN SOLVING MOBILITY AND TRANSPORT PROBLEMS

The analysis of data from the public opinion surveys from the CIVITAS ELAN project show how complex the mechanism of an individual's cost and benefit analysis is in the context of mobility and transport in Ljubljana. The results show that the element of automobility is deeply-rooted within various groups of stakeholders in Ljubljana. Even groups which do not use a car on a daily basis occasionally express strong dependence on mobility patterns based on car use. This leads to the emergence of strongly professed attitudes, i.e. passive activism, which is best illustrated by the data showing strong opposition to any concrete measures which would in practice interfere with the daily routines of car users or cause them an additional 'financial burden'.

The analysis of data opens up the question in what ways it may be possible to overcome passive activism and facilitate the introduction of measures connected with sustainable mobility and transport solutions. Two examples of the introduction of a congestion fee, London and Trondheim, show how important the element of time is in spatial planning, and how important the choice of a correct strategy of transport development is over a longer period. The selected examples show that planning for mobility and transport solutions should not only be a long-term process but also include various phases of social dialogue with various stakeholders, ranging from supportive to antagonistic groups. Gaining sufficient legitimating potential from the most antagonistic groups, which would enable the physical implementation of changes in the real environment, is in this sense of primary importance for any project that strives to enhance the quality of life in Ljubljana and the

Ljubljana region. In this context, the evidence from the data suggest that the existing approaches to mobility and transport issues should be modified and new forms of spatial planning for transport solutions should be introduced.

While modern approaches to mobility and transport issues were considered to be based on self-evident support for measures that would lead to smoother traffic flows, postmodern approaches attempt to include as many different views as possible in order to ensure a high level of mobility, as well as a high quality of life in the cities. Postmodern approaches are based on the assumption that all urban spaces are a symbolic reflection of values, social behaviour, and the individual acts of people, marking a specific location at a given time. Spatial as well as transport planning is thus perceived as the "product of dialectic interaction between society and space" (Soja, 1995). It is indeed clear that there are several political and economic systems, which through their formal, institutionalised systems in various ways include or determine the level of interaction between society and space. In doing so they, they may give more or less consideration to individuals and local communities regarding interventions into space and consequently encounter different kinds of problems. Regardless of the different approaches to the interaction between society and space, it is roughly true that the economically highly developed European countries typically call for a break away from modernist planning methods and for increased consideration of postmodern concepts of spatial planning, which try to ensure the highest possible level of active citizen participation in spatial planning. The effect of strongly professed attitudes shown in the analysis of public opinion surveys (2009) calls for an immediate increase, i.e. intensification of strategies to include the citizens of Ljubljana and the Ljubljana region in matters related to the implementation of sustainable mobility and transport solutions.

The aspect of ensuring a higher level of citizen/user participation is undoubtedly the weak spot of the present system of planning transport solutions in Ljubljana, the Ljubljana region and Slovenia. Considering Arnsteins' ladder of the power relationships regarding interventions into space, the users in Slovenia are granted mainly symbolic power, while the levers of power remain firmly in the hands of formal institutions. The range of participation strategies has seen little change in recent years, as it continues to focus on conventional methods, which largely involve disseminating information to the public, and not on direct inclusion of the users (bottom-up approach) in spatial planning processes. Conventional participation strategies include, for instance, exhibitions, public debates, various publications of statistical data analyses in the media and, in certain cases, consultative referendums and public investigations. Approaches that would allow for a higher level of user involvement in spatial planning are as yet in the initial stage and fail to have an impact.

Unselective professed support, combined with simultaneous rejection of the implementation of measures for a sustainable transport system in Ljubljana, indicates people's distrust, but above all their lack of information or poor communication between the transport users and the institutions that deal with planning mobility and transport solutions. The respondents' 'schizophrenic' answers show that the mechanism for planning transport systems in Slovenia are relatively 'immature' and therefore all the more sensitive to changes in social behaviour, as is indicated in the frequent (micro) conflicts accompanying attempts to change the habits of car users. The biggest problem deriving from the pseudo-planning of mobility and transport in Slovenia is the narrow orientation of formal interventions into space, as they consider only physical and temporary solutions for individual transport situations and do not seek connections with the wider environment and society.

At this point it is clear that direct, physical solutions to mobility and transport problems do not suffice and that they cannot eliminate the undesirable social influences which appear from time to time in response to a modified transport system. Actually, a certain level of conflict in planning for sustainable mobility is inevitable and has to be considered as an important force for changing and adapting transport system to (post)modern trends. In this context, the sensitivity of car users and the potential conflict with them in Slovenia result from individual adaptations to the current conditions. The solutions to this problem do not stem from the direct inclusion of the unexpected or as yet unknown needs of individuals in planning transport solutions, but concern the improvement of a mechanism that would reduce the gap in the communication between planners and users, if and when such needs emerge. As such, mobility and transport planners will have to adapt their communication strategies to various stakeholders regardless of their insistence on the 'higher' objectives of formal transport policies if they wish to avoid the potentially excessive costs for each change they plan in the transport system.

REFERENCES

Arnstein, Sherry. 1969. A ladder of citizen participation. *Journal of the American Institute of Planners* 35: 216–224.

Deadmann, Peter. 1999. Modelling individual behaviour and group performance in intelligent agent-based simulation of the tragedy of the commons. *Journal of Envrionmental Management* 56: 159–172.

Faulkner, Bill and Carmne Tideswell. 1997. A framework for monitoring community impacts of tourism. *Journal of Sustainble Tourism* 5(1): 3–28.

Giddens, Anthony. 1984. *The Constitution of Society – Outline of the Theory of Structuration*. Cambridge: Polity Press.

Gladwell, Malcolm. 2010. Small Change – Why the revolution will not be tweeted. *The New Yorker*, 4. October. Available at: http://www.newyorker.com/reporting/2010/10/04/101004fa_fact_gladwell, 12. 3. 2011.

Gladwell, Malcolm. 2011. Does Egypt need Twitter? *The New Yorker*. Available at: http://www.newyorker.com/online/blogs/newsdesk/2011/02/does-egypt-need-Twitter.html, 12. 10. 2011.

Hardin, Garrett. 1968. The tragedy of the commons. *Science* 162: 1243–1248.

Healey, Patsy. 2003. Collaborative Planning in Perspective. *Planing Theory* 2: 101–123.

Hočevar, Marjan and Drago Kos. 2004. *Vrednote prostora in okolja (3. fazno in končno poročilo)*. Ljubljana: Fakulteta za družbene vede, Center za prostorsko sociologijo.

Inglehart, Ronald. 1997. Modernization and postmodernization: cultural, economic, and political change in *43 societies*. Princeton, N.J.: Princeton University Press.

Kos, Drago. 1993. *Racionalnost neformalnih prostorov*. Ljubljana: Fakulteta za družbene vede.

Kos, Drago. 2002. *Praktična sociologija za načrtovalce in urejevalce prostora*. Ljubljana: Fakulteta za družbene vede.

Kos, Drago, Simona Zavratnik, Matjaž Uršič, Franc Trček in Marjan Hocevar. 2010. *Potovalne navade udeležencev v ljubljanski urbani regiji: porocilo o anketni raziskavi*. Ljubljana: Fakulteta za družbene vede, Center za prostorsko sociologijo.

Russel, Ruth. 1996. *Pastimes: the context of contemporary leisure*. London: Brown and Benchmark.

Soja, Edward. 1995. Postmodern Urbanization: The Six Restructurings of Los Angeles. In *Postmodern Cities*, eds. Sophie Watson and Catherine Gibson, 125–137. Oxford: Blackwell.

Tietenberg, Tom. 1994. *Environmental economics and policy*. New York: Harper Collins.

Urry, John. 1999. *Automobility, Car Culture and Weightless Travel*. Available at: http://www.comp.lancs.ac.uk/sociology/soc008ju.html, 10. 11. 2003.

Uršič, Matjaž, Simona Zavratnik, Franc Trček, Drago Kos, Marjan Hočevar and Anže Zorman. 2009. *Končno poročilo o rezultatih 1. Dela javnomnenjske raziskave: Spreminjanje ureditve javnega prometa v Ljubljani in ljubljanski regiji*. Ljubljana: Univerza v Ljubljani. Fakulteta za družbene vede.

Uršič, Matjaž, Simona Zavratnik, Drago Kos, Marjan Hočevar, Franc Trček and Anže Zorman. 2011. *Javnomnenjska raziskava o možnostih izboljšanja prometne ureditve v Ljubljani – analiza percepcije zgoščevalne takse*. Ljubljana: Univerza v Ljubljani, Fakulteta za družbene vede, Center za prostorsko sociologijo.

Wilson, Richard. 2006. Assessing comunicative rationality as a transporation planning paradigm. *Transportation* 1: 1–31.

SOURCES

CIVITAS ELAN Ljubljana. 2011. Available at: www.civitasljubljana.

si, http://www.civitasljubljana.si/uploads/datoteke/KRATEK%20 POVZETEK%20RAZISKAVE%20-%20Ursic%20Matjaz.pdf, 15. 3. 2011.

Ecopass-Milano. 2011. Available at: http://www.ecopassmilano.com/ecopassarea.asp, 10. 12. 2011.

Transport for London. 2011. Congestion Charging. Available at: http://www.tfl.gov.uk/roadusers/congestioncharging/, 10. 12. 2011.

Trondheim Toll Scheme. 2011. Available at: http://www.trondheim.com/engelsk/, 10. 12. 2011.

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I WANT TO RIDE MY BICYCLE ... BUT HOW BIKEABLE IS MY NEIGHBOURHOOD?

Veronique Van Acker, Elias De Vos,
Begga Van Cauwenberge, Frank Witlox

1 INTRODUCTION

Many studies try to model and measure the relationship between the built environment and aspects of travel behaviour (for a review see e.g. Ewing and Cervero, 2001; 2010; Van Acker and Witlox, 2005; Bartholomew and Ewing, 2009) such as mode choice and cycling (for a review specifically on cycling see e.g. Handy et al., 2002; Saelens et al., 2003; Krizek et al., 2009; Heinen et al., 2010). After all, people mainly travel in order to access activities such as living, working, shopping and recreating, which are in most cases spatially separated. Consequently, it seems commonsensical that travel patterns might be altered by changing the location of these activities and the design characteristics of these locations.

The greater part of these studies uses aggregated or macro-environmental data to characterize the built environment. For example, many studies point out that increasing land use mixing, aggregated in zones such as statistical wards or traffic analysis zones, likely encourages bicycling (e.g. Cervero and Duncan, 2003; Pechora et al., 2003; Moudon et al., 2005; Pucher and Buehler, 2006; Litman, 2007). Having a mixture of land uses or functions such as grocery stores, offices, schools and houses in a neighbourhood reduces travel distances. A decrease in travel distance likely results in cycling having a much higher share in mode choices (Moritz, 1998; Zacharias, 2005; Pucher and Buehler, 2006). Non-cyclists often mention having to travel long distances as an excuse for not travelling or commuting by bicycle (Dickinson et al., 2003; Stinson and Bhat, 2004). A survey among residents of Ghent (conducted within the CIVITAS ELAN project 2009–2012) illustrates that this excuse holds for

30.3% of non-cycling commuters, compared to 16.5% of regularly cycling commuters. Travel distances can thus be a daunting factor for bicyclists (Heinen et al., 2010).

Because of this – at first sight logical – relationship between the built environment and cycling, policy makers and academics try to find out what makes a neighbourhood bikeable (e.g. Winters and Coopers, 2008) and try to rate various neighbourhoods according to their bikeability. Considering the importance of travel distances in cycling, it is no surprise that most bikeability indices are based on the distance from the neighbourhood to important destinations such as grocery stores, offices and schools (e.g. a rating method using counts of destinations by facility type within a specific distance threshold from the origin location developed by McNeil, 2010 – or similarly for walking the Walkscore at www.walkscore.com). Such indices mainly focus on how attractive a specific neighbourhood is for cycling to facilities within bikeable distance. However, such indices do not measure how safe or how easy it is to cycle and do not evaluate the bicycle infrastructure itself. For example, there is no guarantee that people will opt to cycle in a mixed neighbourhood if a safe bicycle infrastructure (width and safety aspects of bicycle path, bicycle sheds, etc.) is missing. Instead of focussing on only the distance to facilities, bikeability indices should also take into account the condition of the bicycle infrastructure itself. Some bikeability indices (e.g. the Bikeability and Walkability Evaluation Table of Hoedl et al., 2010) account for the presence of a bicycle path, but without a thorough evaluation of the condition of this bicycle path (e.g. width, simple marked path or additionally raised path, width of the separation strip, etc.). This paper therefore illustrates the construction of such a systematic, infrastructure-based bikeability index.

The paper is organized as follows. Section 2 presents the methodology of calculating an infrastructure-based bikeability index. The results of this methodology are illustrated in the third section. This third section starts with a statistical analysis of the results before discussing a geographical analysis identifying “green spots” and “red spots” (or neighbourhoods with excellent respectively poor bicycling infrastructure and facilities). Finally, the results are summarized and discussed in Section 4.

2 METHODOLOGY – AN INFRASTRUCTURE-BASED BIKEABILITY INDEX

This section describes the approach developed by researchers of the Department of Geography at Ghent University in collaboration with the mobility department of the city of Ghent to obtain a quick overview of the infrastructure-based characteristics of bicycle paths.

2.1 STEP 1: TERRAIN ANALYSIS

In October and November 2009, five observers cycled 49,760 km and evaluated the infrastructure-based characteristics of 298 street and bicycle path segments. These segments are derived from the Road Information System ("Wegen Informatie Systeem"), a GIS with basic road characteristics in which the mobility department of the city of Ghent administers all road works. Data were collected for bicycle paths especially in the area of the main station, Gent Sint-Pieters, as this area is important for cyclists (mainly commuters and students). The observers cycled down a street and recorded the existence or value of a specific infrastructure-based item for every street and bicycle path segment on a scoresheet. The infrastructure-based items listed on this scoresheet are predominantly based on guidelines from the Flemish Government related to bicycle facilities and described in a cycling handbook (Ministerie van de Vlaamse Gemeenschap, 2006). Table 1 summarizes all items mentioned on the scoresheet. These items mainly refer to safety aspects of bicycle paths, route conditions and interaction with motor vehicles. Such items are likely to influence the likelihood of cycling (Winter et al., 2011).

Item	Description	Scores
Bicycle path		
Bicycle facility	presence of any type of bicycle path	1 = present over the entire length of the segment 2 = partly present 3 = not present
Cycling direction	cycling direction along the bicycle facility	1 = one-way 2 = both ways 3 = no bicycle facility present
Width	width of the bicycle facility including signposting and curb	measured in cm

Type	specific type of bicycle path	1 = bicycle path marked by a different colour ("fietssuggestiestrook") 2 = adjacent bicycle path ("aanliggende fietsstrook") 3 = separate bicycle path ("vrijliggende fietsstrook") 4 = bicycle road ("fietsweg") 5 = bicycle street ("fietsstraat")
Width of separation strip	width of the space between the bicycle path and the roadway	measured in cm
Screening	presence of any type of screening	1 = not present 2 = present
Screening type	specific type of screening	1 = unpaved 2 = fixed objects 3 = closed partition 4 = parking lane
Raised bicycle path	how much cm's the bicycle path is raised compared to the roadway	measured in cm
Accentuation	presence of a specific type of accentuation	1 = red coating 2 = other (other material than roadway)
Marking	presence of any type of signposting	1 = not present 2 = present
Condition	general condition of the bicycle path related to passableness (e.g., no loose tiles, no holes) and maintenance (e.g., no fallen leaves, moss, weeds)	1 = well passable, well maintained 2 = well passable, badly maintained 3 = badly passable, well maintained 4 = badly passable, badly maintained
	Car parking	
Parking	car parking allowed or not	1 = allowed (parking lane, parking places ...) 2 = not allowed
Parking hindrance	car parking in relation to bicyclists	1 = hindrance 2 = no hindrance
	Bicycle parking	
Bicycle shed	presence of bicycle parking	1 = present 2 = not present

Visible defects	any visible defects of the bicycle shed	1 = yes 2 = no
Parking arrangement	bicycles are arranged in the shed	1 = yes 2 = no
Occupancy rate	ratio between the number of bicycles in the bicycle shed and the total number of parking places in the bicycle shed	%
Bicycles outside shed	bicycles parked outside the bicycle shed	1 = yes 2 = no
Bicycles at house façade	bicycles parked at house façades	1 = yes 2 = no
Other		
Green space	presence of any green space	1 = yes 2 = no
Other remarks	other remarks	

Table 1: Summary of all infrastructure-based items mentioned on the scoresheet.

2.2 STEP 2: DATA PROCESSING

Before a bikeability index can be calculated, the initial observed scores must be recoded into values between 0 and 1 (according to the recoding rules in Table 2). We have to note that some recoding rules only hold for bicycle paths in streets with speed limits over 30 km/h ("Zone 30"). In principle, there are no bicycle paths in a Zone 30 since the maximum speed limit of 30 km/h allows mixed traffic of motorized and non-motorized users. If this link with speed limit regimes were to be neglected, streets without a bicycle path, but situated within a Zone 30, would have low scores on the bikeability index since all bicycle path related items would be missing. The bikeability index for streets without a bicycle path but within a Zone 30 is thus only based on the recoding rules related to their condition, car parking, bicycle parking and other items.[1]

1 298 street and bicycle path segments were evaluated. The greater part of these segments is situated in a Zone 30 (281 segments in a Zone 30 versus 17 segments outside a Zone 30). Of all segments in a Zone 30, the majority still has a bicycle path (218 segments with a bicycle path versus 63 segments without a bicycle path).

	0	0.25	0.50	0.75	1
Bicycle path					
Bicycle facility	not present				present
Cycling direction			both ways		one-way
Width	< 150 cm		[150 - 175[		≥ 175 cm
Type	bicycle path marked by another colour				all other types
Width of separation strip	< 25 cm		[25-50[		≥ 50 cm
Screening	no				yes
Raised bicycle path	no				yes
Accentuation	similar to roadway				different from roadway
Marking	no				yes
Condition	badly passable, badly maintained	badly passable, well maintained		well passable, badly maintained	well passable, well maintained
Car parking					
Parking hindrance	yes				no
Bicycle parking					
Bicycle shed	no				yes
Visible defects	yes				no
Arranged parking?	no				yes
Occupancy rate	≥ 100%				< 100%
Bicycles outside shed	yes				no
Bicycles at house façades	yes				no

Other					
Green space	no				yes

Table 2: Recoded scores per infrastructure-based item.

Furthermore, not all infrastructure-based items are equally important and weights must be assigned to each type of item. These weights were assigned based on the Saaty method which is a pairwise comparison of each item (Saaty, 1977). The Saaty method starts by determining a hierarchy of all infrastructure-based items. The top level in the hierarchy consists of only one (most important) item. In our approach, the general condition of the bicycle path is considered the most important item. The importance of the other items is expressed relative to this most important item (see Table 3). For example, all bicycle path items (bicycle facility, cycling direction, width, type, width of separation strip screening, raised bicycle path, accentuation and marking) refer to safety aspects of a bicycle path. We consider safety to be the second most important level. Priorities must then be assigned to each level relative to the other levels. A scale from 1 (both levels are equally important) to 9 (one level is totally dominated by the other level) is used. Since we consider safety aspects as the second most important level in the hierarchy, it receives a priority of 1/3. This means that the general condition is three times as important as safety and so safety is 1/3 as important as the general condition.

Hierarchy	Infrastructure-based item	Priority (relative to condition)
For streets segments with a bicycle path		
1. General condition	State	1
2. Safety aspects	Bicycle facility	1/3
	Cycling direction	1/3
	Width	1/3
	Type	1/3
	Width of separation strip	1/3
	Screening	1/3

	Raised bicycle path	1/3
	Accentuation	1/3
	Marking	1/3
3. Extra bicycle amenities	Bicycle shed	1/5
	Visible defects	1/5
	Arranged parking?	1/5
	Occupancy rates	1/5
	Bicycles outside shed	1/5
	Bicycles at house façades	1/5
4. Hindrance	Parking	1/7
	Parking hindrance	
5. Pleasant cycling	Green space	1/9
For street segments without a bicycle path		
1. General condition	condition	1
2. Extra bicycle amenities	Bicycle shed	1/3
	Visible defects	1/3
	Arranged parking?	1/3
	Occupancy rates	1/3
	Bicycles outside shed	1/3
	Bicycles at house façades	1/3
3. Hindrance	Parking hindrance	1/5
4. Pleasant cycling	Green space	1/7

Table 3: Initial weights according to the Saaty method.

Comparison matrices are then formulated for each pairwise comparison (see Table 4, only for street segments with a bicycle path as an example). The sum of all priorities by column is the total absolute priority of a specific infrastructure-based item (i.e., the sum of all pairwise comparisons). However, calculating an index needs relative weights for each item and thus the total absolute priorities must be translated into total relative priorities (see Table 5, only for street segments with a bicycle path as an example). Total relative priorities are thus assigned to each item by a pairwise comparison of that item with all other items. The calculation of the bikeability index is thus based on these total relative priorities:

- Bikeability index (for street segments with a bicycle path)[2] = 0.18 condition + 0.08 safety aspects + 0.03 extra bicycle amenities + 0.01 hindrance + 0.01 pleasant cycling

  or

- Bikeability index (for street segments with a bicycle path) = 0.18 condition + 0.08 (cycling direction + width + type + width of separation strip + screening + raised bicycle path + accentuation + marking) + 0.03 (bicycle shed + visible defects + accordingly parked + occupancy rate + bicycles outside shed + bicycles at house façades) + 0.01 parking hindrance + 0.01 green space.

2 Bikeability index (for street segments without a bicycle path)= 0.37 state + 0.09 extra bicycle amenities + 0.04 hindrance + 0.02 pleasant cycling or Bikeability index (for street segments without a bicycle path) = 0.37 state + 0.09 (bicycle shed + visible defects + arranged parking + occupancy rate + bicycles outside shed + bicycles at house façades) + 0.04 parking hindrance + 0.02 green space.

	Cycling direction	Width	Type	Width of separation strip	Screening	Raised bicycle path	Accentuation
Cycling direction	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Width	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Type	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Width of separation strip	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Screening	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Raised bicycle path	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Accentuation	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Marking	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Condition	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Parking (hindrance)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Bicycle shed	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Visible defects	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Accordingly parked	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Occupancy rate	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Bicycles outside shed	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Bicycles at house façades	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Green space	0.14	0.14	0.14	0.14	0.14	0.14	0.14
SUM 1	13.32	13.32	13.32	13.32	13.32	13.32	13.32

Marking	State	Parking (hindrance)	Bicycle shed	Visible defects	Accordingly parked	Occupancy rate	Bicycles outside shed	Bicycles at house facades	Green space
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
1.00	0.33	5.00	3.00	3.00	3.00	3.00	3.00	3.00	7.00
3.00	1.00	7.00	5.00	5.00	5.00	5.00	5.00	5.00	9.00
0.20	0.14	1.00	0.33	0.33	0.33	0.33	0.33	0.33	3.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.33	0.20	3.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00
0.14	0.11	0.33	0.20	0.20	0.20	0.20	0.20	0.20	1.00
13.32	5.09	66.33	35.53	35.53	35.53	35.53	35.53	35.53	99.00

Table 4: Comparison matrix in which each infrastructure-based item is compared to all other items (for street segments with a bicycle path).

	Cycling direction	Width	Type	Width of separation strip	Screening	Raised bicycle path	Accentuation	Marking
Cycling direction	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Width	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Type	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Width of separation strip	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Screening	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Raised bicycle path	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Accentuation	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Marking	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Condition	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Parking (hindrance)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Bicycle shed	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Visible defects	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Accordingly parked	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Occupancy rate	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Bicycles outside shed	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Bicycles at house façades	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Green space	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Condition	Parking (hindrance)	Bicycle shed	Visible defects	Accordingly parked	Occupancy rate	Bicycles outside shed	Bicycles at house facades	Green space	SUM 2	TOTAL RELATIVE PRIORITY (weight)
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	1.32	0.08
0.20	0.11	0.14	0.14	0.14	0.14	0.14	0.14	0.09	3.04	0.18
0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.25	0.01
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.50	0.03
0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.15	0.01
									17.00	1.00

Table 5: Total relative priority for each infrastructure-based item (for street segments with a bicycle path).

2.3 2.3 STEP 3: DATA ANALYSIS

The data was then processed and analyzed in ArcGIS 9.2. Within GIS the bikeability index visualized which streets had a good bicycling infrastructure. Moreover, five specific cluster indices were also created (technical condition. safety. extra bicycle amenities, hindrance and pleasantness; see Table 6), explaining positive and negative scores on the general bikeability index.

Cluster	Infrastructure-based item	Weight
1. Technical condition*	- width - state - bicycle facility - cycling direction	1/4
2. Safety*	- type - width of separation strip - screening - raised bicycle path - accentuation - marking	1/6
3. Extra bicycle amenities	- bicycle shed - visible defects - arranged parking - occupancy rate - bicycles outside shed - bicycles at house façades	1/6
4. Hindrance	- parking	1
5. Pleasantness	- green space	1

Table 6: Cluster indices.
Note: * These cluster indices are available only for streets with a bicycle path, not for streets without one.

3 RESULTS

After having specified the construction and calculation of the general bikeability index and its five cluster indices, this section describes the major results.

3.1 STATISTICAL ANALYSIS

Average score on the bikeability index: 49.3% of all street and bicycle path segments obtained a bikeability index between 0.41 and 0.60. However, the bikeability in streets with a bicycle path is considerably higher than in streets without a bicycle path (see Figure 1). The fairly low bikeability index for streets without a bicycle path is mainly due the lack of sufficient bicycle amenities and the fairly low scores for the pleasantness aspect (see Figure 2).

Almost one third (31.9%) of all street segments with a bicycle path scored a bikeability index of at least 0.61. This is mainly due to a positive evaluation of the technical condition (see Figure 3). A good technical condition refers to well passable and well maintained bicycle paths - any other type than a bicycle path marked by another colour – with a minimum width of 175 cm and a one-way cycling direction. However, the lower scores on the safety cluster index indicate that various safety aspects of bicycle paths can be further improved.

Interesting to note is that parked cars generally do not hinder bicyclists. This holds in streets with bicycle paths as well as streets without bicycle paths.

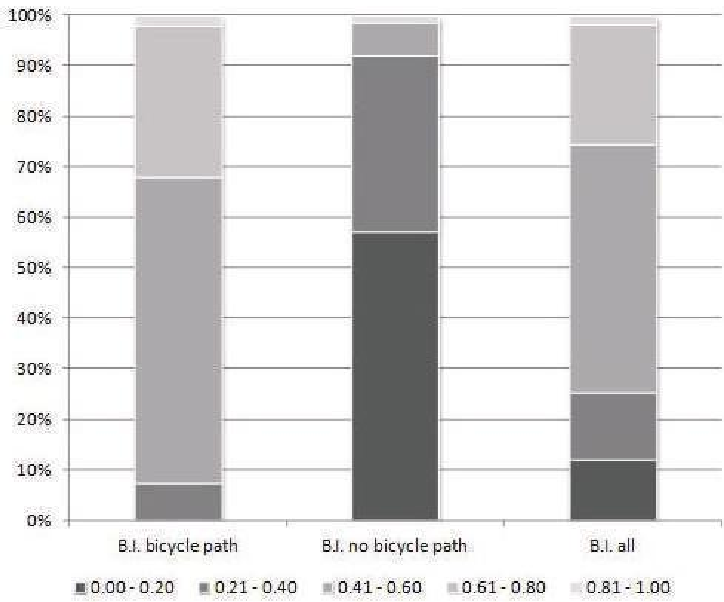

Figure 1: Distribution of scores on the bikeability index.

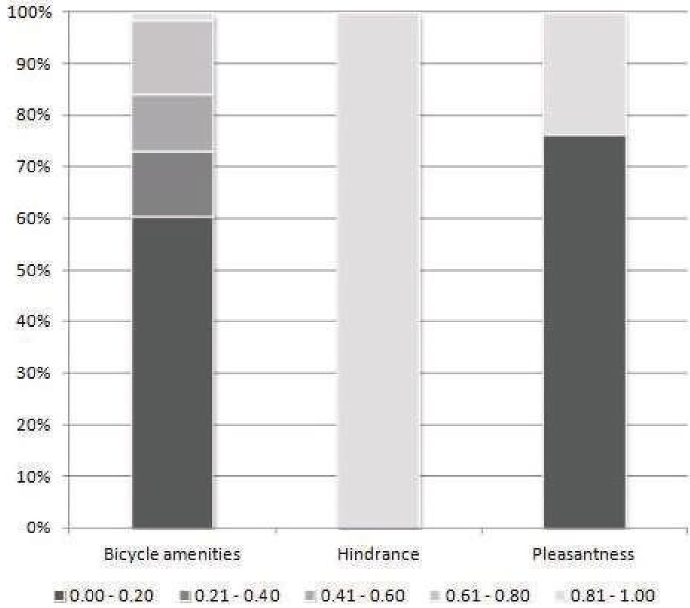

Figure 2: Distribution of scores on the cluster indices for streets without a bicycle path.

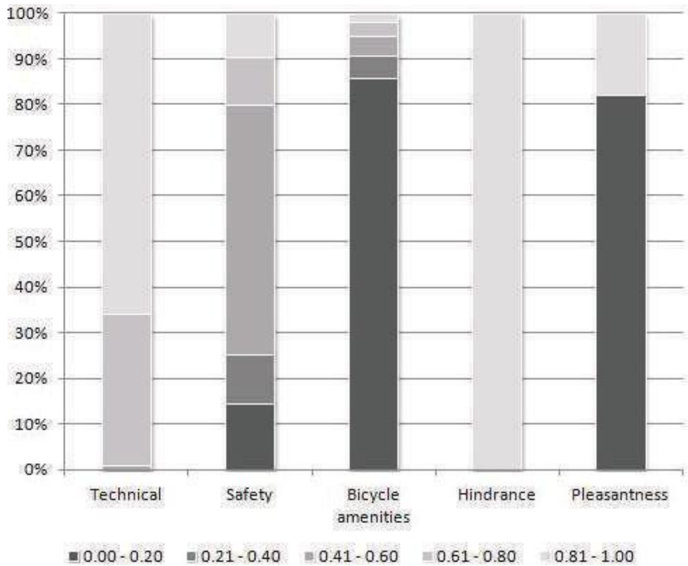

Figure 3: Distribution of scores on the cluster indices for streets with a bicycle path.

3.2 GEOGRAPHICAL ANALYSIS

A geographical analysis in ArcGIS 9.2 allowed us to identify "red spots" (neighbourhoods with poor bicycling infrastructure and facilities) and "green spots" (neighbourhoods with excellent bicycling infrastructure and facilities).

It is noteworthy that streets with high traffic intensities scored higher on the bikeability index. Figure 4 illustrates this for De Sterre, a roundabout which distributes traffic towards the Gent Sint-Pieters railway station, but also towards the city centre of Ghent and other cities such as Kortrijk and Oudenaarde. These high scores are mainly due to the good technical condition of the bicycle paths along these streets.

Figure 5 on the other hand identifies the neighbourhood around the Gent Sint-Pieters railway station as a "red spot". The low scores on the bikeability index in this area are due to the lack of sufficient bicycle amenities in many streets and moderate scores for the safety aspect.

Figure 4: Example of high bikeability scores along streets with high traffic intensities.

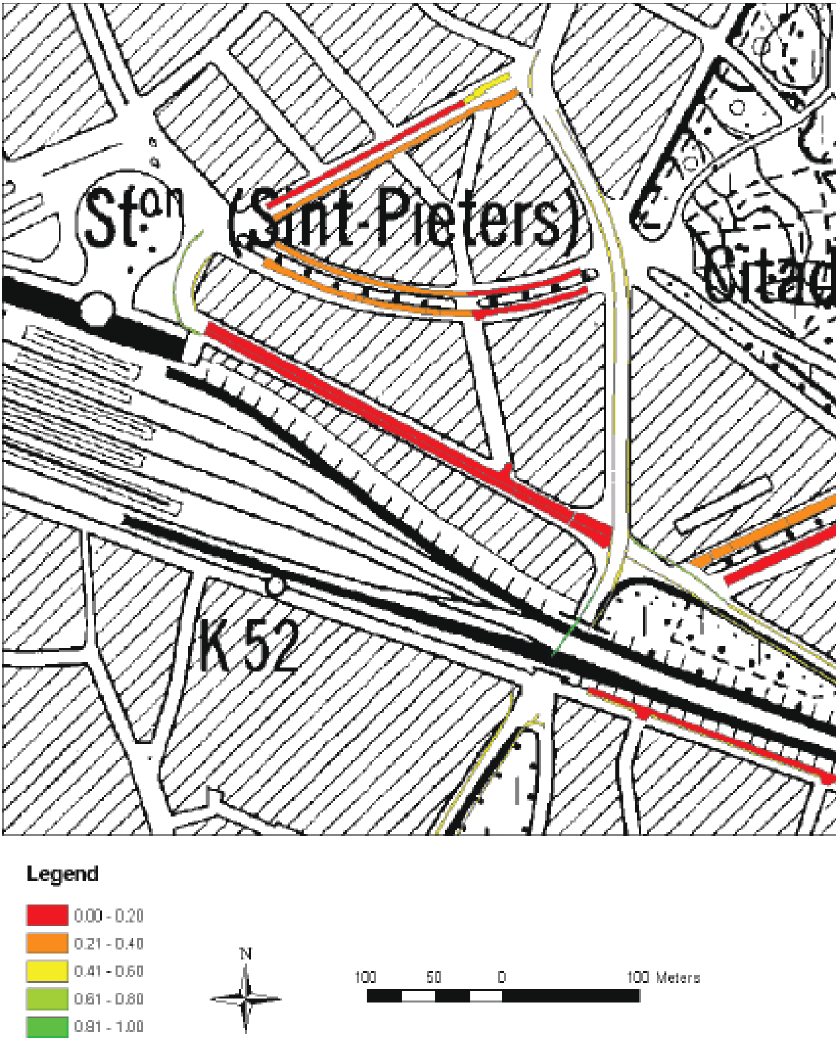

Figure 5: Example of low bikeability scores around the Gent Sint-Pieters railway station.

4 CONCLUSIONS

This paper reports on the construction and calculation of a bikeability index to evaluate the bicycle infrastructure in Ghent. Most existing bikeability indices focus on the attractiveness of a specific neighbourhood for bicycles by measuring the distance to important destinations such as grocery stores, offices, and schools. The bikeability index described in this paper however evaluates the bicycle infrastructure itself and thus illustrates how safe and how easy it is to bicycle to such important destinations.

Our infrastructure-based bikeability index is actually a flexible tool to evaluate the bicycle infrastructure of a specific city. Depending on the interest, other aspects can be added to the score sheet to be evaluated and other weights can also be attributed to the various aspects of the bikeability index. In other words, this bikeability index offers a flexible tool in transport planning, which can be applied in other cities and projects.

This general bikeability index and its specific cluster indices provide us with a micro-scaled and objectively measured indicator of the technical quality of the bicyclist's environment. However, it remains unclear whether bicyclists perceive their environment in a similar way as the bikeability index would indicate. Therefore, it seems interesting to complement this bikeability index with further survey research among cyclists and non-cyclists on their values and attitudes towards cycling and different attributes of the bicyclist's environment. Combining the objective bikeability index with findings from a survey about subjective perceptions of cycling would increase our understanding of the factors that influence bicycling in an urban environment.

REFERENCES

Bartholomew, Keith and Reid Ewing. 2009. Land use-transportation scenarios and future vehicle travel and land consumption. *Journal of the American Planning Association* 75: 13–27.

Cervero, Robert and Michael Duncan. 2003. Walking, bicycling and urban landscapes: Evidence from the San Francisco Bay Area. *American Journal of Public Health* 93(9): 1478–1483.

Dickinson, Janet E., Simon Kingham, Scott Copsey and Deborah J. Pearlman Hougie. 2003. Employer travel plans, cycling and gender: will travel plan measures improve the outlook for cycling to work in the UK? *Transportation Research Part* D 8(1): 53–67.

Ewing, Reid and Robert Cervero. 2001. Travel and the built environment: A synthesis. Transportation Research Record: J*ournal of the Transportation Research Board* 1780: 87–114.

Ewing, Reid and Robert Cervero. 2010. Travel and the built environment: A meta-analysis. *Journal of the American Planning Association* 76(3): 265–294.

Handy, Susan L., Marlon G. Boarnet, Reid Ewing and Richard E. Kwillingswort. 2002. How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine* 23(2): 64–73.

Heinen, Eva, Bert van Wee and Kees Maat. 2010. Commuting by bicycle: An overview of the literature. *Transport Reviews* 30(1): 59–96.

Hoedl, Simon, Sylvia Titze and Pekka Oja. 2010. The bikeability and walkability evaluation table: Reliability and application. American *Journal of Preventive Medicine* 39(5): 457–459.

Krizek, Kevin, Ann Forsyth and Laura Baum. 2009. *Walking and Cycling International Literature Review*. Melbourne: Victoria Department of Transport, Walking and Cycling Branch.

Litman, Todd. 2007. *Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior.* Victoria: Victoria Transport Institute.

McNeil, Nathan. 2010. *Bikeability and the 20-minute neighbourhood: How infrastructure and destinations influence bicycle accessibility. Proceedings of the 90th Annual Meeting of the Transportation Research Board*. Washington D.C.: January 23–27.

Ministerie van de Vlaamse Gemeenschap. 2006. *Vademecum Fietsvoorzieningen*. Versie 2006. Brussel: Ministerie van de Vlaamse Gemeenschap, Departement Leefmilieu en Infrastructuur, Administratie Wegen en Verkeer, Afdeling Verkeerskunde.

Moritz, William E. 1998. *Adult Bicyclists in the United States: Characteristics and Riding Experience in 1996*. Washington D.C.: Transportation Research Board.

Pikora, Terri, Billie Giles-Corti, Fiona Bull, Konrad Jamrozik and

Rob Donovan. 2003. Developing a framework for assessment of the environmental determinants of walking and cycling. *Social Science and Medicine* 56(8): 1693–1703.

Pucher, John and Ralph Buehler. 2006. Why Canadians cycle more than Americans: A comperative analysis of bicycling trends and policies. *Transport Policy* 13(3): 265–279.

Saaty, Thomas L. 1977. A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology* 15(3): 234–281.

Saelens, Brian E., James F. Sallis and Lawrence D. Frank. 2003. Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine* 25(2): 80–91.

Stinson, Monique A. and Chandra R. Bhat. 2004. Frequency of bicycle commuting: Internet-based survey analysis. *Transportation Research Record* 1878: 122–130.

Van Acker, Veronique and Frank Witlox. 2005. Exploring the relationships between land use system and travel behaviour concepts: some first findings. *Solstice* 16: 1–18.

Vernez Moudon Anne, Chanam Lee, Allen D. Cheadl, Cheza W. Collier, Donna Johnson, Thoman L. Schmid and Robert D. Weather. 2005. Cycling and the built environment: a US perspective. *Transportation Research Part D* 10(3): 245–261.

Winters, Meghan, Gavin Davidson, Diana Kao and Kay Teschke. 2011. Motivators and detterents of bicycling: comparing influences on decisions to ride. *Transportation* 38: 153–168.

Winters, Meghan and Adam Cooper. 2008. *What makes a Neighbourhood Bikeable. Reporting on the Results of Focus Group Sessions*. Vancouver: TransLink and the University of British Columbia.

Zacharis, John. 2005. Non-motorized transportation in four Shanghai districts. *International Planning Studies* 10(3-4): 323–340.

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CYCLING IN THE CAPITAL OF A NEW MEMBER STATE: EXPLOITING THE UNTAPPED POTENTIAL OF BIKING TO WORK IN LJUBLJANA

Luka Mladenovič, Aljaž Plevnik,
Mojca Balant, Lea Ružič

1 INTRODUCTION

Creating a cycling culture in cities is one of the most important pillars of a sustainable transport system. After walking, cycling is the simplest, most natural means of transport. It is the fastest means of transport for distances of up to 5 km (Reiter, 2009), and improves the health and well-being of citizens of all generations.

Cycling was well developed and one of the main transport modes in Ljubljana up to the 1970s when motorization started to increase. The available data for the last thirty years show a gradual decline of all transport modes, except private cars. In the last five or ten years, the number of cyclists has been rising again, but since there is no regular, systematic data collection about cyclists in Ljubljana in place, the trend is not captured in any transport study.

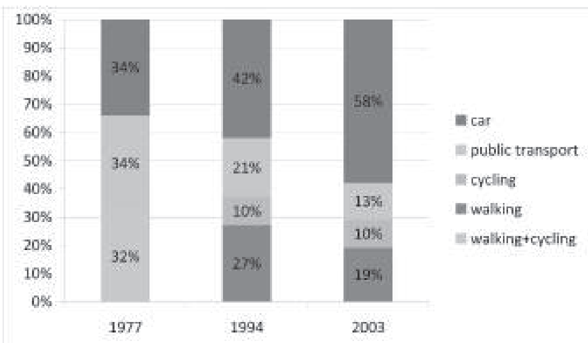


Figure 1: Changes in modal split in Ljubljana in 1977, 1994 and 2003.
Source: Projekt nizke zgradbe, 2003 and Prometnotehniški inštitut, 2005.

With the increasing importance of cycling in the city's transport policy, Ljubljana has become aware of the lack of such data. When setting goals and targets for the transport system's future development, it was impossible to determine even the relevant baseline situation, let alone the potentials for future changes to the shares of trips made by individual transport modes, for instance the increase of cycling.

The last available systematic data collection of the travel habits of citizens and visitors of Ljubljana and the Ljubljana Urban Region was conducted almost a decade ago, in 2003 (Projekt nizke gradnje). Since then, only partial studies tried to follow up the development of the transport system. However, the methodologies used were so different that the collected data are not comparable. Nevertheless, the established trends showed continuous growth of car use even for short trips and a decrease or stagnation for all other transport modes.

The paper describes the current share and potential for work-related trips, an important and stable share of all trips made in the city. Commuting to work has the most important share of all trips. It is also the main reason for the two daily peaks in the transport demand, which usually result in traffic jams. The congestion results from a predictable increase in the number of travels in limited periods of time (between 7.00 and 9.00 a.m. for trips from home to work, and between 3.00 to 5.00 in the opposite direction) and directions (to the employment centres in the morning, home-bound in the afternoon), exceeding the network's capacity.

Data from 2003 show that more than two thirds of all work-related trips in Ljubljana were done by car. The share of trips done by bicycle was only 10.5%. Considering transport modes for individual travel purposes, car use has the highest share for nearly all purposes.

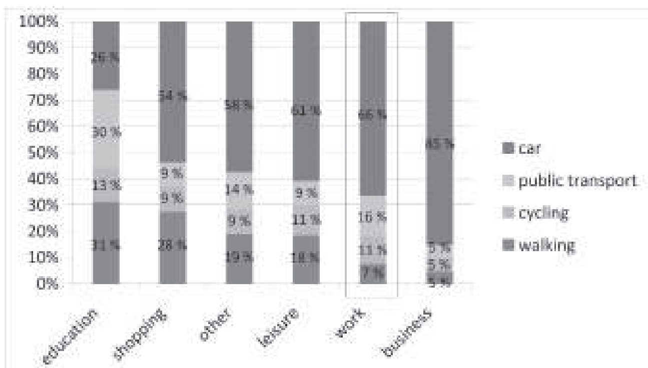


Figure 2: Modal split by travel purpose in Ljubljana.

On the other hand, the Slovene Road Directorate claims that 75% of all trips presently done by motor vehicles in the cities could be done on foot or by bike (Direkcija Republike Slovenije za ceste, 2005). Comparing this to the 18.0% share of walking and cycling in the available data, the actual potential of these two modes is self-evident.

The share of commuting trips of course differs from the total number of trips within a city. It is closely related to the distances the commuters have to cover. The Danish Road Directorate observed (Road Directorate, 2000) that "the share of bicycle use in larger towns varies according to the distance between home and the town centre. The closer to the town centre people live, the more they tend to cycle."

There is, however, no set maximum acceptable distance for these trips as it depends on many aspects. "Half the cycle trips are under 2 km, and 9 out of 10 cycle trips are under 5.5 km. The length of the cycle trip depends on the purpose of the trip, e.g. the trip to work often being longer than other cycle trips" (Road Directorate, 2000).

The UK Department of Transport (2008) sets this distance at about 7 km: "For commuter journeys, a trip distance of over five miles is not uncommon". A similar distance is proposed by the Dutch Ministry of Transport (2009), which states that given that the standard infrastructure is in place "most people believe half an hour's travelling time to and from work is acceptable. Cyclists can certainly cover some 7.5 km in this time". But where a city develops a high quality cycling infrastructure, the distance can further increase: "Until recently, a maximum cycling distance of 7.5 km was considered realistic. However, more and more inter-local commuter routes are being designed with few obstacles and sometimes even real bicycle motorways. In the framework of the 'Fileproof' project, five such routes were constructed. All over the country, there is interest in cycle routes for longer distances. As a result, distances of up to 15 km are achievable, with cyclists able to reach speeds of 25-30 km/hour."

In the case of Ljubljana some infrastructure is available, but not all of it is of good quality, and we can therefore expect regular cyclists to commute for up to 7 km. As we are dealing specifically with cycling to work, a 10 km distance was used as the maximum for most cyclists.

Therefore, the purpose of this paper is to answer the following questions: what is the share of the population that could cycle to work and which we might expect do to so, if or when the conditions for cycling in the city would improve sufficiently to meet to the citizens' expectations. And secondly, what are the barriers that prevent them from doing so.

2 METHODOLOGY

As part of the CIVITAS ELAN project in Ljubljana, two travel plans were prepared for larger traffic generators. A travel plan is a document that helps a company or institution to manage the accessibility of its location and thus influence the travel habits of its employees and visitors. It contains a number of measures aimed at improving the company's/institution's accessibility with all transport modes. Special attention is dedicated to accessibility by public transport, bicycle, or on foot. The plan is based on soft measures like information, awareness raising, education, and the organization of services within the framework of the existing infrastructure. It can include the construction of additional infrastructure, but on a small scale and only as a supplementary measure.

Methods for developing a travel plan are described in many European guidebooks on the topic and they include a series of work steps. One of the first steps is a status analysis, outlining a location's level of accessibility and the activities that are already in place. A status analysis can be conducted using a number of methods: accessibility analysis, interviews with key stakeholders and travel habit surveys. Travel habit surveys help us with the numerical determination of selected elements, for instance modal split or attitudes towards specific topics or transport modes. The method is also very useful for evaluating measures taken since regularly repeated surveys allow us to trace changes.

The paper includes the combined results of four travel habit surveys conducted between January 2009 and May 2010. One of them was part of the CIVITAS ELAN project. Other locations were added to the sample, as the four institutions share similar properties regarding accessibility and type of institution. Two of the analyzed institutions are small and their data are not useful on their own because the samples were too small. The combined data are nevertheless relevant for the analysis of the current state in the central part of the city.

2.1 RESEARCH QUESTION

The question we posed during our work on the travel plans had two parts. Firstly, how large is the actual share of employees that has the physical option to cycle to work. We determined early on that there are groups of employees with health or social issues preventing them from cycling to work. For a large part of the population, however, the most important aspect in deciding is the distance from home to work.

Secondly, we wanted to identify the main barriers preventing those who have the physical option to cycle to work from doing so. We wanted to identify the most common types of barrier and whose competence or jurisdiction is was to try and remove them - the employers' or the municipality's.

2.2 RESEARCH METHOD

The research method used was a standardized survey, tested in previous similar analyses. It consisted of 20 questions falling into several categories: questions about current habits regarding travel to work, motivations and barriers for different travel modes, short business trips and, finally, demographical information. The participating institutions usually wanted to add a set of specific questions regarding the problems they face at their location, attitudes towards ecology, sustainable development, or car use.

Part of the travel plan methodology is that the survey's findings are presented to the project group and employees for consideration. The survey is then repeated at regular intervals so that the changes in travel behaviour can be traced. This requires the survey to be repeated in a similar or the same season of the year, for instance spring or autumn, when the use of different travel modes is balanced.

For the purpose of this paper the methodology used was an extended analysis of collected data. During the review of the general information many new questions arose, which we tried to answer with the available information.

2.3 SAMPLING AND DATA COLLECTION

The aim of the survey was to describe the current state of travel habits in a company or institution. It is important to include all individual groups of employees, such as management, full-time and part-time office workers, as well as maintenance personnel and couriers. Since the institutions we worked with were small or medium sized, we wanted to include as many employees as possible.

All employees were invited to participate in the survey by a superior, the director or a department manager, with a short explanation of the background. Since most of the staff in the analyzed institutions has computer-based jobs, we decided to conduct an online survey using 'SurveyMonkey', a web based tool. The link to the survey was sent to all employees. Where large groups of employees did not use a computer at work, a printed version of the questionnaire was prepared for them and the filled out forms were later transferred to the database with the other results.

A few days after the initial invitation, a reminder was sent to the employees that the survey was still open and that there was still time to participate. The individual surveys were open for two weeks, giving all the employees enough time to participate, even if some were absent for a few days during this period. With this method we managed to achieve a response rate of over 50 % in all cases. This is in line with UK Department for Transport guidance (2002) which sets appropriate samples for 1-200 employees at 100 %, and for 201-1000 employees at 50 %.

Another method to improve the response rate is to add a prize draw for the participants. We discussed this option on many occasions, but in the end decided against it because of survey anonymity. Some employees used different address for their permanent and actual places of residence. As we were not interested in their formal place of residence, but rather in their actual commuting trips, we decided to design the survey so as to prevent connecting individual respondents to the collected travel information.

	Time of survey	Number of employees	Response rate
Site 1	January 2009	30	97%
Site 2	April 2009	10	100%
Site 3	September 2009	373	56%
Site 4	May 2010	194	54%

Table 1: Analyzed locations and basic data on surveys.

The surveys were conducted in four institutions. The four locations share many similarities. They all lie on the edge of the core city centre, within walking distance from the inner city ring road that symbolically represents the centre's edge.

Figure 3: Map of the centre of Ljubljana, inner ring road, analyzed locations.

All locations are well accessible by public transport, cycling, or walking. Parking is regulated in the vicinity of the institutions and they all have a parking lot available for a small percentage of their employees. All locations thus have limited car access compared to the rest of the city. The available number of parking places however maintains a stable share of employees who commute by car regardless of the distance from home to work. Since the city centre generally has good bicycle lanes, bicycle parking lots, and even a bike sharing scheme, we expected a higher share of cyclists in this institutions than in the outer parts of the city.

3 FINDINGS

The current modal split measured by the surveys shows an expected high share of car trips. The share of cyclists is quite high as well. With

16.7 %, it exceeds the generally stated modal split for trips in Ljubljana by more than 5%. Beside the central, well accessible location, this is partly a result of the good infrastructure in place in the wider area of the analyzed locations. In areas with less cycling infrastructure closer to the outer ring road, the share is much lower.

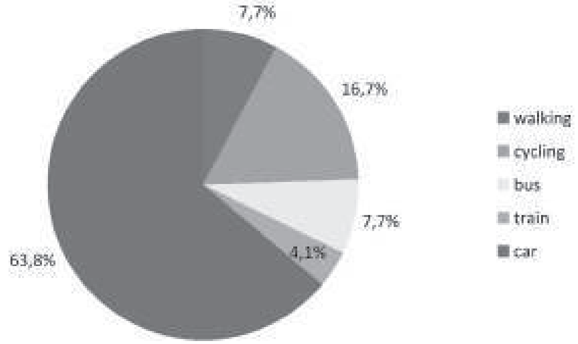


Figure 4: Modal split, usual transport mode for trips to work.

Regarding the transport modes used for trips to work we asked another question: What is the alternative mode of transport that you use when you are not using the main mode. Here, the share of cycling was 7.7%. This group includes employees who are occasional cyclists and who have the physical means and knowledge, but need additional encouragement to cycle more often.

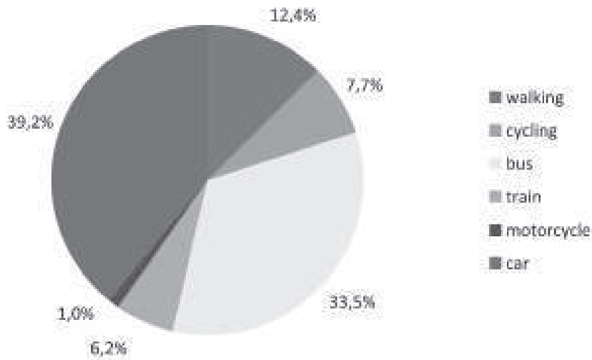


Figure 5: Stated alternative transport modes used for trips to work.

As mentioned above, distance is but one of the main barriers that limit cycling. At this point it is worth mentioning that the distance from work increased drastically in Slovenia in the last twenty years. Besides general trends of suburbanization the cost of commuting to work is reimbursed by law and the amount is calculated according to the distance from the commuter's place of residence, employees are indirectly encouraged to live as far from their place of work as possible.

According to the survey results 10.3% of the institutions' staff lived less than 2 km from their place of work. This distance is appropriate for walking and cycling for all demographic groups. 23.3% lived at a distance of 2 to 5 km, a distance a healthy adult is able to cycle without breaking a sweat. An additional 17.9% lived 5 to 10 km from work, a distance a healthy adult who engages in regular physical activity is able to cycle in 30 minutes.

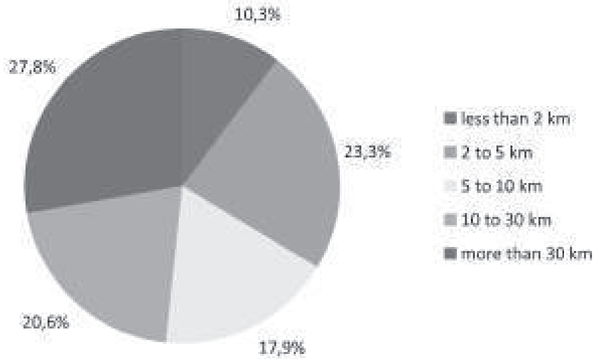


Figure 6: Distance from place of residence to work.

The share of all employees living within a distance of 10 km was 51.5%. This is the total pool of the people who have the option to cycle to work. There are, of course, other barriers to be considered, but given the current spatial dispersion of the population this is the maximum that could theoretically be reached.

Regarding the barriers the employees stated that they considered when thinking about cycling, almost 40% mentioned hygiene issues. Sweating on the way to work is a problem with distances over 2 km. Changing rooms and showers are not common facilities in office buildings. Analyzing the premises, we discovered that even if they were planned, they were not installed.

Distance was stated as the second most important barrier to cycling, and the lack of appropriate infrastructure was in third place with 27%. The latter includes both the cycling network and parking facilities. Most institutions have some kind of bicycle parking area, but usually of low quality and limited capacity. This aspect is then related to the mentioned high fear (25%), of bicycle theft, even though this is not really an important problem at the city level. But if we consider that commuting requires a reliable, usually more expensive bike, this aspect emerges as an important topic in the development of future measures.

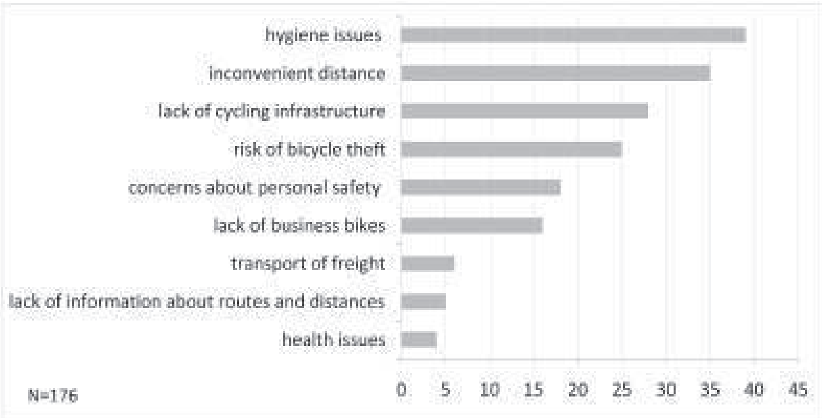


Figure 7: Stated main barriers to cycling to work.

Concerns about personal safety were stated by 18% of employees and the lack of company bikes by 16%. The last three options provided in the survey each stood for around 5%. They included the transport of freight on the bike on the way to or from work, and the lack of information about routes and distances. Health issues ranked last with 4%, indicating that a large part of the population within an appropriate distance could physically cycle to work if other barriers were addressed adequately.

The stated barriers quite clearly point to the topics that should be considered in future to increase the share of cyclists. Given the limited resources, it would make sense to invest in eliminating the most commonly stated barriers.

To understand the habits and needs of the population living up to 10 km from work, an additional analysis was performed, focusing exclusively on this group, which stands for 51.5% of the total population. Here, the modal split is more balanced, with 41% using a car, compared to almost 64% of the total population. 29% regularly cycles to work and 14% chooses to walk. As we see, the shares of sustainable modes are much higher in this population.

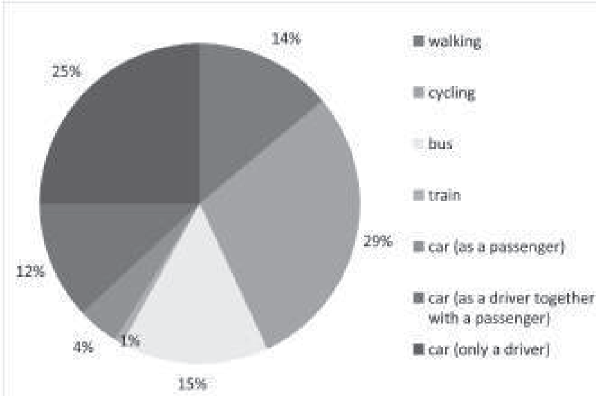


Figure 8: Modal split for employees living less than 10 km from place of work.

To determine this group's potential we combined the shares of respondents stating they already cycled regularly to work, respondents stating that they used their bicycle as an alternative mode, and respondents who chose cycling as a mode they would be willing to consider in the future. The total share of these employees was 72%. If we transfer this to the whole population, it stands for 37.1% or more than double the share of cyclists we have today.

4 CONCLUSION

The Slovene Road Directorate claims that nearly half the population walks or cycles to work in European cities with a well developed cycling culture (Direkcija Republike Slovenije za ceste, 2005). The collected data from the four institutions in Ljubljana show that there is a potential for such development in Ljubljana as well. To determine the actual city-wide potential, more similar research should be done in other, less urban areas with large employment centres. Especially business areas and shopping centres near the outer ring road, with fast access to the motorway system, which attract more employees from wider areas, show a completely different picture.

But even in the wider city centre the current share of those who cycle to work, 16%, is far from the estimated potential of over 35%. In order to maximize it, new measures and improvements are required at the level of both the city and individual locations.

Many of the stated barriers can only be overcome with support on city level. A good cycling network consisting of fast bicycle routes, dedicated bicycle lanes, and areas with slow motor traffic, are preconditions for convincing a greater share of the population to cycle to work. And with some cycle lanes already reaching their capacity limits during the morning and afternoon peaks, the city should start to consider improving the infrastructure in order to meet the needs of twice the number of cyclists using the network than today.

Other important aspects of the cycling infrastructure are adequate numbers, quality and dispersion of bicycle stands. The city has been working on this topic for several years. Many new bike stands are put in use every year. But the lack of a systematic approach is increasingly evident since some important public areas remain without appropriate bike parking facilities or with capacities that meet only a fraction of the demand.

Employers, on the other hand, have narrower competences and can improve the conditions only at their locations. Changing rooms and showers are needed, especially in office-type institutions, which may have a strict dress code. In our experience, the management of the participating institutions is often not in favour of such facilities. Because of their lack of experience with such facilities in an office environment, the management is not certain how to include the time spent for changing and showering in the working process to avoid abuses. But with the increasing flexibility of working hours and therefore long hours spent daily at work, some employers decided to test this measure on a small scale.

Another important measure an employer can implement is to provide adequate parking facilities. Institutions receiving visitors should provide safe bike stands near the entrance. Safer and covered parking lots must be provided for the employees to leave their bike without having to fear theft, including overnight parking.

Regarding the infrastructure, this is usually all an employer can do. But other measures can be implemented, focusing on the promotion of cycling, providing information or incentives and showing general support for those to decide to actively travel to work. Measures such as ‘doctor bike’ or ‘company bikes’ are often implemented and well accepted by employees. After using company bikes for short business trips, some of them find it easier to use a bike for commuting to work as well.

Finally, in the last few years we have been witnessing a renaissance of cycling in European cities. People are rediscovering this healthy and pleasant mode of transport that proves to be very efficient as well, especially for the majority of distances that have to be covered. The number of cyclists is therefore growing, and this has been observed in Ljubljana as well. But the potential for further development of cycling is even greater. As we showed in this paper, cycling to work could double its share if appropriate conditions were developed.

REFERENCES

Department for Transport. 2002. *The travel plan resource pack for employers*. London: Department for Transport.

Department for Transport. 2008. *Cycle Infrastructure Design. Local Transport Note 2/08*. Department for Transport, Scottish Executive, Welsh Assembly Government. Norwitch: The Stationery Office.

Direkcija Republike Slovenije za ceste. 2005. *Zasnova državnega kolesarskega omrežja v Republiki Sloveniji*. Ljubljana: Direkcija Republike Slovenije za ceste.

Ministrie van Verkeer en Waterstaat 2009. *Cycling in the Netherlands*. Ministry of Transport, Public Works and Water Management, Directorate-General for Passenger Transport, Fletsberaad.

Projekt nizke zgradbe. 2003. *Anketa po gospodinjstvih, raziskava potovalnih navad prebivalcev Ljubljanske regije*. Naročnik MOL, Oddelek za urbanizem. Izvajalci Projekt nizke zgradbe, Ninamedia, Urbi. Ljubljana: MOL.

Prometnotehniški inštitut. 2005. *Uvajanje mestne prometne politike – predlog brošure*. Naročnik: Mestna občina Ljubljana. Ljubljana: Prometnotehniški inštitut.

Road Directorate. 2000. *Collection of Cycle Concepts*. Copenhagen: Road Directorate.

Reiter, Karl. 2009. *20 Good Reasons For Cycling*. Developed within the framework of the EU-Project Trendy Travel, supported by the European Commission.

LJUBLJANA I The city administration is “greening” its public fleet with among others 6 hybrid cars and 50 company bicycles.

LJUBLJANA I The city is introducing a sustainable electromobility plan with a set of measures intended to stimulate and promote the use of electric vehicles in urban transport.

LJUBLJANA | The city envisages banning motorised traffic, except PT, from this main arterial road through the city centre. More space will then be dedicated to pedestrians and cyclists.

MaxSUMO: A NEW APPROACH TO THE EVALUATION OF MOBILITY MANAGEMENT PROJECTS

Veronique Van Acker,
Begga Van Cauwenberge, Frank Witlox

1 INTRODUCTION

"You can't manage what you don't measure". This old management adage is still accurate today. You cannot manage for improvement unless you measure what is getting better or worse. This principle also holds for mobility management projects. Mobility Management (MM), also known as "soft policy measures", refers to a concept to promote sustainable transport and manage the demand for car use. "Soft" measures like information and communication campaigns and offering tailor-made mobility services are used to change travellers' attitudes and behaviour. Such "soft" measures are frequently used to support and strengthen "hard" measures like the construction of new tram lines or new bike lanes (EPOMM, 2011). Some commonly used techniques such as cost-benefit analysis exist for the evaluation of these "hard" measures. However, no such standardized evaluation techniques yet exist for "soft" measures.

Interest in MM projects as a solution for mobility problems and associated environmental problems has undoubtedly increased in recent years. For example, the first annual European Conference on Mobility Management was organized in 1997, but afterwards the need was felt to have a platform providing some continuity. Consequently, two years later, in 1999, the European Platform on Mobility Management (EPOMM) was established. It started as a European platform, but soon developed into an international association (in 2006).

If MM projects were given greater policy priority, they could be much more effective than initially assumed. Based on a review of UK and international evidence, Cairns et al. (2004) developed a "low intensity" and a "high intensity" impact scenario for the future implementation of MM projects in local and national transport policies. In the low intensity scenario, they maintain the interest in and attention on MM projects at the current level. The scenario results indicate a reduction in peak period urban traffic of about 5% and a nationwide reduction in all traffic by about 3%. In the high intensity scenario, they assume much more interest in MM projects and many more funding and resources. In the high-intensity scenario, MM projects have the potential to reduce urban traffic during peak hours by about 21% (off-peak 13%), non-urban traffic during peak hours by 14% (off-peak 7%), and a nationwide reduction in all traffic of about 11%. They also estimated the potential effect of various individual MM projects: workplace travel plans can reduce car use between 10 and 30%, school travel plans between 8 and 15%, and personalised travel planning initiatives from 7 to 15% in urban areas and from 2 to 6% in smaller urban areas and rural areas. These projected changes in traffic levels are thus quite large and indicate that MM projects merit serious consideration in local and national transport policies.

However, other transport researchers (e.g. Stopher and Bullock, 2003) warn that results of review studies such as Cairns et al. (2004) might be too optimistic. This is mainly due to the poor quality of the data used in the studies that are reviewed and, subsequently, used as input for scenario development. Moreover, different mobility habits due to cultural, economic, social, or other reasons complicate a cross cultural analysis of MM projects. For these reasons, Möser and Bamberg (2008) critically re-evaluated 141 studies on the effectiveness of three types of MM projects (workplace travel plans, school travel plans, personalised travel planning). They found a much lower potential of 7%.

These inconsistencies between the findings of various studies call for the development of a rigorous evaluation method. Typical methods used to evaluate MM projects generally lack empirical vigour (e.g. small sample sizes, unrepresentative samples, over reliance on self-reported behaviour, the lack of corroborative data to confirm self-reported data, a number of external factors not included in research methodology…) and, thus, serious questions remain about the reliability of these methods (Möser and Bamberg, 2008; Bonsall, 2009; Carreno et al., 2010). There is clearly a need for the development of robust evaluation techniques. MaxSUMO is considered as a suitable technique to evaluate MM projects. This paper therefore illustrates the usefulness of MaxSUMO to evaluate MM projects which were recently undertaken by the city of Ghent, Belgium.

The paper is structured as follows. Section 2 presents the MaxSUMO approach, and the usefulness of it is illustrated in the third section. This third section first describes the study area of Ghent, a medium-sized city in Belgium, before discussing the results of various MM projects undertaken by the city. Finally, results are summarized and discussed in section 4.

2 HOW TO EVALUATE MM PROJECTS?

There is clearly a need for the development of robust evaluation techniques, but in order to accomplish this we must first understand what we are evaluating. Or in other words, a better understanding of how MM projects work and how they affect individuals' modal choices is needed as well. Carreno et al. (2010) mention two key facts.

First, some people are more susceptible, or ready, to change their travel behaviour than others. For example, Curtis and Headicar (1997) found that only a minority of car commuters is susceptible to change. This group is more likely to be male, in their 30s and, most importantly, they travel short commuting distances (5 miles or less). More recently, Anable (2005) segmented a population of day trip travellers into potential "mode switchers". Six distinct groups were extracted, but susceptibility of car users to switch modes was rather limited. These varying degrees of mode switching potential partly relate to differences in objective and subjective factors. For some people the barriers to switch modes can be objectively determined. For example, people will not switch to public transport if no adequate bus services are offered and the quality of public transport is poor. On the other hand, switching potential might also be influenced by subjective factors such as peoples' perceptions, attitudes, value, level of confidence towards their current travel choices, but also towards alternative travel choices, as well as their willingness to actually alter travel choices. For example, if people have negative attitudes towards public transport (whether justified or not), have little or no confidence in public transport or see no reason to change their car use, they are less susceptible to switch from car to public transport. The question however remains whether these subjective factors correspond to reality, and how the switching potential is influenced by a mismatch between these two.

Second, politicians might ultimately be interested only in short-term changes such as a targeted reduction in car use but changing peoples' behaviour is not a one-step process. Changing travel behaviour must instead be seen as a series of transitional stages through which individuals progress (Prochaska and DiClemente, 1984). For example, it takes time to change an individual's modal choices and it usually starts with altering non-behavioural aspects such as attitudes that are not necessarily connected strictly to mobility

Consequently, any MM project is likely to affect people in different ways based on (i) people's susceptibility to change behaviour, and (ii) their stage position within the behavioural change process. Any evaluation methodology must therefore not only focus on behaviour change as such, but also on the more subtle changes in attitudes and perceptions underlying the behaviour change process. Researchers use a variety of pre-existing theoretical frameworks such as, among others, the Theory of Planned Behaviour, the Norm-Activation Model and the Social Cognitive Theory (for a more comprehensive review see e.g. MAX SUCCESS, 2008). However, no consensus exists on which framework is the most appropriate. Each theoretical model conceptualizes other factors of behaviour change instead of the process as a whole, and often uses different terminology to indicate very similar (or even identical) factors (Weinstein, 1993; MAX SUCCESS, 2008). Evaluating the step-wise behaviour change process thus requires specific evaluation techniques. MaxSUMO is such a new standardized evaluation tool that takes this step-wise process into account.

MaxSUMO has been developed as part of the wider MAX project (2006–2009), the largest research project on MM within the EU's sixth framework programme. MaxSUMO is a general evaluation framework that provides step-by-step guidance for users to effectively plan, monitor, and evaluate MM projects (see section 2.1). It is based on a new theoretical behaviour change model MaxSEM which acknowledges the step-wise behavioural change process (see section 2.2).

2.1 MAXSUMO

The evaluation strategy of MaxSUMO is based on the idea of measuring effects at different levels (see Figure 1). The "gap" between the MM project and the expected effects is often large. MaxSUMO divides this gap into smaller steps, or assessment levels. Targets, indicators, and results can be specified at each of these levels, so that each level can be monitored and evaluated separately. This makes it possible to measure effects at an early stage in a project.

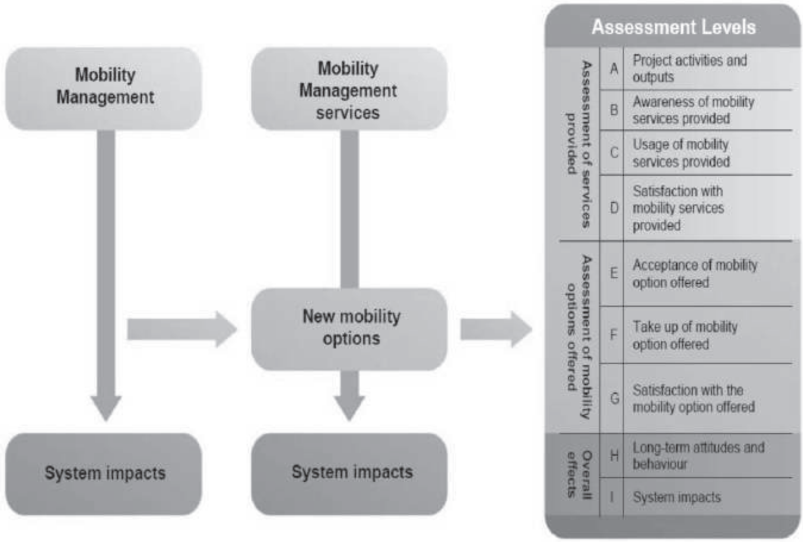


Figure 1: Assessment levels in MaxSUMO (MAX SUCCESS, 2009a).

The different MaxSUMO levels are divided into four main categories:

- *Intervention framework conditions* (although not symbolized in Figure 1) refer to external factors and person-related factors. External factors include background information of the location where the MM project is offered. These external factors are similar for all users (e.g., quality of public transport services). Person-related factors include information about the personal situation of different users. These person-related factors are "objective" factors such as the distance to the nearest bus stop as well as "subjective" factors such as the individual's stage of behaviour change and their travel behaviour before the MM project was offered (e.g., home-work travel distance). In other words, the intervention framework conditions refer to the wider context in which the MM project is organized. These contextual characteristics might thus constrain or facilitate the success of the MM project.
- *Services provided* refer to the different activities of the MM project in order to achieve changes in travel behaviour (e.g. information meetings, distributing brochures and posters).

After describing the project activities and output, researchers should also pay attention to (i) the degree to which people are aware of the MM project, (ii) the usage or interest in the MM project by people who are aware of the MM project, and (iii) how satisfied the users are with the services provided.

- *Mobility options* offered through the services provided refer to the new travel behaviour the MM project aims to encourage. For example, by offering free season tickets for public transport (= service provided) frequent car drivers might switch to public transport for some or all of their trips (= mobility option). One should also distinguish between (i) people who intend to change travel behaviour and are willing to accept the mobility option offered, and (ii) people who eventually test the new travel behaviour and take up the mobility option offered. Afterwards, the latter might also be asked whether they are satisfied with this mobility option. After all, being satisfied with the new travel behaviour remains a pre-condition for long-term changes in attitudes and behaviour.
- *Overall effects*, finally, refers to the main outcomes of the MM project in terms of (i) new attitudes and behaviour (e.g. decrease in car use), and (ii) more general system impacts due to these new attitudes and behaviour (e.g. CO_2 emissions saved by this decrease in car use).

The design of MaxSUMO is thus simple and the methods included are not significantly different from other guidelines for transport and policy evaluations. However, MaxSUMO is unique in how targets, indicators and results can be specified at different assessment levels bridging the gap between implementation of the MM project and its expected effect. MaxSUMO thus provides step-by-step guidance so that MM projects are effectively planned, monitored, and evaluated.

2.2 MAXSEM

As mentioned above, the use of MaxSUMO starts with describing the intervention framework conditions. One of these conditions refers to person-related factors and describes the individual's stage of behaviour change. These stages can be determined using MaxSEM (Max Self-regulation Model). MaxSEM not only measures individuals' stage positions (i.e. their susceptibility to change behaviour), but also stage movement (i.e. progression towards actual behaviour change). It utilizes the most important factors of "static" psychological models of behaviour change, such as norms and goal feasibility, and links them with the temporal dimension of the process of change by incorporating four key "stages" of behaviour change (MAX SUCCESS, 2009a). This helps to analyze and segment the target group and thus to choose and design the most appropriate and effective MM projects for them.

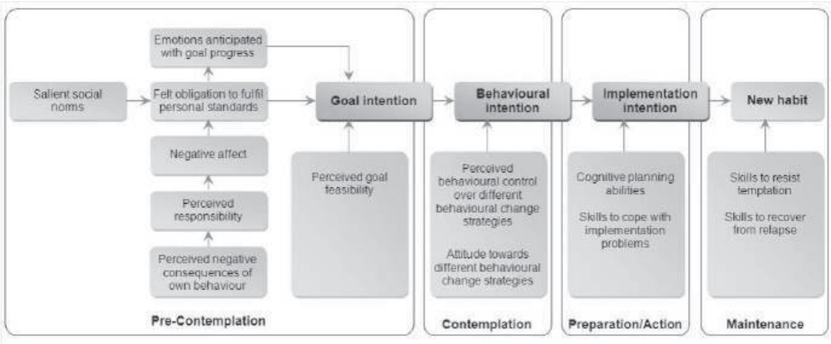


Figure 2: Overview of MaxSEM stages and critical thresholds (MAX SUCCESS, 2009a).

Stage 1: Pre-contemplative stage. Persons in this stage are habitual car drivers who have no intention to reduce their current car use or feel that it would be impossible to change due to objective and subjective reasons. In this stage, travel awareness campaigns are necessary to persuade this group to consider travel alternatives other than their car.

Stage 2: Contemplative stage. Persons in this stage mainly use their cars, but are not content with their current car use and would like to reduce it. However, they are unsure of how to do so or lack the confidence to change their travel behaviour. Persons in this stage thus need tailor-made travel information.

Stage 3: Preparation/action stage. Persons in this stage still use their cars, but already know how to switch to another travel mode (e.g. public transport). Moreover, they also intend to switch to this alternative, have the confidence to do so, and may have already tried this new travel mode for some trips. The aim here is to have the group actually try out new behaviour (e.g. by offering free season tickets for public transport), and to assist them in maintaining this new behaviour (e.g. with a tool visualizing the money saved while travelling by public transport instead of by car).

Stage 4: Maintenance stage. Persons in this stage have successfully changed their travel behaviour and have formed a new habit. MM projects in this stage should reward the new habit so that no relapse to the old behaviour occurs.

The aim of MM projects is to move the persons to the next "higher" stage and prevent relapses to a "lower" stage. Critical threshold criteria must be satisfied before any stage-progression can occur (see orange boxes in Figure 2). For example, for progression from pre-contemplative to contemplative stages individuals must first recognize their current car use as "problematic" (*Perceived negative consequences*). This might eventually result in the formation of a personal goal (e.g. reducing personal car use in order to save CO_2) which must be perceived positively (*Perceived goal feasibility*). Once in the contemplation stage, people seek for the best alternative travel mode. People must first have a positive attitude towards this alternative (*Attitude towards different behavioural change strategies*) and/or need to feel confident that they can use this alternative themselves (*Perceived behavioural control*). Once this is achieved, the previously formulated goal is translated into a more precise behavioural intention (e.g. the intention to use a bus instead of their car for some trips in the weekend). Now, people need to plan more specifically in the preparation/action stage: when, where, and how to use the new travel alternative. It is important that they use their *cognitive planning abilities* to retrieve relevant information (e.g., interpreting the timetable of the local bus) and are able to cope *with implementation problems* (e.g. using a regularly updated web service instead of an outdated timetable). If people make definite plans to try out the travel alternative, their behavioural intention is translated into an implementation intention (e.g. going to the city centre for shopping by bus at 10 a.m. next Saturday). Finally, in the maintenance stage, before a new habit is formed, people need to repeat the newly tested travel alternative (e.g. by travelling by bus for other work and leisure trips and at other times as well). Therefore, they must use their *skills to resist temptation* (e.g. fall back into their old behaviour and use their cars). If they do not resist, they have to *recover from relapse* and take up the new behaviour again.

Question: Which of the following statements best describes how you feel about your current level of car use for daily trips (in city X / to your workplace[1]) and whether you have any plans to try to reduce some or all of these car trips? Please choose which statement fits your current situation best and tick only one box.		Stage allocation
At the moment I use a car for most of my trips. I am happy with my current level of car use and see no reason why I should reduce it.	☐	Pre-contemplation
At the moment I use a car for most of my trips. I would like to reduce my current level of car use, but at the moment I feel that it would be impossible for me to do so.	☐	Contemplation
At the moment I use a car for most of my trips. I am currently thinking about changing some or all of these trips to non-car modes, but at the moment I am unsure how I can replace these car trips, or when I should do so.	☐	
At the moment I use a car for most of my trips, but it is my aim to reduce my current level of car use. I already know which trips I will replace and which alternative transport mode I will use, but as yet have not actually put this into practice.	☐	Preparation / Action
As I do not own / have access to a car, reducing my level of car use is not currently an issue for me.	☐	Maintenance
As I am aware of the many problems associated with car use, I already try to use non-car modes as much as possible. I will maintain or even reduce my already low level of car use in the next months.	☐	

Figure 3: MaxSEM stage-diagnostic questions (MAX SUCCESS, 2009a).

[1] The exact wording of this question will depend on the type of trips the MM project is attempting to change (e.g. random trips or more specific trips such as journeys to/from workplaces, schools, etc.).

MaxSEM provides six so called "stage-diagnostic questions" (see Figure 3) which objectively measure peoples' stage position and readiness to change. This set of questions results from a series of validation studies within the MAX project (MAX SUCCESS, 2009a). With the help of these questions, it becomes clear whether MM projects directly result in changing the actual behaviour or rather that people move to the next stage and move closer to behaviour change. MaxSEM is thus on the one hand a theoretical model explaining the process of behaviour change (see Figure 2), and on the other hand a practical tool determining the different stages of behaviour change (see Figure 3).

By asking the stage-diagnostic questions, people are grouped into different stages. This facilitates the design of appropriate MM projects according to which stage the individuals within the target population are currently in. For example, an appropriate travel awareness campaign might persuade pre-contemplators to consider alternatives for their current car use. By asking the same questions after the travel awareness campaign as well, the effect of this campaign can be evaluated and it then illustrates whether people progressed to advanced stages of readiness to change behaviour (MAX SUCCESS, 2009b).

3 MAXSUMO IN PRACTICE

In this paper, we illustrate the use of MaxSUMO based on the results of an MM project recently undertaken by the city of Ghent, Belgium.

3.1 STUDY AREA

Since 2008, the city of Ghent has been taking part in CIVITAS. The city of Ghent has implemented 24 sustainable mobility measures, grouped into five integrated packages. One of these packages specifically focuses on MM as a tool for changing mobility behaviour. This integrated package contains all types of "soft" measures that will be implemented to improve (i) citizens' awareness of different sustainable transport modes and (ii) citizens' commitment to change their non-sustainable urban mobility behaviour. The measures consist of new communication strategies (e.g. a 3D-model) and new concepts (e.g. school travel plans for secondary schools). In this paper one specific campaign, "*I keep moving, even without my car*", is evaluated using MaxSUMO.

3. 2 THE CAMPAIGN'S COURSE

The integrated package focusing on MM as a tool for changing mobility behaviour consists of six measures. One measure provides tailor-made information to citizens about public transport and bicycle or walking routes in their neighbourhood. Doing so, this measure aims at raising citizens' awareness about options for sustainable mobility, illustrating that a modal shift from car use towards more sustainable transport modes is achievable.

Information on sustainable transport modes was distributed among citizens in the first place by a tailor-made brochure (mobility campaign entitled “*Our district is moving*” or “*Onze wijk beweegt*” in Dutch). The city of Ghent is divided into 20 residential neighbourhoods, each with very specific transport features. Neighbourhood-specific characteristics are therefore included in each brochure (see Figure 4).

Figure 4: The brochure “Our district is moving” for the Mariakerke district (left) and Muide-Meulestede district (right).

Citizens who received this brochure were afterwards invited to join “mobiteams”, groups of citizens per neighbourhood who exchange ideas, information and experiences related to sustainable mobility. Mainly people who already use sustainable transport modes responded to the invitation. The target group of car-dependent people was, however, not interested in being part of a “mobiteam”. They did not respond to the general brochure, which did include neighbourhood-specific characteristics, but neglected the specific characteristics of car-users themselves. After the distribution of the brochures and invitations, no follow-up was organized and citizens were not questioned about why they did or did not wish to participate in the campaign. Consequently, we are not sure whether the disinterest of car-dependent people was the result of an inadequately designed brochure or other reasons. However, the results do suggest that car-dependent people do not spontaneously seek out information on sustainable mobility; therefore, more specifically and carefully designed initiatives had to be undertaken to inform car-dependent people about sustainable travel options.

One possibility was to contact people through the system of "play streets". Play streets are closed for motorized traffic during specific hours or days in the holidays so that children can play freely in the streets, and they are organized by the city on request of citizens. One might expect that the willingness to participate in a project about sustainable mobility is greater in these streets. Consequently, residents of these play streets were invited to participate in a competition between play streets to find the street with the highest modal shift toward more sustainable transport modes (the mobility campaign entitled "*Our street is moving*" or "*Onze straat beweegt*" in Dutch). Residents were asked to use public transport, a bike or walk for trips which are normally travelled by car. They could register their sustainable trips and travel distances in a specifically developed website, which also calculated the amount of CO_2 saved, calories burned, and money saved. This illustrated the environmental, health and monetary benefits of sustainable transport. Despite all efforts, only a handful of households wanted to participate. To gain insight in this total lack of interest, residents of play streets were personally interviewed two months after the start of the campaign. Only one third recalled having received the invitation to participate. Two thirds of them had actually read the invitation letter, but did not reply, mainly due to lack of time. However, many residents became interested in the campaign after the interview. Thus, a very personal approach seems necessary, especially in campaigns aiming at changing attitudes and behaviour. From this notion, a third campaign, entitled "*I keep moving, even without my car*" (or "*Ik beweeg ook zonder auto*"), was developed.

3.3 THE CAMPAIGN "I KEEP MOVING, EVEN WITHOUT MY CAR"

The campaign "*I keep moving, even without my car*" aimed at changing travel behaviour of frequent car users by providing personal guidance and advice on sustainable travel options.

The city planned interviews with at least 300 citizens who frequently use their cars but are willing to switch to public transport, cycling or walking for some of their trips. From this group of 300 citizens at least 10 citizens should be willing to participate in the campaign. This means that these 10 citizens should be very aware of their travel behaviour during one month and use sustainable alternatives for each trip whenever possible. The city thus set targets at different assessment levels according to the MaxSUMO approach (see Figure 5).

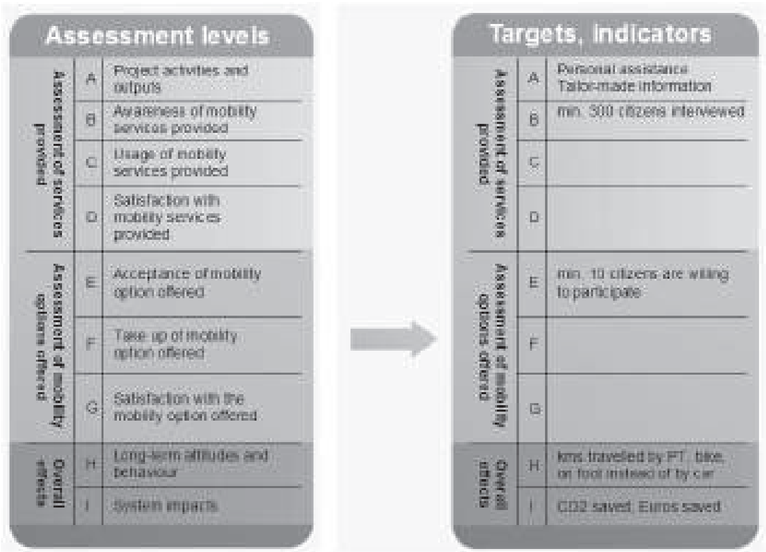


Figure 5: Defining targets and indicators at different assessment levels.

3.4 THE RESULTS

In April 2011, two pollsters interviewed 454 citizens at various public places such as the shopping mall, library, and sports centres. 44 citizens did not own a car, used public transport or walked/biked frequently. These respondents were already in the final maintenance stage of the behaviour change process and, thus, did not belong to the target group of this MM project (i.e. frequent car users). The other 410 citizens all owned a car and might be interested in participating in the campaign. To determine their stage position, five stage-diagnostic questions were asked, similar to the MaxSEM questions mentioned earlier (see Figure 6).

Almost one in ten car owners stated that they frequently used their cars and saw no reason for changing this (9.0% in the pre-contemplation stage). At the other end of the spectrum, one third frequently used sustainable transport modes (33.4% in the maintenance stage). These two groups clearly did not belong to the target group of this MM project. Consequently, more than half of all car owners can be described as frequent car users, who might be willing to switch to sustainable transport modes but have not done this so far for various reasons:

- 7.1% wanted to use public transport and bike more frequently, but were unsure how to replace their car trips with sustainable travel modes (contemplation stage),
- 15.6% already knew how to switch from car to public transport or bike, but had not put this into practice (preparation stage),
- 34.9% already used public transport and bike, but wanted to use these sustainable travel modes more frequently (action stage).

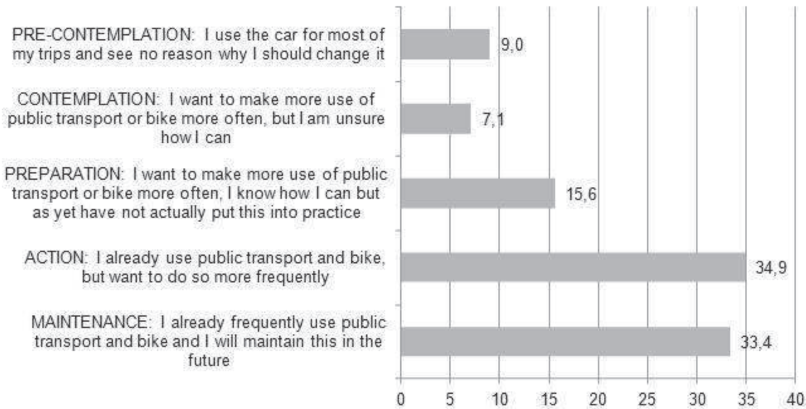


Figure 6: Distribution of stage position according to the campaign "*I keep moving, even without my car*".

These three groups of respondents (236 respondents) might be interested in personal guidance and advice on the use of sustainable travel options. Consequently, these respondents were questioned further about their susceptibility to change travel behaviour. After explaining the content of the campaign "*I keep moving, even without my car*", they were asked what they thought about the campaign. The majority (71.2%) considered the campaign to be a great initiative. One quarter (25.0%) did not have a strong opinion about the campaign, while only a minority (3.8%) thought it a completely useless initiative.

Despite the generally positive opinion about the campaign, people's willingness to participate was significantly lower. The questionnaire did not include any questions on the reasons for (non-) participation. Consequently, no further insights can be gained on the significant gap between the respondents' positive interest in the campaign and their willingness to participate. Only a dozen respondents (7.0%) were willing to participate in this campaign, but ultimately only 6 citizens actually participated. In June 2011, these 6 participants were asked to consider sustainable transport alternatives for each car trip they used to make. They were given personal assistance and detailed information (e.g. city maps, brochures, and websites on sustainable mobility). The consultancy bureau *Traject* was standby 24/7 to give necessary transport information (e.g. which bus or bike route to take to a specific destination). If needed, free bicycles and season tickets were also offered to the participants. During this test month, the participants were contacted several times in order to inquire whether additional help or information was needed.

The 6 participants were asked to forgo as many car trips as possible and to register their sustainable trips on a specifically developed website, which also calculated the amount of CO_2 and money saved. Table 1 illustrates that, during just one month, these 6 participants travelled more than 2,000 km with sustainable travel modes instead of with their cars. This equals almost 340 kg less CO_2 and 600 Euros less spent on travel.

	"sustainable" km	CO2 saved (gr)	Euros saved
Gert	33	5,148	8.84 €
Carole	67	10,452	19.43 €
Doris	296	46,176	81.87 €
Femke	302	47,112	92.00 €
Ann	405	63,180	117.51 €
Daria	1,060.5	165,438	283.00 €
TOTAL	2,163.5	337,506	602.65 €

Table 1: Results of the campaign "*I keep moving, even without my car*".

A follow-up is planned in November 2011. The 6 participants will be surveyed over the telephone, assessing their mobility behaviour after the campaign. This will clarify whether the 6 participants formed new travel habits and really progressed to the final maintenance stage of the behaviour change process.

4 CONCLUSIONS

This paper reports on the usefulness of MaxSUMO as a new methodology to effectively plan, monitor, and evaluate MM projects. It breaks down the complex process of behavioural change into smaller steps, facilitating monitoring and evaluation. These steps are presented in MaxSUMO as different assessment levels. For each assessment, level targets and indicators must be defined, but some levels can be skipped as it is neither possible nor necessary to monitor all levels in some MM projects. This approach is illustrated by Figure 7 which summarizes the evaluation of the campaign "*I keep moving, even without my car*", recently organized by the city of Ghent, Belgium.

This campaign aimed at changing travel behaviour of frequent car users, who were willing to change but did not know how to, or had not changed their car use yet. The participants received personal guidance and tailor-made advice on sustainable travel options so that they could switch from car trips to more sustainable trips by public transport, biking or walking as much as possible. The city targeted that at least 300 citizens should be made aware of the campaign, with at least 10 citizens willing to participate in the campaign, resulting in more sustainable trips and less CO_2 and money spend on travel. Eventually, 454 citizens were interviewed on the street, but only 236 respondents belonged to the target group of frequent car users willing to change their travel behaviour. The campaign was presented to these respondents only. Consequently, the initial target of 300 citizens to be made aware of the campaign was not fully achieved. Furthermore, 71.2% of the respondents considered the campaign a great initiative. Although no initial target was set for the respondents' interest in or usage of the mobility services provided, the interviews revealed great interest in the campaign. However, 7% of the target group, or 16 respondents, were effectively willing to participate in the campaign. The willingness to participate was thus higher than targeted, but eventually only 6 respondents participated in the campaign. A large gap seems to exist between the respondents' interest in the campaign, their willingness to participate, and their actual participation. However, the reasons behind this significant gap are unclear since the questionnaire did not account for this issue. This offers avenues for future research. Gaining insight into the reasons why someone decides to (not) participate in a campaign might provide useful information so that campaigns can be designed more successfully.

Although only 6 persons participated in the campaign and received personal advice on how to switch their car trips to more sustainable trips, the results are quite positive. During only one month, these 6 persons travelled more than 2,000 sustainable km and saved more than 300 kg CO_2 and 600 Euros.

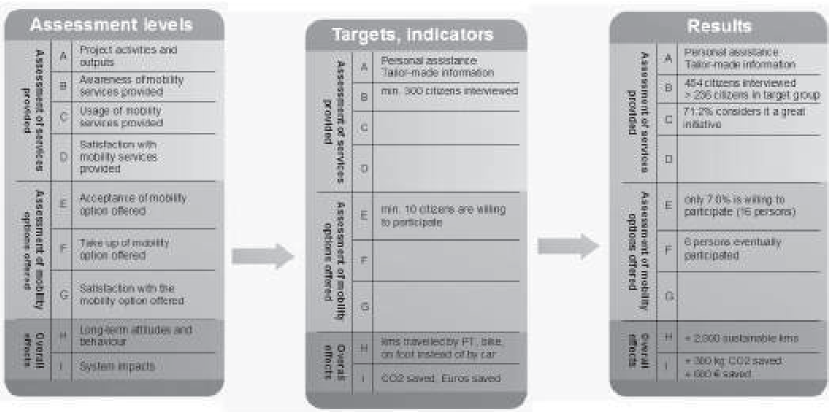


Figure 7: Summary – Results at different assessment levels according to MaxSUM.

This paper also reports on the many efforts that were needed to design a successful campaign. The campaigns prior to the "*I keep moving, even without my car*" campaign illustrate that contacting a target group is not always an easy undertaking. However, this step was facilitated by using the stage-diagnostic questions of MaxSEM at the beginning of the interviews on the street. These stage-diagnostic questions easily clarified that almost one in ten respondents would not change their car use, one in three respondents had already changed their car use to more sustainable travel options, and half of all respondents belonged to the target group of frequent car users willing to change their travel behaviour. This narrowed down the initial sample of 454 citizens interviewed on the street to a specific target group of 236 respondents, facilitating the further steps within the MM project.

Although a tendency exists to report only good practice case studies of MM projects (Möser and Bamberg, 2008), using the step-wise approach of MaxSUMO offers better insight into both the positive and negative aspects of a MM project. For example, the final results in terms of more sustainable kms and the amount of CO_2 and money saved are clearly described. However, the drop from great interest in the campaign to limited willingness to participate, and even more limited actual participation in the campaign, is significant. This step-wise approach thus offers valuable insights for anyone organizing a MM project as it clearly illustrates at which specific steps the MM project was successful (or not).

Some reservations should, however, be raised since any model of behavioural change is a reduction of real processes. It is obvious that there are numerous reasons for supporting behavioural change, which cannot be included in every model. Furthermore, the evaluation of a mobility campaign promoting sustainable travel options must take into account the broader context of modern societies, which are mainly "automobility" cultures. Therefore, every campaign against individual car use will face (informal, veiled) pro-automobility campaigns, (in) directly supported by fossil fuel energy producers, car manufacturers, car dealers, and others with a stake in the car industry.

REFERENCES

Anable, Jillian. 2005. 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy* 12: 65–78.

Bonsall, Peter. 2009. Do we know whether personal travel planning really works? *Transport Policy* 16(6): 306–314.

Cairns, Sally, Lynn Sloman, Carey Newson, Jillian Anable, Alistair Kirkbridge and Phil Goodwin. 2004. *Smarter Choices – Changing the Way we Travel*. London: Department for Transport.

Carreno, Michael, Sebastian Bamberg, Janina Welsch and Tom Rye. 2010. *How best to evaluate mobility management projects: Can psychological theory help? Proceedings of the 12th World Conference on Transport Research*. Lisbon: Portugal.

Curtis, Carey and Peter Headicar. 1997. Targeting travel awareness campaigns: which individuals are more likely to switch from car to other transport for the journey to work? *Transport Policy* 4(1): 57–65.

EPOMM. 2011. Mobility Management: a Definition. The Definition of Mobility Management and the Categorisation of Mobility Management Measures as approved by the MAX-consortium and EPOMM. Available at: http://www.epomm.eu/index.phtml?Main_ID=820, 6. 7. 2012.

MAX SUCCESS. 2008. Comprehensive State of the Art Report Annex B1.1 Behaviour Change Models. Available at: http://www.max-success.eu/downloads.phtml, 6. 7. 2012.

MAX SUCCESS. 2009a. Work Package B. Final Report. Available at: http://www.max-success.eu/downloads.phtml, 6. 7. 2012.

MAX SUCCESS. 2009b. MaxSumo. Guidance on How to Plan, Monitor and Evaluate Mobility Projects. Available at: http://www.max-success.eu/downloads.phtml, 6. 7. 2012.

Möser, Guido and Sebastian Bamberg. 2008. The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence. *Journal of Environmental Psychology* 28: 10–26.

Prochaska, James O. and Carlo C. DiClemente. 1984. *The Transtheoretical Approach: Crossing Traditional Boundaries of Therapy*. Homewood IL: Dow Jones/Irwin.

Stopher, Peter P. and Philip Bullock. 2003. *Travel behaviour modification: A critical appraisal. Proceedings of the 26th Australasian Transportation Research Forum*, Wellington: New Zealand.

Weinstein, Neil D. 1993. Testing four competing theories of health-protective behaviour. *Health Psychology* 12: 324–333.

GHENT I Cycling paths have been restored and new cycle lanes have been installed.

GHENT I The “measuring” tram led to technical adaptations. De Lijn saves up to 200,000 euro per year.

GHENT I Cycle monitor counts every cyclist on a daily base.

DEFINING QUANTITATIVE IMPACTS OF THE PT PRIORITY SYSTEM AND COMPARING DIFFERENT DATA COLLECTION METHODS

Marko Matulin, Štefica Mrvelj,
Hrvoje Gold, Niko Jelušić

1 INTRODUCTION

Public transport (PT) is generally perceived as a public service of great importance. It is a service that meets the needs of mobile citizens and contributes to overall quality of life and sustainability. This is true of many CIVITAS cities, but especially in the ELAN cities in which improving the quality of life and sustainability are among the specific project objectives. The PT system itself can be described as a system with complex relations between transport infrastructure, transport demand, economy, politics, land use planning, and, more recently, marketing, environment, and the quality of life. These relations define the development of PT through its accessibility, availability, usability, flexibility and, ultimately, through its performance. An efficient way to of improve PT performance is to give priority to PT vehicles at signalised intersections. In this case, the PT system is supported by a traffic control system that ensures the progression of public transport vehicles through the city's traffic signals on the tram or bus corridors. This paper is based on the research undertaken within the CIVITAS ELAN project where one of the objectives (within measure 8.2-ZAG Public transport priority and traveller information) was to introduce such a system in the City of Zagreb (see The Civitas Initiative)

1.1 QUANTITATIVE AND QUALITATIVE INDICATORS

The benefits of introducing PT priority systems are often expressed through their economic impact, where we can see in which way and to which extent specific implications affect the PT company, city authority, users, society, etc. Currie et al. (2005 and 2007) and Vedagiri et al. (2009), among others, report on the results of these economic analyses. Detection and evaluation of transport impacts of PT priority system include comprehensive evaluation of PT performance on different PT lines. This means defining performance indicators and conducting field measurements.

By reviewing the literature we found that PT performance is often expressed with a mix of quantitative and qualitative indicators. This lack of standardisation was previously indicated by Pullen (1991). After an extensive review of the literature on measuring PT performance, Pullen concluded that there was a distinct lack of standardisation in the definition of the attributes (i.e. indicators) which comprise PT performance, and argued for improved definition and clarification of these attributes.

After two decades, the merits of PT performance are still ambiguously defined. Harrison et al. (1998) defined "hard" quality attributes as such which are more quantifiable (e.g. access time), and "soft" quality attributes as "non-journey time attributes" such as information provision, staff attitude, and satisfaction. In their research, Prioni and Hensher (2000) grouped bus performance attributes into six quality dimensions: accessing the bus stop, waiting time, trip, vehicle, driver, and information. In 2002, the EU deployed a standard for certification of public transport system performance (EN13816) which categorises qualitative and quantitative performance indicators into eight categories: availability (network, operation time, reliability), access (interfaces, ticketing), information (travel information), time (travel time, punctuality, regularity), customer service (staff availability, competence, assistance), comfort (space, driving), security (criminal attacks, accidents), and environment. PT companies are not obliged to comply with this standard and to date the standard and certification has been implemented in only a few PT companies in the EU. Evidently, few PT companies have so far recognized the benefits which unified standardization across the EU would bring (the most important benefit: the ability to compare results).

Egmond et al. (2003) defined four levels of PT performance: external, strategic, tactical and operational. The first level performance focuses on population attributes, population density and distribution; the strategic level refers to political interest and regulations; the tactical level performance analyses the organisational and financial framework; and the operational level deals with the accessibility of different PT modes, inter-modality, marketing and information. A further distinction between different views of PT performance was put forward by Thompson and Schofield (2007). They attribute higher importance to the user perspective of PT performance and state that "hardcore" performance is a good indicator for the service provider, but that "true" performance can only be evaluated with customer satisfaction surveys.

This brief overview of the literature serves for the purpose of showing how different interpretations of PT performance can lead toward inconsistency in the approach to evaluation and in defining performance indicators, which are important for defining PT's priority effects. This implies that a set of indicators is needed to describe PT performance in a qualitative and quantitative manner.

In order to solve the problem of connecting qualitative and quantitative indicators for describing the quality of service of any PT system, an analogy is drawn with telecommunications systems. This is because the definitions of indicators and their relations are much better investigated in this kind of system. In general, two equally important sets of indicators can be defined when evaluating a PT system:

- performance indicators (or "hard" indicators) – this set of indicators describes the performance of PT in a *quantitative manner* (e.g. operating speed, dwell time, service intervals, number of accidents, punctuality, etc.),
- quality of service indicators (or "soft" indicators) – this set of indicators is used for surveying user opinions about specific aspects of the PT service and describing it in a *qualitative manner* (e.g. satisfaction about punctuality, travel time, safety, ticket price, comfort, company image, etc.).

For the purpose of evaluating different impacts of PT priority we focused exclusively on the operational performance of the tramway lines. The vagueness of PT performance definitions encouraged us to define our own evaluation indicators, which were then used for evaluating the conditions before the implementation of the PT priority system in Zagreb. This approach, which was developed during the ELAN project, was presented by Matulin et al. (2010) and then updated by Matulin et al. (2011). A complete evaluation of the impacts of the PT priority system would also require investigating user satisfaction (i.e. investigating the qualitative indicators[1]), but this is outside the scope of this paper. We present the results of the performance analysis of one tramway line which passes through the ELAN demonstration corridor.

1 Note that the measurement results (e.g. PT vehicle travel time or operating speed) are not influenced by user opinions (qualitative indicators) in any way.

1.2 THE ZAGREB CASE

As mentioned before, measure 8.2 of the CIVITAS ELAN project was the introduction of a PT priority system in Zagreb. The objective was to implement the PT priority system at signalised intersections within the ELAN demonstration corridor, and to evaluate its impacts (the majority of ELAN measures was implemented in this corridor in order to maximize the project's impact). The ELAN corridor area is a 3.2 km long two-way street (*Savska cesta*, located in between *Ilica* street to the north and *Selska cesta* street to the south) with mixed traffic conditions (i.e. the traffic infrastructure is often shared by PT and individual transport modes).

In order to collect the data for this purpose, four data collection methods were used and analysed: manual time recording, GPS vehicle tracking, PDA computer system, and manual video data processing. After a comparative analysis of these methods, several use-case scenarios were defined in order to elicit a preferable combination of methods for this type of measurement. Use-case scenarios describe different traffic situations on the PT vehicle's itinerary which are closely related to the location of the PT station and PT vehicle occupancy.

The remainder of this paper is structured as follows: section 2 defines the impacts of the PT priority system and connects specific impacts with performance indicators. The different data collection methods which were applied are described in section 3, as well as their pros and cons. In section 4 we present the results of the measurements and in section 5 the conclusions.

2 EVALUATION APPROACH

2.1 IMPACTS OF THE PT PRIORITY SYSTEM

A single journey of a tram has two terminals (origin terminal A and destination terminal B) and a finite number of PT stops and signalised intersections in between. The main impact of the PT priority system on the operational performance of trams is the reduction of intersection delay (see Figure 1). This reduction should result in a decrease of travel time between adjacent PT stops and terminals on the same PT line, but sometimes this is not the case due to the various background impacts, which will be described in detail in this chapter: mixed traffic conditions, number of PT users, number of PT vehicles in operation, time-gap between PT vehicles and partial implementation of the PT priority system.

An analysis of the tramway infrastructure in the city of Zagreb shows that on most tramway lines the infrastructure is shared by other transport modes (mostly individual transport). This is due to the structure of the city, the limited available space, the costs of building new infrastructure (e.g. underground systems), and other factors. Due to this mixed traffic conditions, queues of cars build up at signalised intersections, often blocking the tram tracks, during the peak and off peak periods of the day, when transport demand is at its highest level. The tram tracks are occasionally blocked by traffic accidents, resulting in further performance deterioration. Sun et al. (2008) detected and described the complex interactions between PT vehicles and general traffic vehicles in such mixed traffic environments. In this case, the positive impacts of giving priority to the PT vehicles at signalised intersections are easily cancelled out because the trams cannot reach the intersections.

Several measures of the CIVITAS ELAN project in the city of Zagreb are devoted to the promotion of PT services and improvement of its quality (e.g. safety and security improvements, introduction of energy efficient PT vehicles, a PT electronic ticketing system, etc.). The main objective of these measures is to increase the number of users and contribute to a more sustainable urban transport system. More users may require more PT vehicles in order to satisfy the increased transport demand. More trams may increase the possibility of congestion because seven tramway lines are in operation in some parts of ELAN corridor. This means that the time-gap between two trams may become too short, and several PT vehicles may arrive at the same PT stop at the same time, negatively affecting boarding and alighting times. Moreover, one could argue that with more PT users it will also take longer for passengers to board and alight at the PT stops. This means that tramways will spend more time at the PT stops, and their round trip times and passenger travel times will increase as well.

Furthermore, the effects of the PT priority system may be reduced if the system itself is only partially implemented. This can happen in two cases:

- if the PT priority system is not implemented at all signalized intersections of the selected line/corridor (in this case PT vehicles may pass through one intersection to cause blockage at the next one),

- if the priority equipment is not installed in all PT vehicles travelling on the same line/corridor (in this case a vehicle that is not equipped with the priority equipment may disturb the traffic flow of equipped PT vehicles).

All the above described background impacts affect the tramway's operational performance. In the analysis of the possible benefits of a PT priority system, such impacts must not be ignored. In our case, when a PT priority system is implemented only for a certain part of the tramway line, improvements achieved at the micro level (e.g. at specific intersections or between two adjacent PT stops) may remain undetected if the operational performance is not evaluated for each segment of the line.

2.2 DEFINITION OF EVALUATION INDICATORS

To detect all impacts of the PT priority system in the demonstration corridor, as well as background impacts, we introduced operation time decomposition as depicted in Figure 1. A list of expected events on the PT vehicle's itinerary is included at the bottom of Figure 1, and a specification of specific operation time segments in relation to these events is included at the top of Figure 1.

Apart from the indicators presented in Figure 1, two more indicators, which can be derived, are described: speed per segment and operating speed (see Table 1). Note that the running time indicator can also be related to user perception about his/her travel time between adjacent PT stations.

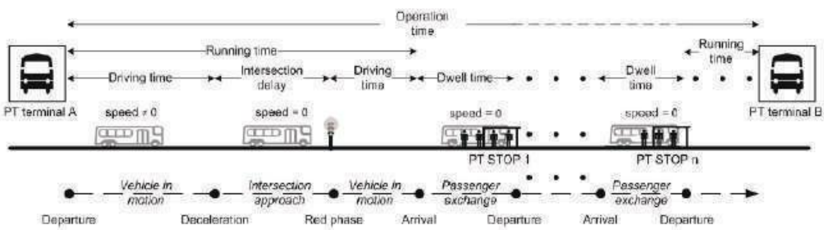


Figure 1: Operation time decomposition.

Indicator	Description
Operation time	The time that elapses from the departure of a PT vehicle from one terminal to its arrival at the line's other terminal.
Operating speed	The average journey speed of PT vehicles between an origin and a destination terminal, including any delay arisen in the course of the journey.
Dwell time	The time a vehicle spends at a PT stop due to passenger exchange. The time needed for opening and closing the doors is also part of the dwell time.
Intersection delay	The time that elapses from the arrival of a PT vehicle at an intersection until it leaves the intersection.
Speed per segment	Vehicle speed for predefined segments of the line (a segment represents a part of the PT line between two adjacent PT stops).
Running time	The time that elapses from the departure of a PT vehicle from a stop to its arrival at the next stop.
Driving time	The time a vehicle spends in motion.

Table 1: Indicator description.
Source: Matulin et al., 2011.

The mathematical equations for the group of indicators defined in Table 1 are presented below. According to the definition (Štefancic, 2008), the total vehicle operation time (T_{op}) is defined by:

$$T_{op}=T_{dw}+T_{rt} \quad (1)$$

T_{dw} is the total time spent at PT stops and T_{rt} is the total time spent on running between PT stops by the PT vehicle on a journey between two terminals. For a known length of a PT line ($s_{P/Tline}$) and after having calculated T_{op}, the operating speed of the PT vehicle (v_{op}) can be derived:

$$v_{op}=\frac{s_{P/Tline}}{T_{op}} \quad (2)$$

The total time spent at PT stops is the sum of dwell times elapsed at different PT stops of the same PT line:

$$T_{dw}=\Sigma^{n}_{i=1}t_{dw_i} \quad (3)$$

t_{dw_i} is the dwell time for PT stop i and n is the number of PT stops on the PT line, (Štefancic, 2008). The total running time between PT stops is equal to:

$$T_{rt}=\Sigma^{n-1}_{j=1}t_{rt_{j,j+1}} \quad (4)$$

$t_{rt_{j,j+1}}$ is the running time between two adjacent PT stops and n

is the number of PT stops, (Štefancic, 2008). The first PT stop is the origin terminal A and *n*-th PT stop is the destination terminal B. We now decompose running time between two adjacent PT stops ($t_{rt_{j,j+1}}$) into:

$$t_{rt_{j,j+1}} = t_{dt_{j,j+1}} + \Sigma^{m}_{i=1} t_{id_i} + \Sigma_k t_{loss_k} \quad (5)$$

$t_{dt_{j,j+1}}$ is the time which a PT vehicle spends in motion between two adjacent PT stops (i.e. driving time) and $\Sigma^{m}_{i=1} t_{id_i}$ is the total intersection delay which is caused at the finite number of intersections *m* between two adjacent PT stops (*j,j+1*). Any additional loss of time (e.g. delay caused by mixed traffic conditions) is included in $\Sigma_k t_{loss_k}$ (*k=0,...,N* where *N* is the number of events which caused unplanned vehicle stopping). Note that expression $\Sigma^{m}_{i=1} t_{id_i}$ can be equal to 0 in two cases; firstly, when the PT vehicle passes through the intersection without stopping, and secondly, when there are no intersections between two adjacent PT stops.

Speed per segment ($v_{j,j+1}$) is the distance travelled between two adjacent PT stops ($s_{j,j+1}$) divided by $t_{rt_{j,j+1}}$:

$$v_{j,j+1} = \frac{s_{j,j+1}}{t_{rt_{j,j+1}}} \quad (6)$$

This group of evaluation indicators and their mathematical equations allowed us to detect even minor changes in operational performance because we were able to analyse the performance on an *intersection-by-intersection* basis. Moreover, the data analysis helped to detect critical spots in the network where performance deteriorates rapidly, especially during certain periods of the day.

3 DATA COLLECTION DESCRIPTION

3.1 METHODS USED

In order to collect the data about the operation time and its segments, four data collection methods were used:

- Manual time recording. Six students equipped with stop watches travelled in trams in the time period of one week and manually recorded the time at tramway stops and signalised intersections. The data was then manually imported into an Excel table. During data processing, the above-mentioned indicators were derived.

- GPS vehicle tracking. Four GPS receivers were installed in four trams travelling on the same line. Recording took place in a period of one week, each day from 6 AM to 10 PM. Every device recorded the vehicle position and actual speed for each second. GPS data was extracted from the devices and imported into an Excel table.
- Manual video data processing. A video was extracted from the vehicle surveillance system (for one working day). While observing the recorded video, two students manually entered the data for performance indicators directly into Excel spreadsheets.
- Personal Digital Assistant (PDA) computer system. By using the application installed on a PDA device one student recorded arrival/ departure times at PT stops and at intersections, as well as the duration of every dwell time. The application recorded and calculated the values of the performance indicators. Data from the section's database on the PDA device were exported to the section's database in the computer for data processing.

While experimenting with different data collection approaches some advantages and disadvantages were detected. This experience serves as a good basis for a comparative method analysis.

3.2 COMPARATIVE ANALYSIS OF METHODS

For the purpose of conducting a comparative analysis of data collection methods, a set of criteria was developed:

- Accuracy of the measurement. The accuracy of the measurement has been assessed based on the analysis of collected data and results. For instance, while applying a manual time recording method, errors in the running time and intersection delay occurred. Depending on each individual student and their perception, errors were in the range of 5 to 10 seconds for the ELAN corridor. The PDA computer system reduced that error to about 1 to 2 seconds. While applying the GPS vehicle tracking method the source of errors is a mismatch between the geographical locations of the PT stations or signalised intersections and the vehicle's actual position recorded by the GPS receiver. This error has special significance if it occurs at PT stops and intersections when vehicle speed is 0 km/h.

- Resolution of the measurement. The resolution of the measurement means the frequency of data input (e.g. the GPS vehicle tracking method had the best resolution because vehicle position and speed were recorded every second and data was thus collected for the entire ELAN corridor instead of at control points only).
- Method reliability. The method reliability criterion refers to representativeness of the data and results. For example, while applying the manual time recording method, the students sometimes did not record the exact date and time when the measurement took place. Furthermore, after the data were processed, we established that a few derived speeds per specific segment of the tramway line were simply inaccurate.
- Data processing. An easy conclusion is that for some of the applied methods data processing is the main disadvantage (e.g. manual time recording method and GPS vehicle tracking) whilst for the PDA computer system method partially processed data is exported into a computer database. This aspect was evaluated with a data processing criterion.
- Method execution (preparation, human resources, duration, equipment cost and simplicity). The intention of the method execution criterion is to point out different aspects. The preparation sub-criterion is associated with activities that have to be undertaken before measurement. For instance, manual time recording includes organising the students and designing the layout of the data entry forms, while GPS vehicle recording requires only the installation of the device. The number of people needed to execute the measurement and data processing is evaluated with the human resources sub-criterion. Likewise, the time interval from the preparation phase to the production of results is graded by the duration sub-criterion. Equipment cost refers to the approximate cost of the used equipment. A last sub-criterion is introduced to evaluate the simplicity of the method.

The results of the comparative analysis of data collection methods are presented in Table 2 in a scale from 1 to 5 (1 meaning *worst performance* and 5 meaning *excellent performance*). As Table 2 indicates, the manual recording method performed the worst (average grade). A slightly better method is the manual video data processing method, but it still has a large number of disadvantages, which makes it unattractive to use. The initial evaluation of methods shows that the PDA computer system method performs very well, thanks to the user-friendly application (developed specifically for this use). The same grade applies to the GPS vehicle tracking method, but the data processing first has to be improved, i.e. map matching has to be used to improve the accuracy of the recorded tracks.

	Manual time recording	PDA computer system	GPS vehicle tracking	Manual video data processing
Accuracy	2	4	4	4
Resolution	3	3	5	4
Reliability	2	3	5	3
Data processing	2	5	1	2
Preparation	2	4	3	2
Human resources	2	3	5	4
Duration	2	5	2	3
Equipment cost	5	2	3	2
Simplicity	2	4	5	1
Average grade	2,44	3,67	3,67	2,78

Table 2: Initial method evaluation.

3.3 USE-CASE SCENARIOS

Based on the results of the initial evaluation of data collection methods, it is evident that the PDA computer system method and the GPS vehicle tracking method produced the best results. During the measurement some specific traffic situations occurred in which additional differences between those two methods emerged. Based on those traffic situations three use-case scenarios for one signalised intersection were synthesised.

Figure 2: a) recorded GPS track; b) actual PT vehicle position.
Source of orthophoto: Croatian State Geodetic Administration.

Figure 2 shows the recorded GPS track (white line) for that specific intersection. The white triangles on the map indicate the movement of a single tram (v ≠ 0 km/h) and rectangles mean that the tram was stopped (v = 0 km/h).

In general, the GPS vehicle tracking method gives very accurate results for the vehicle operation time and average operating speed. But when the speed is around 0 km/h and due to the GPS signal reflection, GPS tracks can indicate the tram's position as around 30–40 meters away from its actual position. Without map matching (Figure 2.b) it is impossible to determine the vehicle's actual position at a specific point in time, which is important for the calculation of different operation time segments.

If two trams arrive at the same station at the same time, as is depicted in Figure 3.a, it is not possible to determine the exact reason why tramway B stopped with the GPS vehicle tracking method. In this specific situation, the geographical location of the PT stop and the position of vehicle B, when the speed is 0 km/h, do not overlap. Having the GPS signal reflection problems in mind, it is hard to determine during the data processing whether vehicle B has reached the PT stop and started to board passengers or another vehicle (PT or even personal car) was occupying the PT stop at the time.

When the PT stop is located directly before a signalised intersection and the "red" period is activated (Figure 3.b), intersection delay and dwell time measurements are incomplete when using the GPS vehicle tracking method. This results in an inaccurate calculation of driving time and speed per segment. While processing the data extracted from the GPS device it is easy to establish when the vehicle speed was 0 km/h, but in this case the difference between dwell time and intersection delay cannot be determined.

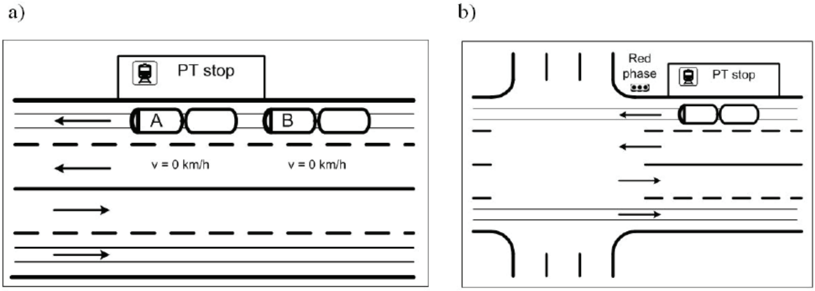


Figure 3: Two use-cases: a) arrival of two trams at the same PT stop; b) specific geographical location of PT stop.

Applying a PDA computer system method avoids the above-mentioned problems, because the measurer can distinguish dwell time from intersection delay. Furthermore, the measurer travels in the PT vehicle during the measurement and he/she can initialise the dwell time measurement only when the PT vehicle reaches the PT stop. Although the GPS vehicle tracking method has several disadvantages, it is still very appealing in comparison with the PDA computer system method because data is recorded every second, enabling a more detailed analysis. Hence, the following results of the measurements were produced based on the data collected with the GPS method.

4 RESULTS

4.1 DWELL TIME

The amount of time a tramway spends at a specific PT stop depends on the stop's location and can vary during the day. As an example of these variations, we present the results of the measurement of dwell times (t_{dw_i}) for several PT stops during one PT vehicle journey (Table 3). In order to obtain dwell time results we had to conduct a comparison between a tram's speed and position and the location of PT stops. When a tram reaches a specific PT stop (a geographical position), its speed equals 0 km/h and this is the point in time when the dwell time starts. The end of the dwell time is identified when the tram's speed becomes different from 0 km/h (departure time). In this example, two time intervals were analysed on a typical working day. The presented results show that the tram spends less than 15 seconds at some PT stops, meaning that only few passengers board or alight there.

Name of the PT station_ sequence number	First interval		Second interval	
	□□□□	Departure time	□□□□	Departure time
Frankopanska_1	0:00:33	14:40:38	0:00:29	16:40:50
Trg_marš_Tita_2	0:00:58	14:43:38	0:00:27	16:42:43
Vodnikova_3	0:00:35	14:45:13	0:00:25	16:44:03
Stud_centar_4	0:00:15	14:47:58	0:00:26	16:47:27
Zagrebčanka_5	0:00:19	14:51:29	0:00:13	16:50:23
Učit_akademija_6	0:00:17	14:52:51	0:00:20	16:51:59
Vjesnik_7	0:00:12	14:54:38	0:00:12	16:53:44
Prisavlje_8	0:00:10	14:55:43	0:00:14	16:54:59
Veslačka_9	0:00:08	14:56:25	0:00:12	16:55:50
□□□=	0:03:27		0:02:58	

Table 3: Result of measurements.

Knowing the values of dwell times can be important when analysing the running time between specific PT stops. For example, if there is an increase of passengers, and consequently an increase of the dwell time (this is one of the detected background impacts), while the running time between two stops remains the same – i.e. when comparing the conditions before and after the implementation of the PT priority system – then this means that the priority system has significantly contributed to the operational performance on that segment of the line.

4.2 INTERSECTION DELAY

PT vehicles travel in urban environments and their operational times may be significantly affected by the intersection delays on their routes. Where PT vehicles do not have priority at signalised intersections, $\sum^{m}_{i=1} t_{id_i}$, can be a major part of T_{op}. Based on the Level of Service (LoS) framework, defined in the Highway Capacity Manual 2000 (Transport Research Board, 2000), which comprises six LoS classes for signalised intersections (A, B, C, D, E and F with defined t_{id_j} intervals expressed in seconds [0, 10), [10, 20), [20, 35), [35, 55), [55, 80) and [80, + ∞], respectively), we present the daily variations of average intersection delay (ID) for three selected intersections (Figure 4). For each in a specific time period we assigned a LoS class beneath the horizontal axes. The vertical grey lines in the diagrams correspond to the upper and lower limits of the assigned LoS class for the specific time period. This allows us to see, for instance, that on the northbound approach to the "Vjesnik_10" intersection (Figure 4.a.) the $t_{id_{10}}$ falls under class C in the period from 6 p.m. to 8 p.m., but it is very close to the upper limit of that class, i.e. its performance deteriorates toward class D.

Comparing this with another intersection ("Zagrebčanka_8") reveals that the signal plans on that intersection and the transport demand cause lower performance in the period from 10 a.m. to 6 p.m. for southbound PT traffic, compared to the performance in the northbound direction (Figure 4.b and Figure 4.d). In other periods, however, the situation is almost exactly the opposite. Based on these findings, a strategy for the implementation of priority measures can be defined more easily and background impacts can be detected. For instance, if the PT priority system is installed at specific intersections, and there is no change in intersection delay, this indicates that the PT vehicles are having difficulties reaching that intersection. This may be caused by mixed traffic conditions and infrastructure sharing or by partial implementation of priority equipment in the PT vehicles. Furthermore, Satiennam (2005) elaborated the importance of intersection delay measurements in the development and evaluation of priority system's control logic.

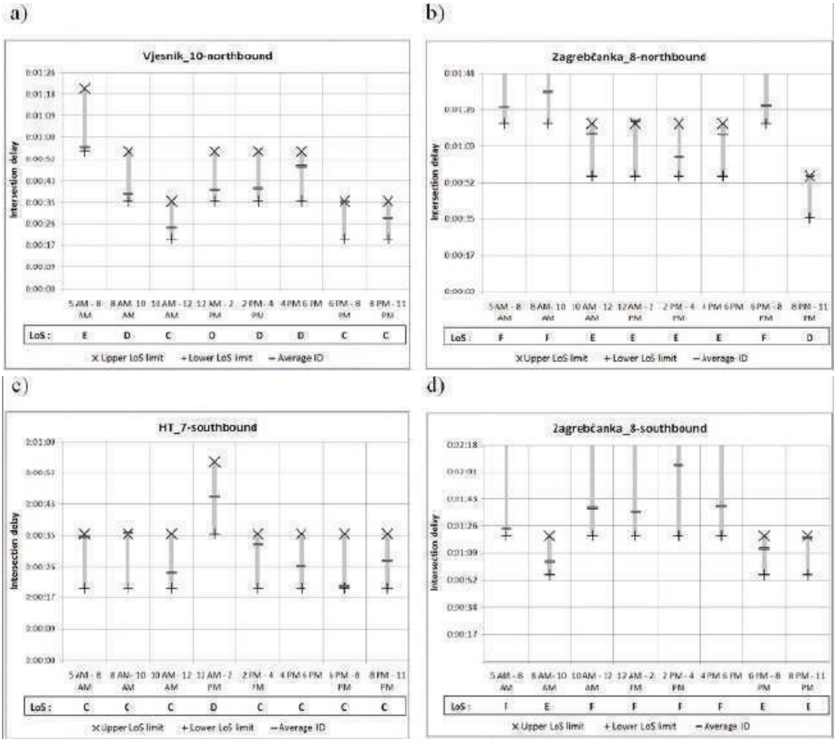


Figure 4: Daily variations of intersection delay at: a) Vjesnik_10-Northbound; b) Zagrebčanka_8-Northbound; c) HT_7-Southbound; d) Zagrebčanka_8-Southbound.

4.3 SPEED PER SEGMENT AND RUNNING TIME

As an example of speed per segment analysis, Figure 5 shows the comparison of measured PT vehicle speeds between two adjacent PT stops ("Stud_centar_4" and "Zagrebčanka_5") during different time periods.

The speed trajectories depicted in Figure 5 are useful for examining the main reasons for deceleration and stopping. The slow progress with an almost constant-speed trajectory in the beginning, recorded for the monitored PT vehicle in the 2–3 p.m. period, is the result of a blocked PT lane, i.e. mixed traffic conditions. In addition, this speed trajectory shows a long delay at the second intersection ("Zagrebčanka_8") – over one minute (see Table 4). The time spent waiting to move forward to the intersection is included in t_{id_i} because the length of the intersection's approach lane is defined by the GPS measurement.

The time spent waiting to move forward to the intersection is included in □□□.

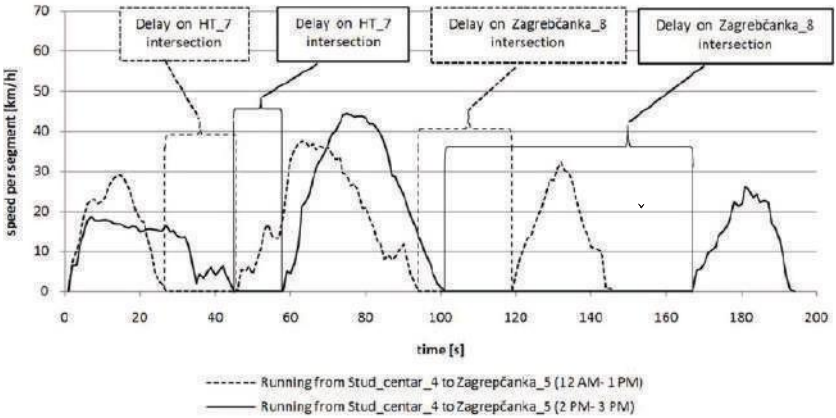


Figure 5: Comparison of measured PT vehicle speeds between two adjacent stops.

Time of running	$t_{dt_{j,j+1}}$	t_{id_1}	t_{id_2}	$\Sigma^2_{i=1} t_{id_i}$	$\Sigma_k t_{loss_k}$	$t_{rt_{j,j+1}}$	$v_{j,j+1}$ [km/h]
12 AM - 1 PM	0:01:36	0:00:21	0:00:27	0:00:48	0:00:00	0:02:24	13.09
2 PM - 3 PM	0:01:49	0:00:14	0:01:08	0:01:22	0:00:00	0:03:11	10.83

Table 4: Decomposition of running time $t_{rt_{j,j+1}}$.

These two indicators (speed per segment and running time) are important for evaluating operational performance on specific segments of the ELAN corridor. By comparing the same line segments, but in different time periods, fluctuations in transport demand can be identified with more precision and this may be helpful when developing a signal control scheme for PT priority.

4.4 OPERATION TIME AND OPERATING SPEED

Since we conducted the measurements in the predefined demonstration corridor, we considered operation time to be the time that elapses between the moment when a tram enters the corridor and the moment of its exit from the corridor.

For example, for the time period between 4 p.m. and 5 p.m. and for both directions of travel, the tram's operation times (T_{op}) are shown in Table 5. For the northbound and southbound directions we recorded four and nine journeys of PT vehicles, respectively, in the above-mentioned time period. The shaded cells in the table indicate the minimum values (recorded on Sunday) and the maximum values are indicated as bold text (for the northbound and southbound directions the maximums were recorded on Tuesday and Wednesday, respectively). The data in Table 5 reveals that, in this period, the trams travel faster when they are heading north and generally travel faster during weekends.

Northbound		Southbound	
Journey number		Journey number	
1	0:14:43	1	0:19:16
2	0:13:28	2	0:15:31
3	0:15:37	3	0:12:22
4	0:13:08	4	0:19:12
		5	0:19:40
		6	0:17:53
		7	0:19:19
		8	0:13:07
		9	0:13:11

Table 5: Operation time comparison.

Figure 6 depicts the arithmetic mean (AM) of the derived operating speed in the demonstration corridor of different PT lines and each direction of travel. Depending on the direction of travel, it is evident that the operating speed significantly differs on every PT line. If we exclude PT line number 4, we may conclude that trams travel faster when they are travelling northbound (for some PT lines the difference is close to 50 %).

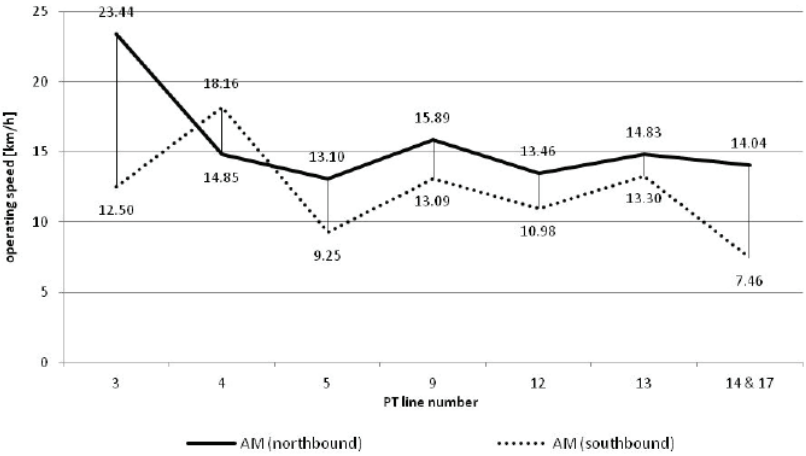


Figure 6: Comparison of operating speeds for two directions of travel.

If the PT priority system would be installed at every signalised intersection along a specific PT line, it should be possible to determine the overall improvement of operation performance on that line by keeping track of these two indicators.

5 CONCLUSIONS

The analysis of the data collection methods reveals that the GPS vehicle tracking method provides a very wide resolution of collected data because it records vehicle position and speed every second. Despite some disadvantages in comparison to the PDA computer system method, it is still very appealing because it enables a more detailed analysis. It must be noted that in the past 5 to 10 years all newly produced PT vehicles are equipped with GPS receivers, meaning that this data collection method can be implemented with relatively small efforts from the PT companies.

The positive impacts of the PT priority system (reduction of running time between PT stops) can be cancelled out by the background impacts described throughout this paper. To determine the actual impact of the PT priority system we introduced operational time decomposition, enabling us to evaluate public transport performance on an *intersection-by-intersection* basis. Hence, all the positive impacts of priority systems can be quantified and expressed in financial terms, where necessary, in later analyses. The measurements were conducted with the GPS vehicle tracking method in real-life traffic conditions and the results show that our evaluation approach is valid, and that analyses are possible even on the smallest scale.

By recording and monitoring intersection delay and running time indicators, operational performance can be determined for a specific segment of a PT line. If there is no improvement in network performance after the introduction of the priority system, a detailed analysis of every specific evaluation indicator can provide clarification (i.e. background impacts can be identified).

REFERENCES

Currie, Graham, Majid Sarvi and Bill Young. 2005. Road space allocation for public transport priority. *Proceedings of the AITPM National Conference*: 77–94.

Currie, Graham, Majid Sarvi and Bill Young. 2007. A new approach to evaluating on-road public transport priority projects: balancing the demand for limited road space. *Transport* 34(4): 413–428.

Egmond, Patrick van, Peter Nijkamp and Gabriella Vindigni. 2003. *A comparative analysis of the performance of urban public transport systems in Europe.* Oxford: Blackwell Publishing Ltd.

Harrison, S., G. Henderson, E. Humphreys and A. Smyth. 1998. Quality bus corridors and green routes: can they achieve a public perception of 'permanence' of bus services? *Proceedings of the 26th European Transport Conference PTRC*: 225–236.

Matulin, Marko, Štefica Mrvelj and Hrvoje Gold. 2010. Evaluating the public transport priority system – Identifying background data impact. *Proceedings of the 17th ITS World Congress.*

Matulin, Marko, Štefica Mrvelj and Niko Jelušić. 2011. Two-level evaluation of public transport system performances. *Promet – Traffic &*

Transportation: Scientific Journal on Traffic and Transportation Research 23(5): 329–339.

Prioni, Paola and David Hensher. 2000. Measuring service quality in scheduled bus services. *Journal of Public Transportation* 2(3): 51–74.

Pullen, William Thomas. 1991. *The Measurement of the quality of local bus services with respect to the effects of bus deregulation in Scotland.* Newcastle: University of Newcastle upon Tyne.

Satiennam, Thaned, Atsushi Fukuda, Toshiaki Muroi and Sarawut Jansuwan. 2005. An enhanced public transport priority system for two-lane arterials with nearside bus stops. *Proceedings of the Eastern Asia Society for Transportation Studies* 5: 1309–1321.

Sun, Huijun, Bingfeng Si and Jianjun Wu. 2008. Combined model for flow assignment and mode split in two-modes traffic network. *Journal of Transportation System Engineering & IT* 8(4): 77–82.

Štefančić, Gordana. 2008. *Tehnologija gradskog prometa 1*. Zagreb: Faculty of Transport and Traffic Sciences.

The Civitas Initiative. Cleaner and Better Transport in Cities. Available at: http://www.civitas-initiative.org/index.php?id=70&sel_menu=6&proj_id=10, 6. 7. 2012.

Thompson, Karen and Peter Schofield. 2007. An investigation of the relationship between public transport performance and destination satisfaction. *Journal of Transport Geography* 15: 136–144.

Transport Research Board. 2000. *Highway capacity manual 2000*. US: National Research Council.

Vedagiri, Perumal and Venkatachalam Thamizh Arasan. 2009. Estimating modal shift of car travelers to bus on introduction of bus priority system. *Journal of Transport System Engineering and Information Technology* 9(6): 120–129.

ZAGREB I Real-time travel information has been made available via 147 displays installed at PT stops.

ZAGREB I 70 new trams provide more comfort and a higher level of security to all passengers.
Security improvements were achieved by introducing CCTV cameras in the vehicles.

ZAGREB I A series of workshops on safer use of PT has been held with senior citizens. The main focus of the workshops was on PT, the most important transport mode for seniors apart from walking.

IDENTIFICATION OF RISKS REGARDING THE INTRODUCTION OF MEASURES AIMED AT IMPROVING CITIZEN MOBILITY IN THE CITY OF ZAGREB

Ivan Grgurević, Marko Slavulj,
Veselko Protega

1 INTRODUCTION

The City of Zagreb with its about 800,000 inhabitants has to deal with a sudden increase in the level of motorization. The modal split has been constantly shifting in favour of passenger cars (44 percent in 1990, 59 percent in 2003, according to The Croatian Bureau of Statistics) and the city centre is thus faced with traffic network congestion, generating negative effects such as increased pollution and noise, a growing number of traffic accidents, illegal parking, and longer journey times. In response to the existing traffic system, attempts have been made to implement various mobility management solutions (MVA, 1999).

The realization of mobility management objectives is still related to the proposals from the 1999 Traffic Study of the City of Zagreb. Attempts are made to use partial projects and solutions, based on annual plans and in accordance with the city's current financial options, to improve its traffic throughput capacity and enhance the mobility of citizens. In Europe, many international projects have been started (among them the CIVITAS Initiative) aimed at improving the mobility of citizens and their daily migrations, regardless of the purpose of their movements, including walking.

Given the 555,372 officially registered vehicles in 2008 (compared to 380,464 in 2000 and 226,676 in 1995; exclusive of transit vehicles and vehicles from the city environs), the City of Zagreb has intensively invested in studies and projects in the last decade (1999 Traffic Study of the City of Zagreb, 2007 research project: "The realization of the underground-overhead light rail system in the City of Zagreb" etc.) to improve the urban traffic system and to manage mobility. These efforts have intensified due to the forthcoming accession of the Republic of Croatia to the European Union and the accessibility of its structural funds.

Before starting the CIVITAS ELAN project, there had been almost no constructive dialogue related to traffic issues. Within the CIVITAS projects' activities a constructive dialogue started among stakeholders, but, on the other hand, this dialogue proved to be a great challenge to inexperienced stakeholders.

In Croatia, citizens have been included in decision-making processes regarding urban development through public hearings and in various other ways since the 1960s. However, in relation to mobility issues, the main decisions are taken by professionals and the public most often can react only after decisions have been implemented. The inclusion of the interested representatives of the public will help to reach appropriate decisions, reduce dissatisfaction, and introduce shared responsibility for the implemented solutions. Appropriate decisions had to be reached on issues of crucial importance for the project's success. The mentioned issues are further addressed in the project's procedural structure and relate to several potential risks regarding the successful implementation of solutions.

Considering the improvement of citizen mobility as the major goal, citizens' participation in the decision-making process has been emphasised. Citizens participate in different processes, such as: searching for suitable mobility solutions, evaluation of proposed (customized) mobility solutions, and evaluation of risks regarding the introduction of solutions.

The paper investigates citizens' participation in introducing solutions referring to the following measures: 4.4 "Mobility management for large institutions", 3.2 "Study on Congestion Charging and Dialogue on Pricing", 7.4 "Freight Delivery Restrictions" (Civitas inicijativa, 2012). The first measure (4.4) is oriented towards citizens as employees and students, while the other two measures (3.2 and 7.4) are oriented towards citizens as traffic participants.

2 RISK ASSESSMENT REGARDING THE ANALYZED MEASURES

All projects involve certain potential risks and uncertainties, both in relation to the broader environment in which the project operates (e.g. financial markets, political situation) and the execution of the project itself. Some of these can be minimised through the way in which the project is managed and financed, while in other cases the best solution is to prepare contingency plans, so that any problem can be addressed with minimum delay. Risk management procedures should be applied to identify potential sources of uncertainty and risks, as well as their likely causes, and to then prepare countervailing or contingency plans, as appropriate.

Challenges to the implementation of innovative urban transport solutions are not always of a technical nature. The main obstacles rather tend to be behavioural, changing implementation conditions, or institutional issues. CIVITAS ELAN adopts a process-oriented approach and accentuates risk management, including contingency plans and early warning systems for project risks.

In general, two levels of risks were differentiated:

- risks to measure implementation and success,
- project management-related risks.

For the first level, all local project partners had identified and described potential risks and contingencies in their measure descriptions using the following risk types for categorisation:

- technical risk – e.g. due to failure or low performance of (immature) technologies, technical systems or methodologies, incompatibilities between systems, safety hazards of particular technologies,
- financial risk – e.g. related to delayed payments from third parties (cash flow), substantial cost increases for major components, parallel investments and budget modifications,
- organisational risk – e.g. dependency on a single supplier, interdependence of implementation steps and stages, coordination between project and other measures, availability of management skills and capacity,
- political risk – e.g. cooperating agencies are governed by opposition political parties, politicization of measure topics, existing resistance or lobbying against measures,
- institutional risk – e.g. related to the restructuring or privatisation of organisations, project tasks beyond usual practices or competencies, changing composition of boards or committees,
- legal Risks – e.g. due to conflicts of interest between actors, legal gaps or uncertainties,
- spatial Risks – e.g. related to the physical interference between measures and urban structures (infrastructures, operation area).

Each of the mentioned risks has numerous characteristics that require a comprehensive analysis in order to implement the solution and improve the city's traffic capacity. The risk management and contingency plans regarding the introduction of a carpooling system in the City of Zagreb are summarised in Table 1.

Risk type	Risk Description	Contingency Plan	Probability (high/ medium/low)	Potential Impact (high/medium/low)
Legal	Possible questions concerning insurance of passengers in carpooling schemes	Explore legal possibilities	medium	medium
Financial	Price of necessary web application for carpooling	Finding sponsors	medium	medium
Technical	Possible problems in the operation of web applications	IT professionals tasked to maintain the system	low	low
Organisational	Lack of support by possible user groups Lack of motivation	Communication campaign	low	low
Political	Not understanding the problem	In terms of support and decision making	medium	medium
Institutional	Insufficient cooperation between involved partners	Regular meetings	low	high
User Acceptance	Insufficient number of users	Communication campaign, provide links to carpooling website from various sites	low	high
Spatial	Defining area for use of carpooling scheme Determining trip origin carpooling locations in urban areas	Study will determine optimal area for use of carpooling system	low	low

Table 1: Risk management and contingency plans for the introduction of a carpooling system in the city of Zagreb.

A risk analysis we conducted showed that user acceptance and institutional risk have a high potential impact on the introduction of a carpooling system in Zagreb. Carpooling is a basic indicator of mobility management and the occupancy of private cars in the City of Zagreb has shown low values: 1.44 (1999), 1.37 (2009), and 1.40 (2010). For the observed years, minor deviations from the average values have been noted, ranging from a total of 27.4 to 28.8% (1.4%). Alternative modes, such as a carpooling system, cannot by themselves generate an economically (self) profitable service of sufficient dimensions. To achieve better effects, support at the institutional (local and national) level is important.

Risk management and contingency plans regarding the study of congestion charging and the views on pricing are summarised in Table 2. Principled types of risks are presented according to their probability and potential impact (high/medium/low/very low).

Risk type	Risk Description	Contingency Plan	Probability (high/ medium/low/very low)	Potential Impact (high/ medium/low/very low)
Legal	Lack of legal tools for implementation	Close cooperation with the respective authorities	medium	medium
Financial	No risks identified	-	very low	very low
Technical	No risks identified	-	very low	very low
Organisational	Difficulties in conducting public procurement process	Measure timetable will allow for delays up to 6 month	medium	low
Political	Lobbying of consumer associations by political opposition	Communication campaign - Explanation of priorities	medium	medium
Institutional	Insufficient cooperation between involved partners	Regular meetings	low	high
User Acceptance	Potential users could oppose charging	Communication campaign	medium	high
Spatial	Delay in definition of zones where congestion charging is made	Communication with city authorities	medium	medium

Table 2: Risk assessment and contingency plans for the study of congestion charging and dialogue on pricing.

The risk analysis detected two major issues with a high potential impact on the implementation process: user acceptance and institutional risk (see Table 2). The possibility that the proposed congestion charge solution would be rejected can be reduced by a high level of acceptability.

Analysing the main objectives of measure 7.4 Freight delivery restrictions – raising the acceptance of a delivery restriction policy and reducing the traffic congestion level – it becomes obvious how important stakeholders' participation is. One has to be aware of the various risks involved during the analysis and implementation phases (see Table 3).

Risk type	Risk Description	Contingency Plan	Probability (high/ medium/low/very low)	Potential Impact (high/ medium/low/very low)
Legal	Non-obeying of existing regulation	Strict implementation by municipal guards	high	high
Financial	No risks identified	-	very low	very low
Technical	Specific demands for freight deliveries by various users	Pooling among possible users	low	high
Organisational	Delay in defining acceptable means of transport	Measure timetable allows for delays up to 6 months	low	low
Political	Lobbying for rejection of any motorized traffic by some groups	Communication campaign	medium	medium
Institutional	Insufficient cooperation between involved partners	Regular meetings	medium	high
User Acceptance	Users may consider joint deliveries complicated	Communication campaign	medium	medium
Spatial	Finding out area of implementation	Study will define area	low	medium

Table 3: Risk assessment and contingency plans for new urban freight delivery regulations.

Similar to the former freight delivery regulations (Službeni glasnik Grada Zagreba 8/2007; 10/1998), which were not properly observed, the proposed new regulations may (if not observed) cause increased daytime congestion and further discourage pedestrians and cyclists as traffic participants. Municipal guards and traffic police should be able to reduce this legal risk with a high potential impact (see Table 4) by ensuring strict implementation of the new regulations. The fact that various businesses have different supply demands (various kinds of goods, quantities of goods, different working hours, locations, etc.) may cause difficulties in defining common delivery schemes. The planned action of pooling businesses from different branches should prevent this technical risk with a high potential impact.

A typical organisational risk is a delay in the measure's time schedule (of a small step or an entire phase). In this case, the possibility of a delay in defining suitable transport means as an important element of the freight delivery solution, would be prevented by anticipating an up to six-month delay in the measure's schedule.

Achieving the measure's objective, i.e. decrease the number of vehicle movements (as key a source of nuisance), is only a small step in the long run to the final goal. Citizens with a higher awareness level of the importance of environmental issues, expecting more than a small step, may lobby for more "radical" solutions, like a general ban of motorized traffic in the city centre. Due to the contingency plan, this political risk can be avoided through communication campaigns targeting different citizen groups.

An institutional risk with a high potential impact (see Graph 10) is the insufficient cooperation between measure partners. The contingency plan includes the planning and scheduling of regular meetings between measure partners, where necessary, to avoid these types of risks.

One of the project objectives is to increase the acceptance of new traffic management policies in Zagreb. However, this also represents a risk. Users may, for example, consider the proposed delivery solution too complicated or too difficult to achieve in the present circumstances. The contingency plan seeks to avoid this user acceptance risk by communication campaigns aimed at all stakeholders.

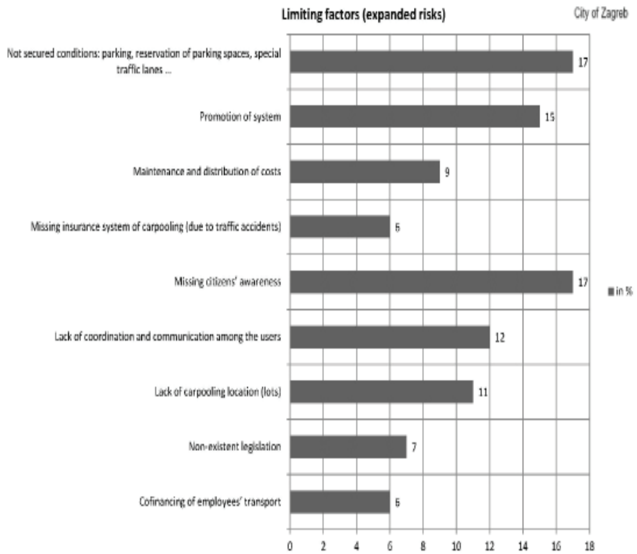
Another risk may be how to define an area that is suitable for implementing the proposed scheme and, at the same time, will yield positive effects of the delivery solution. This spatial risk is avoided by first using a suitable demo zone in which the delivery-system parameters (characteristics of infrastructural objects, road network, businesses, operators, traffic flows, goods flows, etc.) can be analysed.

3 IDENTIFICATION OF RISKS REGARDING THE IMPLEMENTATION OF CITIZEN MOBILITY SOLUTIONS

The majority of countries with a developed traffic system are giving up the past concept of adjusting traffic to private cars to replace it with a concept of active mobility management through alternative transport modes. Alternative mobility in this case refers to the introduction of a carpooling system (measure 4.4), the development of transport plans for the employees of certain companies and the student population, as well as the development of the preconditions for greater usage of bicycles (The Civitas Initiative, 2012). Before the start of the CIVITAS ELAN project, there had been no systemic implementation of mobility management strategies such as carpooling, carsharing, etc. in the City of Zagreb. Carpooling, for instance had been mainly applied sporadically at the level of personal acquaintances and usually without sharing the transport costs. The basic aim of introducing carpooling is to implement an efficient and high-quality solution that will improve citizen mobility. One of the reasons why carpooling was not practiced earlier in Zagreb was that the necessary (institutional, user acceptance, etc.) conditions for successful implementation were not met, while these were achieved in the majority of countries in which the system is functioning successfully. There are multiple reasons for developing the concept of shared rides and they can be considered from several angles that are typical both of Croatia and other European countries. This refers mainly to: the overload and reduced capacity of urban roads, citizens expect greater mobility in the cities, citizens prefer private cars because of the poor-quality public urban transport, the low average occupancy of private cars, reduction of costs when sharing rides, etc.

In April 2010, data was gathered by means of a survey conducted by Faculty of Transport and Traffic Sciences to determine the current state of citizens' traffic mobility on the target corridor in the City of Zagreb, and to analyse the possible risks of introducing carpooling measures. By analysing a target group of employees and potential users of the carpooling system, very positive responses were obtained regarding passenger carsharing with other people on their way to work. About 57% of the citizens questioned considered the possibility of sharing a passenger car with one or more persons as acceptable. About 37% of respondents exclusively referred to travelling together with fellow workers or family members, whereas 3% of respondents did not want to share a private car. The group of persons who do not want to share a private car in any way are all drivers and most of them are vehicle owners. When considering only drivers of company vehicles, the percentage is 0.2. Company policies on employee mobility play an active role in this distinction.

The survey method has identified the limiting factors or enhanced risks of greater usage of the system of sharing vehicles and rides (for the city of Zagreb); they are presented in Graph 1.



Graph 1: Limiting factors to greater usage of the systems of sharing cars and rides.

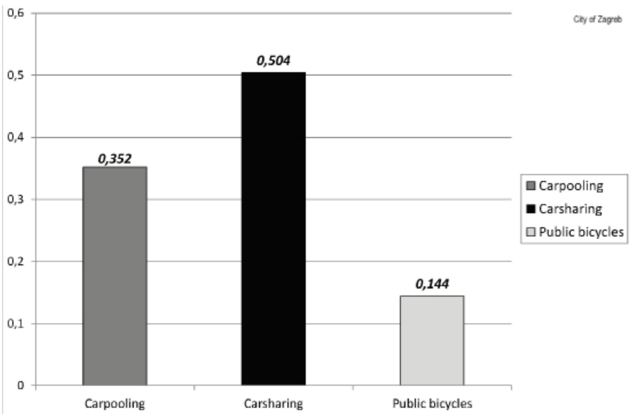
The infrastructure required to expand ridesharing has not yet been developed in the City of Zagreb. It is therefore necessary to first elaborate a plan for the introduction and operationalization of a ridesharing system. The introduction of a pilot project is expected, motivated by the CIVITAS ELAN project.

Various internet portals are being developed for better coordination and communication between users and to facilitate reservations of vehicles and rides. Coordination among users can be more easily established through the cooperation of business subjects (companies) regarding their support to the mentioned system (co-financing of transport) or through the academic community.

Legislation needs to be harmonized by introducing the concept of carpooling and the system must be defined in detail with legal regulations. Also, the legislator needs to find models of subsidizing this transport mode, either through tax reliefs (e.g. through excises when a purchased vehicle is intended for carpooling, by subsidizing the costs of regular or special vehicle technical inspections), or through direct subsidies from the government (or municipal) budget, making the carpooling system as cheap as possible for the end user.

The research included a multi-criteria analysis of the issue of introducing three alternative transport modes: carpooling, carsharing, and public bicycles (measure 4.4). Each of the three transport modes is in its early beginnings in the city of Zagreb. The analysis considered the following criteria: Political/strategic; Institutional; Cultural; Problem-related; Involvement (communication); Positional; Planning; Organizational; Financial; Technological; Spatial and Other. Graph 2 shows the three analysed alternative transport modes from the position of identified risks. Considering these alternative travelling modes, the meteorological data for the city of Zagreb have not been considered, i.e. the values of climate elements such as air temperature, sunshine, precipitation, the number of days of bright, foggy, rainy, frosty, snow, freezing ($t_{min} \leq -10^oC$), cold ($t_{max} < 0^oC$), chilly ($t_{min} < 0^oC$), etc. weather.

Using the method of assigning the actual (current and planned) values of certain alternatives to the criteria evaluated on the basis of the results of studying the traffic demand, a model has been developed that shows the selection of the optimal alternative transport mode from the position of identified risks. Evaluating all the criteria from the position of identified risks of introducing the mentioned alternative transport modes in the city of Zagreb, the most favourable option would be the introduction of public bicycles (0.144), followed by the carpooling system (0.352), and with the carsharing system in third place (0.504).

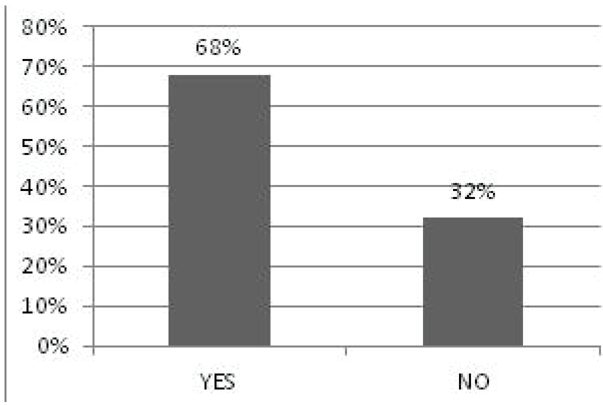


Graph 2: Presentation of alternative transport modes regarding identified risks for the coty of Zagreb.

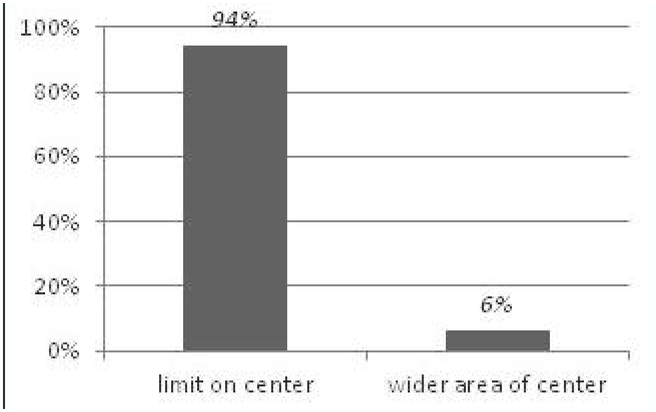
One of the main obstacles of non-formal carpooling today is that a critical mass of users has to be achieved to make it really attractive to drivers and passengers. The research on the CIVITAS ELAN project shows that (as yet) informal carpooling is used by 8.73% of the survey participants (2010) in the city of Zagreb. Greater usage of ridesharing would be achieved through more concrete user incentives (from the city, companies/institutions).

The development of a proposal for a congestion charge scheme in Zagreb was the main aim of ELAN measure 3.2 “Study of congestion charging and dialogue on pricing”. After many meetings with the collaborators to elaborate a proposal for a congestion charge scheme, the option of users purchasing annual vignettes was selected and the prices for certain types of vignettes were agreed upon.

In order to avoid misunderstandings and because of their importance, some terms have to be defined. The term “acceptability” describes the prospective judgement of measures to be introduced in the future. Thus the target groups will not have experienced any of these measures, making “acceptability” a constructed attitude, subject to strong situational and temporal factors. “Acceptance” involves respondents’ attitudes, including their behavioural reactions after the introduction of a measure (Schade and Schlag, 2003). A public survey on acceptability (see Graph 3), showed that 68 percent of respondents support the introduction of a congestion charging zone in the centre. Other survey results are presented in Graph 4.



Graph 3: Level of support for paying traffic congestion charges in the city of Zagreb (2011).



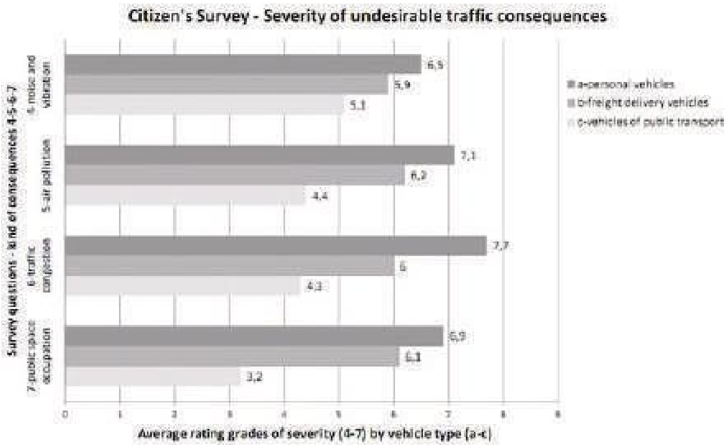
Graph 4: Question about the scope of the zone (2011) .

Based on well-known technical solutions for road urban charging, an analysis of applied urban charging strategies, and an analysis of the existing transport system of the City of Zagreb, the proposed preliminary solution suggests the introduction of an eco-zone in the city centre.

The main objective of the measure is not to generate additional income for the city, but to reduce congestion and improve air quality. The potential funds should be used for the operation of the congestion charging system, and for the implementation of further measures discouraging the use of personal vehicles.

When studying citizen mobility in the context of urban freight delivery in general, one first has to identify all kinds of situations where citizens face freight deliveries and the different locations where this confrontation occurs. Furthermore, citizens can have different roles (depending on their interests – reasons for being at the location) and freight delivery processes can vary as well (depending on the driver's activities and the vehicle's location).

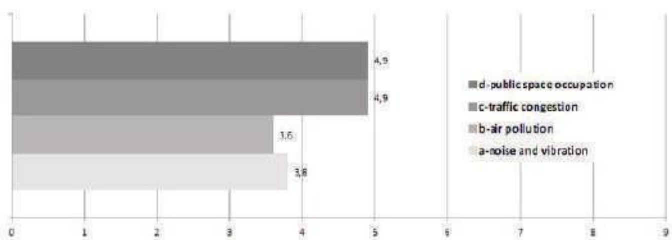
In April 2010, a survey on the awareness and acceptability of freight delivery restrictions was conducted with a random sample of 600 citizens in the area of the city centre. The citizens participating in the questionnaire considered passenger cars as the principal cause (average grade 7.05) of all sorts of undesirable impacts in the city centre (see Graph 5). In the citizens' perception a combination of temporal and spatial restriction (Bestufs, 2011) (see Graph 6) would be the best solution, while restricting freight traffic to a few street-corridors through the city centre (see Graph 7) was ranked as the second best solution.



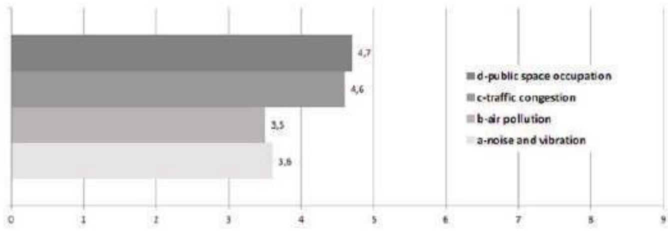
Graph 5: Citizen survey – weight of undesirable traffic impacts.

In May 2010, a survey on the awareness and acceptability of freight delivery restrictions was conducted on a random sample of 60 businesses. Every respondent represented a business (shops, coffee shops, bistros, restaurants, hotels, etc.) with delivery demands.

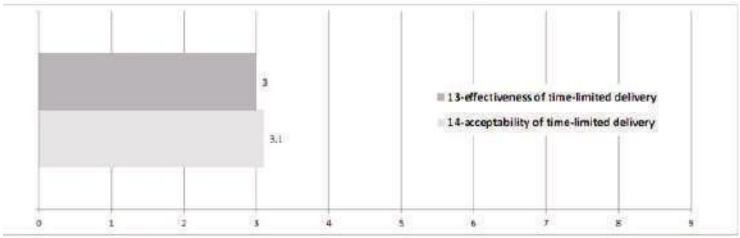
The analysis of the possible acceptance of solutions revealed that businesses in this area generally regard most of the suggested solutions as unacceptable. The most acceptable measure (avg. mark 3.9) was time-limited delivery in some specially marked zones, (similar to the present situation) and the implementation of freight corridors for delivery (avg. mark 3.9). Taking into account its effectiveness in alleviating the consequences (3.1) and its acceptability (3.0) (see Graph 8), the weight of the proposed solution – time-limited delivery – is 0.114 by businesses.



Graph 6: Citizen survey – effectiveness of temporal and spatial restrictions.



Graph 7: Citizen sirvey – effectieness of limited delivery corridors.

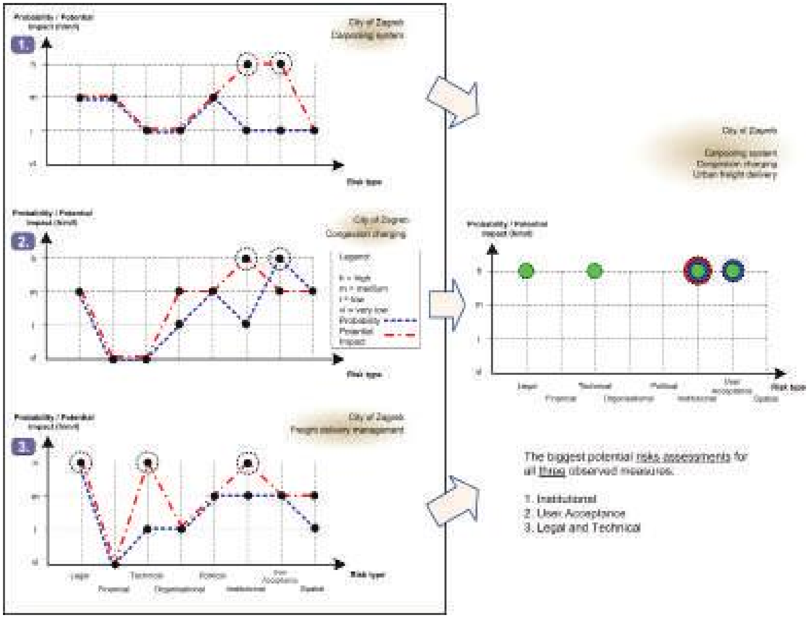


Graph 8: Business survey – effectiveness and acceptability of time-limited delivery.

Given the perception of vendors on the low efficiency of the proposed measures and highlighting the low acceptability of the measures from the standpoint of their businesses, two measures could be extracted as "averagely effective", but also as the "least unacceptable" by the vendors as stakeholders: time-limited delivery and delivery corridors. In order to extract a solution proposal based on the stakeholder survey's results, a freight delivery model had to be designed that anticipates the implementation of either one or a combination of these two measures.

4 CONCLUSIONS

The measures described above might seem very different, but they actually have a lot in common, in particular their major goal: to increase citizen mobility. However, in order to achieve that goal, some threats or risks have to be taken into account and eliminated. Picture 1 represents the risk assessment of the introduction of suitable solutions for the three analyzed measures.



Picture 1: Risk assessment for measures on citizen mobility in the city of Zagreb.

Since citizens are involved in all the measures in varying roles, their cooperation is extremely important to the risk assessment, because the same types of risk might manifest themselves differently in various measures. Citizens are vital participants in developing and implementing solutions, and in evaluating their results.

The implementation of measures included in the CIVITAS ELAN project has revealed risks which appear to be high in two (user acceptance) or even all three observed measures (institutional risk). The biggest potential risks assessed for all three observed measures were:

- institutional (3x),
- user acceptance (2x),
- legal (1x) and technical (1x).

To establish an efficient carpooling system in the City of Zagreb requires cooperation and dialogue between all stakeholders (user acceptance). The first phase of implementation is most easily implemented by big and small-size companies or state institutions and the student population, which are particularly interested in the savings yielded by alternative transport modes. The advantages of alternative travelling methods, i.e. carpooling, need to be clearly emphasised. In spite of the mentioned significant savings (reduction of travel costs for individuals, reduction of air and noise pollution levels and the occupation of public urban areas, reduction of traffic congestion, reduction of the load on traffic places, and other advantages), an action plan for additional user motivation is required. Dialogue with citizens should not be neglected, since they act as a corrective of traffic-oriented decisions.

The most important risk for the success of the congestion charging measure is citizen (non-) acceptance of the proposed solution. Another important risk is the quality level of its implementation by the municipal institutions. With a proper approach and high-quality dissemination a lot can be achieved in order to make the majority of citizens accept the proposed congestion charging scheme. In line with the decision of the Zagreb City Council on the introduction of congestion charging, the municipal institutions will need to get organized in order to implement the proposed solution. After the introduction of a congestion charging scheme, its feasibility needs to be continuously verified and improved.

Implementing the proposed solution to decrease the share of delivery vehicles in the traffic flow during morning peak hours should among others result in reducing congestion and CO_2 emissions. A new freight delivery regulation should be beneficial to all involved stakeholders, in particular the citizens. The success of this measure depends on the acceptance level of the shippers and vendors, but it also and maybe even more depends on the citizens' willingness to cooperate in evaluating the solution as such and, last but not least, in evaluating the implemented solution. At this point, the importance of high-level potential impacts of legal, technical and institutional risks on freight delivery regulations had to be emphasized.

It would be interesting to observe risk assessments in future research from the citizens' perspective, especially regarding the implementation of other measures and activities aimed at improving citizen mobility.

REFERENCES

BESTUFS. 2011. *Good Practice Guide on Urban Freight Transport*. Available at: http://www.bestufs.net/download/bestufs_II/good_practice/English_bestufs_guide.pdf, 1. 12. 2011.

MVA. 1999. *Traffic Study of the City of Zagreb. Report on General Traffic Plan*. Zagreb.

Schade, Jens and Bernhard Schlag. 2003. Acceptability of urban transport pricing strategies. *Transportation Research Part F*: 45–61.

Službeni glasnik Grada Zagreba 8/2007 (28th June). Available at: http://www1.zagreb.hr/slglasnik.nsf/, 10. 7. 2012.

Službeni glasnik grada Zagreba 10/1998.

The Croatian Bureau of Statistics (CBS). 2011. *Statistical Yearbooks 2011*. Available at: http://www.dzs.hr/default_e.htm, 10. 7. 2012.

Civitas Inicijativa. Available at: http://www.fpz.unizg.hr/civitaselan/civitasFpz.php, 1. 10. 2011.

The Civitas Initiative. *Cleaner and Better Transport in Cities*. Available at: http://www.civitas-initiative.org/index.php?id=79&sel_menu=20&measure_id=693, 1. 10. 2011.

ZAGREB I The info point, a refurbished heritage tram, serves as an information hub. "Tram Wednesdays" and round table discussions were an excellent opportunity for citizens and journalists to obtain information on Zagreb's sustainable mobility issues.

ZAGREB I The new low-floor trams provide better access to elderly citizens, as well as to all other passengers.

ZAGREB I A brochure with tips on how to use PT safely has been published and a short film, “Alojz and Vlatka”,produced.

TRANSPORT PLANNING: PUBLIC TRANSPORT USER SATISFACTION AS A TOP PRIORITY IN BRNO

Jana Válková, Květoslav Havlík,
Iva Machalová, Daniel Seidenglanz

1 INTRODUCTION

Transport is fundamental to our economy and society (White Paper – Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system). But at the same time transport is a still growing source of greenhouse gas emissions. Hence, it is essential (also in line with the objectives of the EU's Europe 2020 growth strategy) to find solutions to mitigate the undesirable effects of transport, but without negative effects on the economy and people's mobility. One of the best solutions for the sustainable mobility of people is to foster the use of public transport and improve its quality.

The share of public transport in daily commuting is remarkably high in Brno. According to the results of the 2010 Modal Split Survey, almost 65% of Brno's commuters use public transport for travelling to work. The best way to maintain this high share is to adapt the range of public transport services in Brno to people's needs.

The City of Brno, which commissions public transport services as a public service, provided by the Brno Public Transport Company (a 100% city-funded enterprise), decided to identify the most important issues, which needed to be changed or improved, through a series of mobility dialogues called Transport Plans. These are based on annual sociological surveys known as Transport Barometers, focusing on the evaluation of public transport services by their users. The gathered data are processed with a SWOT analysis that highlights the service's strengths and reveals what needs to be improved. Additional inputs are gathered from representatives of Brno's city districts. Together with a demographic analysis and city development data (such as new residential areas), the Transport Plans represent the basis for finding the most efficient mode of operation for the public transport.

Reflecting the public opinion in an annual update procedure brings the Transport Plans closer to the public, with the hope of increasing the number of public transport passengers.

2 THEORETICAL BACKGROUND

Transport is of great importance in the contemporary world; one could even say that transport in particular is a supporting structure to the current spatial and functional relations, including at the global scale. According to Rodrigue et al. (2006) or Seidenglanz (2008), the reason for the powerful impact of transport is its ability to overcome spatial barriers, which can be understood in different ways, i.e. highlighting either physical or social barriers. As a result of the ability to overcome spatial barriers, transport can create interactions (functional links) between differently disposed places of the Earth's surface (enhanced complementarity, for details see McBride 1996; Wheeler and Muller 1981), contributing thus to the formation of settlements and the economic structure of the world or its individual regions (although the impact of transport on the economy is neither unequivocal nor straightforward – for details see e.g. MacKinnon et al., 2008; Banister and Berechman, 2001; Knowles, 2009; Matthiessen Coe et al., 2007), and also their spatial structuring and organization. The above-mentioned ability of transport to promote the formation of functional links is reflected even on the scale of a city/urban region, for example by allowing the existence of phenomena such as commuting to work, school, services, medical care, cultural and other facilities, leisure etc. within its space.

These days, the hegemon of short-distance transport mobility in western cities definitely is the car. This fact can be illustrated by the increasing number of cars and their increasing use, as well as by the ever-growing size of cities/urban regions and their greater adaptation to the general availability of cars, which is reflected in phenomena such as residential and commercial suburbanization. Marada (2006) and Urbánková and Ouředníček (2006) analyzed the links between transport and the suburbanization in Czech settings on the example of Prague, while foreign authors worth mentioning are Sheller and Urry (2000), Urry (2004), Volti (1996), Adey (2010) and others. The said authors introduced the concept of "automobility" that covers all conceivable social implications of universal access to cars in contemporary societies. Automobility in their view is defined as a system including cars, drivers, roads, gas stations, roadside rest areas, spare parts, tuning parts and many other new objects, technologies and features; a system spreading around the world, affecting, reconfiguring and restructuring people's perception of time and space (enabling personalized, subjective temporalities and de-synchronization of individuals), while at the same time reproducing and strengthening itself.

However, the increasing dependence of contemporary society and contemporary western cities on cars, associated with high mobility, has negative impacts as well. In this context and randomly picking, we may emphasize the strong environmental impact of road traffic, the number of accidents, the extensive consumption of resources (oil and petroleum products, space), as well as emerging issues for certain groups of people lacking access to a personal car (individual aspects are discussed in detail by Vickerman, 1998; Hall, 1998; Crawack, 1993; and others). In contemporary cities, such persons are exposed to a higher risk of social exclusion (Kenyon et al., 2002), because compared to more mobile persons they are face with limited availability of jobs and other opportunities. A number of authors have carried out research on these phenomena; the most important concepts emerging from their works are mobility gap, forced specialization, new prisoners of the city, etc. (Cebollada, 2009).

A partial solution to the above outlined situation is public transport, which in our opinion might at least alleviate the urgency of some of the above issues in the areas of cities/urban regions. Therefore, it is appropriate for the public sector to support/finance it. For such support to be reasonable and responsive to the needs of the users (passengers) of the services provided, it is important to carry out user satisfaction surveys. This chapter presents the results of the Transport Barometer, a survey carried out annually and aimed at including public opinion in transport planning in the city of Brno.

3 METHODOLOGY

3.1 RESEARCH QUESTION

Promoting the use of public transport becomes a necessity to keep large cities clean and sustainable. This research wants to investigate the perception of citizens themselves as passengers and their satisfaction with public transport services. Therefore, our aim was to answer the following research question: "What is the perception of Integrated Transport System (ITS) passengers of the use and their satisfaction with the public transport services in Brno and the South Moravian Region?" This research question may be divided into two sub-questions:

- What is the perception of use of the Integrated Transport System (ITS) in Brno and the South Moravian Region?
- How satisfied are Integrated Transport System (ITS) users with its services?

3.2 RESEARCH METHOD

A quantitative approach was chosen as the most adequate, as the city wanted to assess the level of satisfaction with public transport among a large group of people, representative of the city's population and its visitors. The survey, which was to collect as much information as possible, was conducted using a completely new questionnaire, developed specifically for this purpose. The questionnaire, also called the Transport Barometer, contains questions covering various issues related to public transport:

- use of the ITS (frequency, intensity, modes of transport),
- perception of ITS (reasons for using the ITS, recommending the ITS to others, repeated choice),
- satisfaction with the ITS services,
- specific questions related to current problems.

The Transport Barometer contains different types of questions, some of them using a five-point scale to express satisfaction levels. Several reasons were behind this decision. First, compliance and comparability of the data with other existing research. A survey using these scales was conducted in Germany (EMNID) and in five Czech cities in 2001. The second reason is the ease of filling out the questionnaire for the respondents[1]. Thirdly, the point of this assessment was not to find out whether the respondents were more in favour of one side or the other, but how they really evaluate the service in question. In this case, even mark 3 (neither satisfied nor dissatisfied) may still be considered satisfactory.

1 Respondents were able to assign values in the way that is typical of the Czech schooling system and every mark had a clear meaning to them.

3.3 OPERATIONALISATION

The main research question was divided into two parts, exploring people's perception of the ITS in the South Moravian region and their satisfaction with the ITS services. Below we describe which components were examined and the indicators used to answer our following questions.

"What is the perception of the use of the ITS in Brno and the South Moravian region?" The following information was collected to answer this question:

- reasons for using the ITS,
- repeated choice,
- recommending the ITS to others.

"How satisfied are the users of the ITS with its services?" The survey collected information on the following aspects of the ITS system:

- general satisfaction,
- services – network, interchange hubs, distances, interchange and interconnection of services,
- time – frequency, punctuality, reliability of services, maintaining timetables, travel times,
- ticketing – range, availability, user-friendliness of ticket machines,
- information – amount, availability, timetables at stops,
- comfort and cleanliness of vehicles and stops,
- security – during daytime and at night,
- staff – behaviour and appearance.
- value-for-money ratio between fares and quality of services.

3.4 SAMPLING AND DATA COLLECTION UNIT

To achieve the research objective, a representative sample had to be defined. The total population that would ideally be part of the survey are all the passengers using the ITS in the South Moravian Region. To define the sample for this survey we used a strata and quota sampling method.

In order to obtain sufficiently accurate results while minimising costs, a sample of approximately 500 to 700 respondents was selected.

A sample of this size offers sufficient data for evaluation and further work with the data. The statistical deviation at the level of 20% is approximately 3%. This dispersion can be considered acceptable given the outputs. Beside the sample size of the target group, the selection of quotas is another key factor influencing accuracy. The quotas may be divided into two groups – quotas per interview location and quotas per socio-demographic characteristics of the respondents.

The first group of the quotas was based on the fact that the research objective was to evenly cover the entire area of the city of Brno. In order to achieve this, the locations (interchange hubs) or routes (radials) where the interviews took place, were selected – approximately 20 of them in Brno. Based on the known approximate movement of the passengers, the number of respondents was then selected.

Setting the other group of quotas was more complicated. The reason for this was the unknown age and gender structure of the passengers. This required screening public transport vehicles to establish the passenger structure by these two indicators. This was done by counting the passengers in approximately 100 vehicles, noting their gender and approximate age (distributed into age categories) – approximately 1,000 passengers in total. A further comparison established that the obtained passenger structure in public transport correlated with the structure of the inhabitants of Brno according to public records. The share of women was a little higher and that of middle-aged passengers a little lower, as was expected. Men and middle-aged passengers indeed use public transport less frequently than all other groups.

The quotas of the numbers of respondents by gender and age were then set based on the mentioned screening criteria. Setting other quotas, e.g. by education or other characteristics, was deemed inadequate. These data were not available and, moreover, it was interesting to discover the education structure of the passengers.

3.5 DATA COLLECTION

The survey was conducted at the designated locations over a period of approximately 3 weeks, whenever there were no school holidays and the weather was as average as possible (no rain or frost). Every interviewer had an assigned location or locations where he/she could operate. Apart from interviewing at the stops, using the spare time the passengers had on their travel to work proved effective as well. The total number of filled out questionnaires in 2011 was 599.

3.6 LIMITATIONS

The creation of a SWOT analysis of the transport service might be considered an important part of the methodology used to evaluate the survey. Unlike in other, similar surveys, we did not rely on the respondents' subjective assessment in rating the respective elements of the transport service. We used a correlation between the overall assessment of the transport service (1 figure) and the assessment of each specific element (27 elements).

In the field of transport, it is typical to encounter deeply rooted stereotypes which often lead to misleading statements by the respondents in their rating of the service. The correlation method significantly decreases the risk of distortion due to their conventionally shaped answers.

The research's limitations show in the selection of proper locations for interviewing. While in a relatively compact city as Brno is - the important interchange hubs and the number of passengers using them, were easily identified, this might be more complicated in other, bigger cities. Another potential problem arises from the setting of the socio-demographic quotas for the interviews. There are no exact records of public transportation users that would contain relevant socio-demographic data. Adequate screening can eliminate these obstacles.

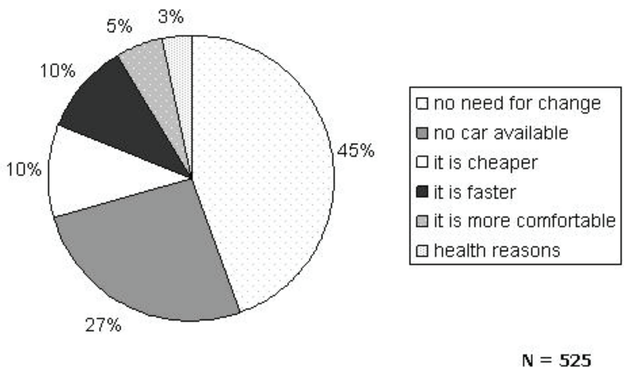
3.7 TRIANGULATION

The Transport Barometer has been conducted every year since 2004 and by now allows a timeline comparison of the data. The validity of the results can also be double-checked against the results of the Modal Split Survey, organised in 2010 the framework of the CIVITAS ELAN Project. This large survey assessed some aspects of satisfaction with public transport in Brno. The Biannual Survey on Passengers' Satisfaction organised by the Brno Public Transport Company is another available data source allowing for a triangulation of results.

4 FINDINGS

First of all, let us look at the perception of the ITS in Brno and the South Moravian Region by its passengers. The survey contained questions asking about people's motives to use public transport, their perception of using PT in the coming year, and their overall perception of PT as reflected in their willingness to recommend public transport to visitors and tourists in Brno and the South Moravian Region.

One important aspect considered in the survey were the motives of the ITS passengers to travel by public transport. The main reason for travelling by public transport in the South Moravian Region (see graph 1) was that the passengers were used to do so and did not feel any motivation or pressure to change their habits. This most frequently stated reason indicates a good overall perception and satisfaction with the services provided, embedded in the lifestyle of Brno and South Moravian residents. The Modal Split Survey from 2010 also confirmed the good perception of the IT System in the Region (Modal Split Survey, 2010). The second most significant reason was the unavailability of a car, while the third was the price of transport and time spent on travelling. These reasons were the most important ones for 10 % of all ITS passengers.



Graph 1: Reasons to use public transport.
Source: Transport Barometer, 2011 and own contribution.

The perception of the ITS may also be assessed by asking how the passengers felt as public transport users. We therefore focused on their intended frequency of travels in the coming year. Table 1 shows that almost 90% of passengers intended to use public transport in Brno and the South Moravian Region in the following year, with at least the same or higher frequency than in the current year. Only around 10% of respondents expected to use public transport less frequently in the future. These are passengers whose needs should be further assessed and better addressed in order not to affect their favourable attitude towards public transport.

	Frequency	Percent	Valid Percent	Cumulative Percent
more often	73	12,2	12,2	12,9
same frequency	458	76,5	76,5	89,3
less often	64	10,7	10,7	100,0
missing	4	,7	,7	,7
Total	599	100,0	100,0	

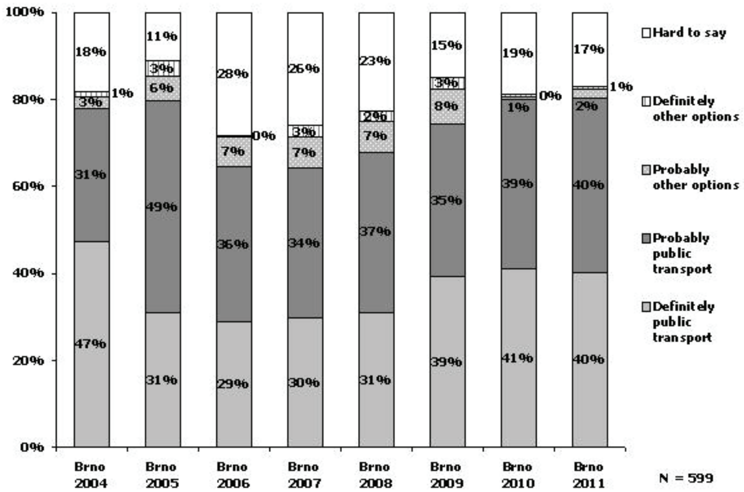
Table 1: Perception of the frequency in public transport use.
Source: Transport Barometer, 2011 and own contribution.

Another interesting way to assess user perception of public transport is to ask them if they would recommend it. The issue is addressed by asking them if they would recommend either public transport or another means of transport to tourists for travelling around the city and the region.

	Frequency	Percent	Valid Percent	Cumulative Percent
definitely public transport	240	40,1	40,1	40,4
probably public transport	239	39,9	39,9	80,3
hard to say	102	17,0	17,0	97,3
probably other options	13	2,2	2,2	99,5
definitely other options	3	,5	,5	100,0
Missing	2	,3	,3	,3
Total	599	100,0	100,0	

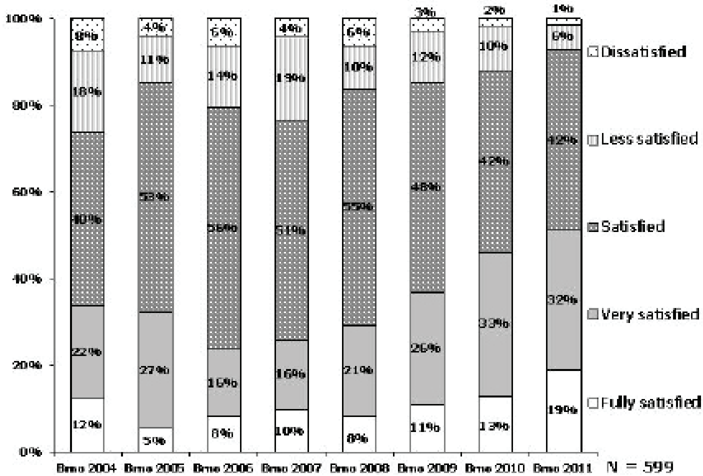
Table 2: Recommendations to use public transport.
Source: Transport Barometer, 2011 and own contribution.

80% of the respondents would recommend to tourists to travel around Brno and the region by public transport. This shows that the public transport provided by ITS is perceived as a good quality and comfortable way of travelling. Graph 2 shows that the share of ITS passengers who would recommend public transportation has been growing since its last downturn in 2006. In 2010 and 2011, the share of people who would definitely recommend or prefer to recommend local PT remained the same.



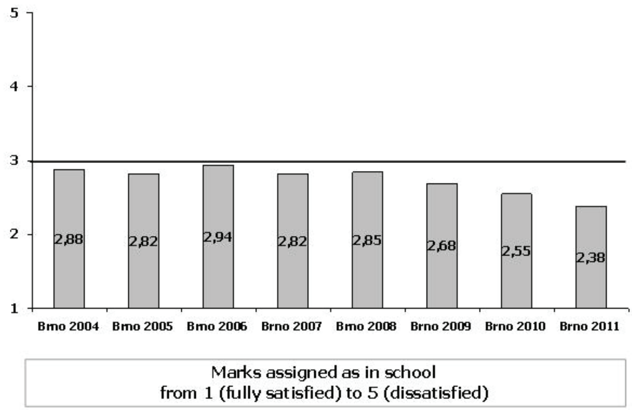
Graph 2: ITS passengers who would recommend public transportation.
Source: Barometr spokojenosti cestujících, 2011.

Public transport user satisfaction is a concept composed of different elements or aspects of satisfaction. This paper looks both at the notion of general satisfaction and its components. Passengers of the ITS in Brno and the South Moravian Region are quite satisfied with the provided services – 93% of Brno commuters by PT are happy with the services. Only 7% of PT users are rather or fully dissatisfied with the IT system. Compared to the previous year, the number of people that are fully satisfied has been growing steadily and they represented one fifth of the total number of respondents in 2011.



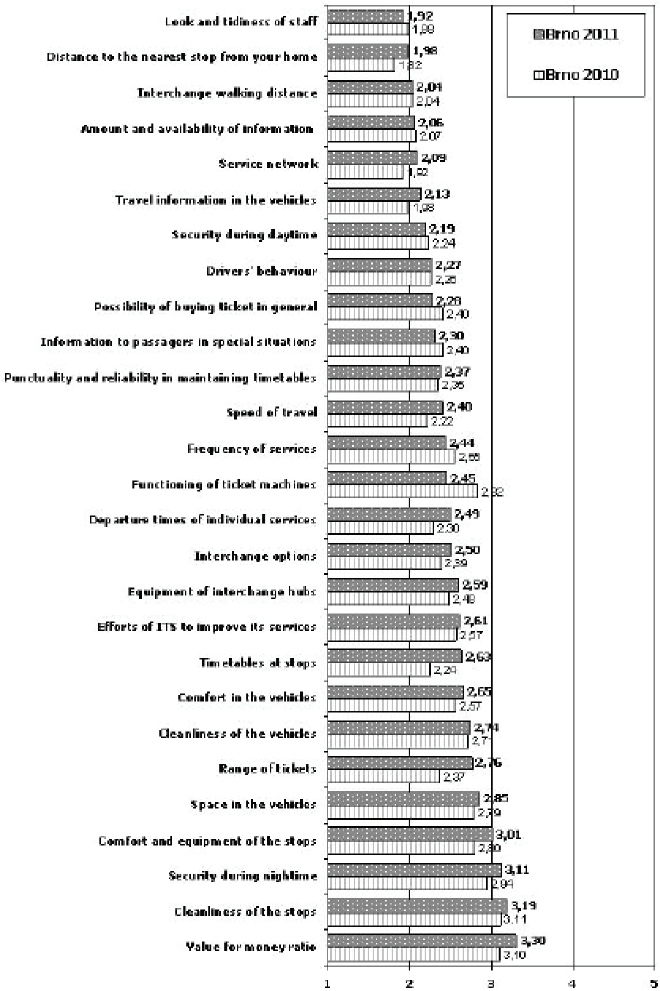
Graph 3: General satisfaction with the ITS in Brno and the South Moravian Region.
Source: Barometr spokojenosti cestujících, 2011.

Looking in detail at the average grade of general satisfaction with the ITS, we can see an improvement – the medium grade assigned to the ITS (on a scale from 1 to 5, similar as in Czech schools, mark 1 meaning the best and mark 5 the worst grade) reached 2.38 in 2011, which was the best grade ever since the launch of the Transport Barometer in 2004.



Graph 4: Satisfaction with the ITS in Brno and the South Moravian Region - weighted average.
Source: Barometr spokojenosti cestujících, 2011.

The level of satisfaction was also assessed through various aspects of satisfaction. These aspects were defined in detail to cover among others interchange hubs, interconnection of services, time dimension of travelling, ticketing, provision of information, comfort and safety. Respondents were also asked to rate the value-for-money ratio between the fares and the quality of service provided. Graph 5 shows how these aspects of satisfaction changed over the last year.

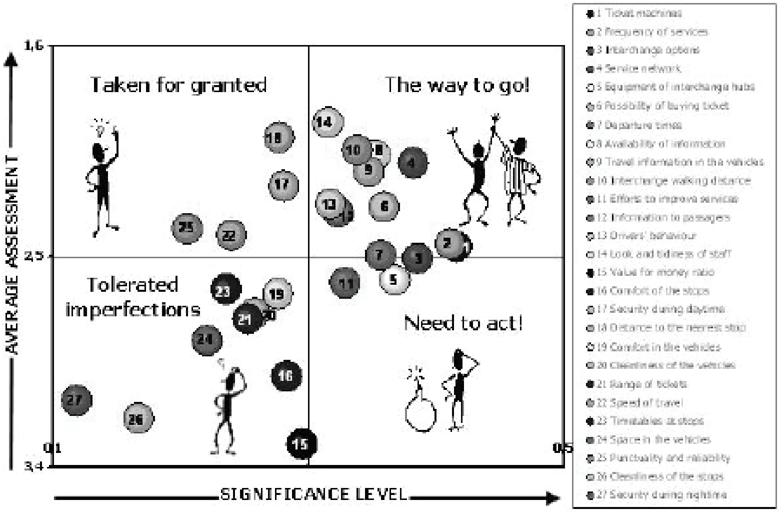


Graph 5: Components of satisfaction - comparison between years 2010 and 2011.
Source: Barometr spokojenosti cestujících, 2011.

Among the aspects perceived as most satisfactory were staff appearance and neatness, distance from to the nearest stop, walking distances at interchanges, provision of information on public transport and the network of services. On the other hand, the worst rated features of the ITS included the comfort and cleanliness of bus stops, safety at night, and prices in relation to the quality of service - the value-for-money ratio. The average rating of the ticket vending machines' functioning improved from 2010 to 2011. This finding may be explained by the implementation of a new diagnostic system for ticket vending machines in Brno. This measure was implemented as part of the CIVITAS ELAN Project (8.7 BRN) and has led to better diagnostics of problems and defects in the ticket vending machines and to their quicker fixing thanks to immediate online signalling of these defects to the control room of the Brno Public Transport Company. The introduction of the ticket vending machine diagnostic system was organised in two phases – pilot functioning and testing of the new system and up-scaling of the measure to the whole city area and on all ticket vending machines. The operational phase of the measure started in July 2010. The Transport Barometer from 2011 already proved that this measure had led to higher satisfaction among PT passengers.

However, there are also challenges to be addressed, namely the range of tickets available and the value-for-money ratio. The range of tickets was seen as less satisfactory in 2011 than in 2010. This may have been caused by changes to the fares and the time validity of individual ticket types. Generally speaking, the time validity of tickets was extended, but this was followed by an increase in fares. This fact may effectively be reflected in the value-for-money ratio that expresses the relation between price and quality. Nevertheless, the ITS in Brno and the South Moravian Region is seen as fully satisfactory or very satisfactory with only some aspects of it needing to be continuously developed and improved.

The Transport Barometer allows us to make a SWOT analysis in which the general level of satisfaction is correlated with different measured aspects of satisfaction. The vertical axis displays the satisfaction with various characteristics of the ITS, and the horizontal axis represents the correlation coefficients of the impacts of given characteristics on the general satisfaction.



Graph 6: SWOT analysis of the ITS in the South Moravian Region.
Source: Barometr spokojenosti cestujících, 2011.

The measured aspects of the ITS operation may be divided into four groups. The first group has a strong impact on the overall satisfaction, but is perceived as dissatisfactory in the group entitled "Action needed!" These are ITS features that should be better addressed because of their comparatively lower rating in 2011 and their overall importance to satisfaction. Together with KORDIS JMK, the City of Brno is committed to better planning service interconnections and interchange options, further planning to develop the interchange hubs and strengthen the efforts to enhance the services provided.

5 CONCLUSION

This chapter investigates the perception of the ITS in Brno and the South Moravian Region by its users and their satisfaction with the services provides. These are the main questions that need to be answered to plan transport in the city and region effectively and in line with the citizens' needs. One way to learn how the public opinion about the ITS can be incorporated into the process of transport planning is to conduct a representative survey. This challenging task was addressed by KORDIS JMK, a company managing the Integrated Transport System in the South Moravian Region, and resulted in the development of the Transport Barometer. The survey has been carried out in the city and the region every year since 2004, covering various aspects such as the use of the ITS, perception of the ITS, satisfaction with the ITS, and other specific issues. Regular data collection allows for a year-to-year comparison of the results and for a definition of strengths as well as problems to be tackled.

The results of the 2011 Transport Barometer showed that the perception of the ITS was generally very good and had even improved comparing 2011 to the previous years. For instance, the number of people that would recommend travelling by public transport to a tourist in the city and the region has grown.

The satisfaction with the services provided by the ITS is generally very high and still developing positively. There are, however, certain aspects of the ITS that need to be paid attention to and that require additional action to be taken. The SWOT analysis provides a clear insight into the different dimensions of the ITS. It revealed that developing the interchange hubs in terms of interconnection of services, but also new and improved equipment, are very important to ITS passengers and should definitely become a priority of the city. CIVITAS ELAN helped the City of Brno to take the firsts steps by means of the common measure 2.8 Participatory Intermodal Infrastructure Planning.

The Transport Barometer is an extremely useful tool helping the City of Brno to improve the quality of public transport services. The City of Brno reflects the needs of citizens, hoping to increase the number of public transport passengers in order to create a better and cleaner environment in Brno.

REFERENCES

Adey, Peter. 2010. *Mobility*. Abingdon: Routledge.

Banister, David and Yossi Berechman. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography* 9: 209–218.

2011. *Barometr spokojenosti cestujících IDS JMK v Brně: Zpráva z průzkumu spokojenosti cestujících s kvalitou poskytované služby ve Statutárním městě Brně*. KORDIS JMK: spol. s r.o.

Cebollada, Angel. 2009. Mobility and labour market exclusion in the Barcelona Metropolitan Region. *Journal of Transport Geography* 17: 226–233.

Coe, Neil M., Philip M. Kelly and Henry C. W. Yeung. 2007. *Economic geography: a contemporary introduction*. Oxford: Blackwell Publishing.

Crawack, IME. 1993. Traffic management and emissions. *The Science of the Total Environment* 134: 305–314.

Europe 2020 targets. Available at: http://ec.europa.eu/europe2020/reaching-the-goals/targets/index_en.htm, 12. 4. 2012.

European Commission. 2011. *WHITE PAPER – Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF, 6. 7. 2012.

Hall, Derek. 1998. Urban transport, environmental pressures and policy options. In *The new Europe: economy society, and environment*, ed. David Pinder, 435–454. Chichester: Wiley.

Kenyon, Susan, Glenn Lyons and Jackie Rafferty. 2002. Transport and social exclusion: investigating the possibility of promoting inclusion through virtual mobility. *Journal of Transport Geography* 10: 207–219.

Knowles, Richard D. and Christian W. Matthiessen. 2009. Barrier effects of international borders on fixed link traffic generation: the case of Øresundsbron. *Journal of Transport Geography* 17: 155–165.

Kokavec, Peter. (Factum Invenio). 2010. *Sociologický průzkum – Dělba přepravní práce ve městě Brně*. Odbor územního plánování a rozvoje Magistrátu města Brna.

MacKinnon, Danny, Gordon Pirie and Matthias Gather. 2008. Transport and Economic Development. In *Transport geographies: mobilities, flows and spaces*, eds. Richard Knowles, Jon Shaw and Iain Docherty, 10–28. Oxford: Blackwell Publishing.

Marada, Miroslav. 2006. Dopravní vztahy v Pražském městském regionu. In *Sociální geografie Pražského městského regionu*, ed. Martin Ouředníček, 64–78. Praha: Univerzita Karlova v Praze.

McBride, Patrick J. 1996. *Human Geography. Systems, Patterns and Change*. Surrey: Nelson and Sons.

Rodrigue, Jean-Paul, Claude Comtois and Brian Slack. 2006. *The Geography of Transport Systems*. New York: Routledge.

Seidenglanz, Daniel. 2008. *Geografie dopravy. In Ekonomická a sociálni geografie*, eds. Václav Toušek, Josef Kunc and Jiří Vystoupil, 231–269. Plzeň: Aleš Čenek.

Sheller, Mimi and John Urry. 2000. The City and the Car. *International Journal of Urban and Regional Research* 24(4): 737–757.

Urbánková, Jana and Martin Ouředníček. 2006. Vliv suburbanizace na dopravu v Pražském městském regionu. In *Sociální geografie Pražského městského regionu*, ed. Martin Ouředníček, 79–95. Praha: Univerzita Karlova v Praze.

Urry, John. 2004. The 'System' of Automobility. *Theory, Culture & Society* 21(4/5): 25–39.

Vickerman, Roger. 1998. Transport, communications and European integration. In *The new Europe: economy society, and environment*, ed. David Pinder, 223–238. Chichester: Wiley.

Volti, Rudi. 1996. A century of automobility. *Technology and Culture* 37(4): 663–685.

Wheeler, James O. and Peter O. Muller. 1981. *Economic Geography*. Toronto: Wiley.

Up: BRNO I You don’t need to call a repairman when a problem arises. Every ticket vending machine automatically sends a message to the control centre.

Down: BRNO I Low-floor minibuses help the disabled to travel by public transport. Their interior is specially designed to carry up to six wheelchairs.

BRNO I If you need information about travelling by public transport or bike in Brno or the South Moravian Region, go to the Integrated Mobility Centre or check its website.

BRNO I Minibuses can be used in the parts of the city where the demand for PT is low. PT services can thus be provided during the weekends and in the evening as well.

APPLICATION OF SIMULATION MODELS FOR IMPACT EVALUATION IN URBAN ROAD NETWORKS

Cristina Vilarinho, Jose Pedro Tavares

1 INTRODUCTION

Within the CIVITAS ELAN project the city of Porto implemented six measures. One of them refers to the development and implementation of "Integrated Accessibility Planning in Asprela" (Measure 3.5-OPO, see Civitas Initiative). For the research and development phase, before the actual implementation of the measure, it was decided to use a traffic simulation model that would support the tests and analyzes of different traffic circulation solutions.

The traffic simulation model is a powerful tool for analyzing a wide variety of dynamic problems that are difficult to analyze by other means. Model simulation is a technique that simulates the real conditions of a network and through which analyzes and forecasts can be carried out by replacing physical experiments with representations in a computer programme. The ability to draw conclusions and to test new solutions without having to disturb the real system and undertake new data collection are the great advantages of simulation models that make their use so important. Other potentials of simulation models are the evaluation of inputs and their relationship, as well as information availability with temporal and spatial sequences in terms of average and deviations. However, due to the unavoidable simplification of the reality the models must be practical (Ortúzar and Willumsen, 1990), and because of the way data is collected and encoded there a certain degree of error and uncertainty remains. Furthermore, traffic modelling consumes a large amount of resources because it requires a wide range of data, specific knowledge of the model, and time to perform the different modelling phases.

Concerning the demonstration area on which this model focuses, each CIVITAS ELAN partner city selected a corridor within the city to work on as a “living laboratory”, where the measures were implemented and evaluated. In the city of Porto the CIVITAS ELAN corridor is called Asprela one of the fastest growing areas in the city over the last decade, mainly because of the increasing number of educational institutions transferred to the area (28,500 students of higher education). The major hospital in the north of Porto, Hospital de São João, is also located in this area, as well as several faculties and other large institutions. Overall more than 50,000 people daily enter the area for work or study, resulting in more than 100,000 trips per working day. This area is also a major entrance point for public and private transport to the city centre. These facts cause severe mobility and accessibility problems associated with illegal car parking and traffic congestion, which happen in spite of the good provision of public transport (buses, metro light rail).

The objective of the work undertaken was to find the best traffic circulation scheme for the area to reduce traffic congestion levels on the roads and at the same time free up space in the network for introducing cycling lanes and improving the infrastructures for pedestrians and public transport. The temporal scope of the analyses was morning (M) and afternoon (A) peak hours.

The present paper aims to contribute to the application of microscopic traffic simulation models for impact evaluation in urban road networks, using the AIMSUN software. This paper is organized as follows: the methodology used in the model development is described in section 2, the introduction to the new policies in section 3, the analyses of tested scenarios in section 4. Section 5 includes a discussion of the results and the conclusions are presented in section 6.

2 METHODOLOGY

Once the aim of the model had been defined, the methodology applied for the traffic model development of the area was divided into six main steps: (1) selection of the traffic simulation model to be used, (2) definition of the study area, (3) description of the supply and demand data (including their collection), (4) codification of the network, (5) calibration and, finally, (6) validation of the model.

Once the base model was set up, it was possible to define the different scenarios for the circulation scheme, which again had to be codified and evaluated through the analyses of different performance indicators. Also, a “base” model was codified in which the new policies for the pedestrians at traffic lights were implemented.

2.1 SELECTION OF SIMULATION MODEL

One of the objectives of this study was to build a base model reflecting the existing traffic conditions. In this way the traffic model can be used for testing different circulation schemes in order to improve citizens’ mobility. To build a traffic simulation model detailed data of three types have to be collected: (1) origin-destination flow patterns (OD Matrix) for private vehicles, (2) routes and frequency of public transport and (3) transport system characteristics (lane configurations of roads, signalized intersection characteristics, etc.).

A microscopic traffic simulation model was selected as the ideal approach for this case study. More specifically, the AIMSUN (Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks) model, developed by the Universidad Politecnica Catalunya (UPC) and by Transportation Simulation Systems (TSS) of Barcelona, Spain (Barceló, 2001). It should be noted that the European Project SMARTEST (Barceló et al., 1999) classified this model as highly applicable and suitable for urban and highway networks.

As a microscopic traffic simulation model, AIMSUN can show the individual performance of each vehicle’s network during the simulation time, established in accordance with the various theories of vehicle behaviour. AIMSUN has proven to be very useful in testing new traffic control systems and the management of policies based on traditional technologies or the implementation of Intelligent Transport Systems (Transport Simulation Systems, 2005). The model can also estimate the environmental impact of air pollution emissions and fuel consumption.

The demand codification in AIMSUN can be done in two different ways, depending on the available traffic demand data. One is based on the input of traffic flows and turning percentages, and the other is based on O-D matrices and routes or paths. During their journey in the network, vehicles are updated according to vehicle behaviour models: “car-following”, “lane-changing” and “gap acceptance” (Hoogendoorn and Bovy, 2001). For example, drivers tend to drive at their desired speed in each section, but the environment influences their behaviour.

Unlike other vehicles, public transport operates on set routes and timetables that determine the frequency. For each line the route, its stops, stationary time, departure time and type of public transport (bus, metro, tram) can be defined.

2.2 STUDY AREA

The CIVITAS ELAN demonstration area in the city of Porto is called Asprela, located in the northern part of the city. Its 3 km^2 represent 7% of Porto's city area (Figure 1). This area is largely occupied by functional buildings (education, health, R&D) (42,500 workers/students) and houses (12,000 inhabitants). The area is intersected by the highway that connects Porto to the north of the country and is bordered by the city's ring road to the south. The rest of the road infrastructure consists of local roads.

Figure 1: Study area.

As the modelling area should be bigger than the study area in order to understand the traffic condition in the boundary areas, which might influence the behaviour in the study area (Federal Highway Administration, 2004), the modelled area was extended to the closest high-capacity roads (Figure 2): to the highway (N14) to the west, and to a large avenue (Avenida Fernão Magalhães) to the east.

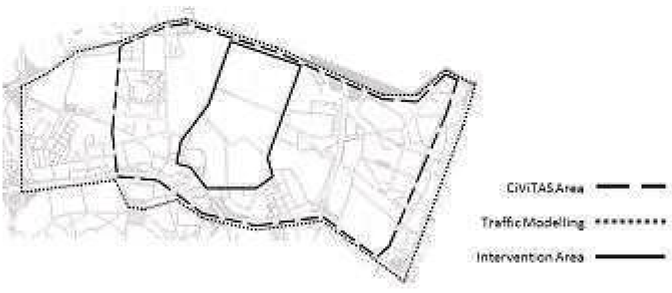


Figure 2: Area limits.

One of the project objectives was to describe traffic conditions in the CIVITAS demonstration area. However, due to a municipal policy guideline, the study area was limited to the centre of Asprela (cf. Figure 2) where due to the high concentration of large institutions the major congestion problems are concentrated.

2.3 NETWORK SUPPLY

The network supply data were obtained by consulting the digital cartography and aerial photographs of the area provided by the Municipality and imported in the AIMSUN software in order to overlay the length and curvature of sections (roads) and intersections. Unfortunately, details such as lane lines and other pavement markings were not always available from these information sources. Therefore, additional information had to be obtained on site through several visits, recording the missing data about roads, surface metro line, and intersections (traffic lights, vertical signs).

Traffic control data was obtained from the files of the city's Traffic Control Department and updated on site, when there was a risk of outdated files.

2.4 TRAFFIC DEMAND

Measuring traffic demand of private transport was performed trough directional traffic counts and O-D surveys in the area, during morning (07:45–09:45) and afternoon (17:00–19:00) peak hours in order to include the traffic congestion periods. To ensure that the network conditions and traffic signals were operating normally and that there were no other unusual activities (road works, festivals, traffic incidents, etc.), the surveys were conducted from Tuesday to Thursday in the last week of September and the first two weeks of October 2009. The survey encompassed 7,014 private vehicles during morning peak hours and 7,129 vehicles during afternoon peak hours.

The public transport demand (bus, light metro) was generated by AIMSUN based on the encoded information, consisting of the route, frequencies and bus/ metro stop locations of each line. In this way, all data was collected for the selected peak hours.

The first step for the development of the O-D matrix was splitting the Asprela area in smaller sub-areas. The definition of the sub-areas had to be done very carefully: if too small, they would have been too numerous and require too many resources. But if too large, some trips would be lost because trips inside the sub-areas were not accounted for (Her Majesty's Stationery Office, 1997). Altogether, 34 sub-areas were defined, 15 within the area and 19 external ones.

After data collection and processing (codification of the survey responses and extrapolation of the number of responses according to the traffic counts) the ME2-Method of Maximum Entropy (Van Vliet and Hall, 2004) was applied to obtain the O-D matrix. For safety reasons it was not possible to conduct some O-D surveys, mainly on the highways, and consequently a large number of trips was not surveyed.

As the AIMSUN model does not have ME2 functionality, the CIVITAS demonstration area had to be modelled in SATURN (Van Vliet and Hall, 2004). Once the area had been modelled in SATURN, it was possible to expand the O-D matrix, using the ME2 to obtain the "Final Matrix" for each peak period.

The final O-D matrices represent a total of 73,456 trips in the morning peak hours and 76,452 trips in the evening peak hours. In Figure 3, the trips are analysed by type of movement:

- 75% in the morning peak hours and 77% in afternoon peak hours are trips crossing the demonstration area,
- 6% in the morning peak hours and 3% in afternoon peak hours are trips that have their origin and destination within the area,
- 19% in the morning peak hours and 19% in afternoon peak hours are trips between the demonstration area and external areas.

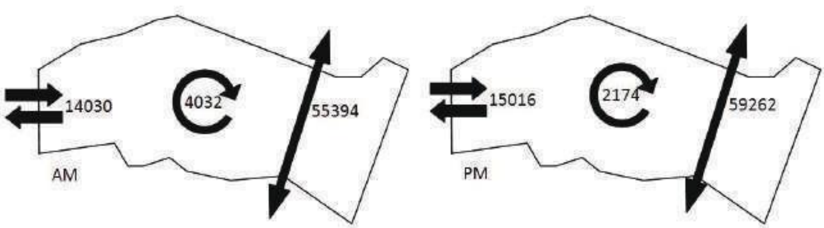


Figure 3: Type of movement, for morning peak (left) and afternoon peak (right).

2.5 BASE MODEL DEVELOPMENT

The development of the micro-simulation traffic model, using AIMSUN software, started by coding links and nodes, including traffic control data (lanes assignment, green waves, stop signs, yield signs, etc.), public transport routes and bus stop locations, travel demand data into the network (O-D matrices for private cars, routes and frequencies for public transport), data associated to traveller behaviour and vehicle performance, as well as selecting the control parameters for the model run. After this stage, tests were carried out to identify possible errors to ensure that the model was built correctly.

The modelling area includes five hundred and fifty seven sections (links) with a total of 73 km in section length and 135 km in lane length; one hundred thirty one intersections, of which twenty are regulated by traffic lights: two traffic lights with signal pre-emption, one centralized (UTC GERTRUDE), nine semi-actuated, four fully actuated and four fixed signals.

In order to develop a proper working model network, checking is an important task. To this purpose, AIMSUN has a specific tool that reviews the coded traffic demand, turning conflicts and control plan (Transporting Simulations System, 2005) and divides the check results into errors and warnings. Another verification test consisted of running the simulation model and analysing the animation output in close detail to observe vehicle behaviour: anomalous vehicle behaviour (such as unexpected braking or routes) is a quick indicator of possible coding errors. The test was performed at a low demand level and at the real demand level, i.e. the two peak periods (morning and afternoon), to isolate congestion problems when (private and public) transport demand changed during the day and traffic control was able to respond to the specific time of the day.

2.6 CALIBRATION AND VALIDATION PROCEDURE

After checking for possible errors, the simulation model was ready for testing. However, there was no guarantee that the results reflected the exact reality, not just another “similar” situation. The process that determines when a model is sufficiently close to the real system is usually referred to as validation, which is an iterative method involving the calibration of the model’s variables and comparing their performance with the real system, using the parameters and two different samples of real traffic data. These two steps are essential and crucial to ensure the model’s credibility.

During calibration, the variables in the model were adjusted to improve the ability to reproduce driver behaviour and the characteristics of the network elements. To evaluate the network performance we defined which variables would be subject to calibration and compared the observed values with the simulated ones.

Parameters require associated criteria, which serve as acceptable limits. When parameter values are within the criteria, the model is calibrated. Therefore, model calibration is performed to adjust the variable values that are responsible for representing the network's condition/behaviour; the aim is for the performance estimated by the model to reflect the actual reality.

A micro-simulation model has a set of variables that can be defined and modified by the user to enable model calibration for local conditions. In the literature (Barceló and Casas, 2004; Hourdakis et al., 2003) default values are being suggested, but during calibration some tests must be carried out in order to verify if they are suited to local conditions. The calibration of simulation models is a necessary process, since one cannot expect any model to be suitable for all possible traffic conditions.

To assist the procedure, variables can be classified into three groups according to their influence on the network elements: general, local section, and particular vehicle type (Barceló and Prado, 2006). General variables influence all vehicles, independent from their type, while driving anywhere in the network: reaction time, reaction time at stop, queue up speed and queue leaving speed. Local section variables influence all vehicles regardless of their type when driving on a particular section of the network: speed limits, turning speed, and visibility distance. Vehicle variables influence all vehicles of a specific type when driving anywhere in the network: maximum desired speed, maximum acceleration, normal and maximum deceleration.

Table 4 presents examples of the calibrated variables used in this article, which are frequently mentioned in the research literature (Barceló and Casas, 2004).

Variables		Default Value	Calibrated Value
General	Reaction Time	0.75	0.55
	Reaction Time at Stop	1.35	0.90
Vehicle (private car)	Headway	0	1.00
	Critical Gap	10.00	7.00

Table 4: Example of calibrated values.

Various methods can be used for the output evaluation of the micro-simulation model (Hourdakis et al., 2003; Tavares, 2003; Barceló and Casas, 2004): defined parameters, graphical representation, or statistical analyses.

Usually, performance evaluation of traffic simulation models is made by comparing the values observed in the system with simulation model values. After selecting the parameters, the input data on traffic supply and demand should be collected at the same time as the data collection activities described above. When comparing the actual values with the values of the variables obtained by the model, it is important to ensure that sufficient data was collected to specify each variable, and that the values are compared with a certain level of accuracy. In urban networks, this issue assumes even greater importance given the temporal variability of traffic behaviour, and this consequently affects the values of the variables that characterize it.

Calibration and validation should have two separate sets of data; if the same set of values is used for calibration and validation, the results might be flawed and not reflect the reality (Her Majesty's Stationery Office, 1997). In this case, the data used was the traffic flow of several movements. Then the set of traffic counts was divided in two, the first set (85 movements) was used to calibrate the model's variables and the second one (50 movements) to validate the calibrated model.

The selected parameters for model calibration and validation presented in Table 5 were: GEH statistic < 5 for individual link flow, GEH statistic for the sum of all link flows, GEH statistic for the sum of 85% link flows with a minor GEH value, positive relative mean error (EMRP) and negative relative mean error (EMRN) (Van Vliet and Hall, 2004; Tavares, 2003).

Parameter		Calibration		Validation		Criteria
		M	A	M	A	
$GEH = \sqrt{\frac{(E-V)^2}{(E+V)/2}}$	GEH<5	71%	61%	68%	47%	85%
	GEH	4	5	5	6	≤4
	GEHM	3	3	3	5	≤2
$EMRP = \frac{\sum_k \Delta q}{\sum_k q_{o_k}} \text{ with } \begin{cases} \Delta q = q_{m_k} - q_{o_k} \ f \ q_{mk} - q_{o_k} \geq 0 \\ \Delta q = 0 \quad f \ q_{mk} - q_{o_k}' < 0 \end{cases}$	EMRP	0.06	0.08	0.14	0.19	-
$EMRN = \frac{\sum_k \Delta q}{\sum_k q_{o_k}} \text{ with } \begin{cases} \Delta q = q_{m_k} - q_{o_k} \ if \ q_{mk} - q_{o_k} < 0 \\ \Delta q = 0 \quad if \ q_{mk} - q_{o_k} \geq 0 \end{cases}$	EMRN	-0.05	-0.04	-0.13	-0.13	-

Where: E = model estimated volume, V = field count,
= Observed volume in section k, - Model estimated volume in section k.
Table 5: Parameters of calibration and validation.

Although the recommended criteria were not always fully achieved, the model was considered validated and calibrated for application.

The journey times of private cars were collected for five defined routes in the CIVITAS demonstration area. Data was collected repeatedly five times for each route during each peak period. The observed data were compared to the simulated data to support the process of model calibration and validation.

2.7 SCENARIO TESTS

The tests of alternative conditions of traffic flow were the reason for developing and calibrating/validating the present network. The study goal was to find a solution for the traffic circulation scheme with better network performance.

The tests carried out considered only changes in the central part of the network (see Figure 2), in order to identify the impact changes within the circulation scheme of the intervention area had on the surrounding area. If the focus had been only on analysing the intervention area, the network's performance might have improved in this area, while deteriorating in the surrounding area, because traffic would simply move out of the intervention area.

The scenario tests took into account only the existing road infrastructure network, with the exception of a proposed new 100m long street. The studied scenarios considered changes in: road directions, traffic control management at intersections, allowed turning movements and new bus corridors for the same demand conditions. Scenario development took into account the reorganization of the road space due to the introduction of a cycling network, a better pedestrian network, and a new parking regime that will reduce on-street parking supply. Figure 6 presents the base circulation scheme and two of the seventeen scenarios that were studied.

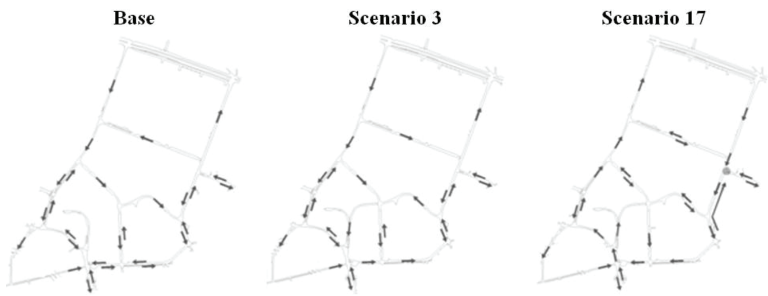


Figure 6: Base circulation and examples of studied scenarios.

The evaluation of the scenarios was based on measures of effectiveness (MOE), i.e. indicators quantifying the degree to which a particular scenario met the project's objectives (Federal Highway Administration, 2004). They were selected according to the project's purpose and the simulation model's outputs. The used MOE were divided into two sets: average indicators and general indicators for the whole traffic modelling area.

The average indicators included:

- average travel time, mean of the difference between exit time and entrance time for every vehicle that has crossed the network, converted into time per kilometre,
- average delay time, average difference between travel time and the time it would take to traverse the system under ideal conditions, delay time per vehicle per kilometre,
- average travel distance, total travel distance divided by the average number of vehicles per hour that have passed through the network,
- density, average number of vehicles per kilometre for the whole network.

The general indicators included:

- total travel time, the sum of travel time experienced by all vehicles that have crossed the network, in hours,
- total travel distance, the sum of the kilometres travelled by all vehicles that have crossed the network, in kilometres.

The analysis of the indicators should be undertaken with caution since they depend on the network's load (the number of vehicles in the network during simulation time), which differs according to the capacity of each tested scenario. The simulated value of each indicator for each tested scenario in the morning and afternoon peak hours is presented in table 7.

Scenario	Average Travel Time (s)		Average Delay Time (s)		Average Travel Distance (km)		Density (veh/km)		Total Travel Distance (km)		Total Travel Time (h)	
	M	A	M	A	M	A	M	A	M	A	M	A
Base	75,78	84,97	43,67	34,65	3,32	3,30	17,57	20,98	117 675	117 441	2 173	2 420
1	77,56	87,79	46,61	36,45	3,34	3,31	18,13	22,01	117 461	117 193	2 220	2 525
2	78,67	83,98	42,78	37,78	3,32	3,29	18,03	21,09	117 748	115 676	2 232	2 351
3	81,21	91,44	50,52	40,13	3,31	3,31	18,37	21,53	116 416	118 031	2 249	2 527
4	76,79	83,98	42,78	35,86	3,34	3,29	18,12	21,09	116 907	115 676	2 178	2 351
5	75,52	103,37	62,32	34,42	3,30	3,27	17,46	27,28	117 441	108 520	2 161	2 847
6	75,81	79,98	39,26	34,99	3,32	3,34	17,40	18,66	118 550	121 788	2 161	2 338
7	89,23	85,61	44,76	48,36	3,32	3,29	20,21	21,66	115 938	114 415	2 411	2 349
8	77,78	79,26	38,57	37,71	3,39	3,35	21,11	19,34	113 580	121 148	2 125	2 340
9	75,39	77,72	37,02	34,45	3,37	3,33	19,09	20,61	115 610	118 151	2 176	2 228
10	74,32	85,57	45,03	33,20	3,32	3,33	17,04	21,51	119 788	119 746	2 216	2 430
11	74,54	80,58	40,03	33,42	3,32	3,32	17,30	20,46	118 330	119 603	2 203	2 319

17	16	15	14	13	12
71,04	70,58	75,08	74,48	71,53	75,99
74,51	78,05	82,52	80,67	77,13	76,20
33,40	36,94	41,83	39,94	36,18	35,82
29,91	29,42	33,98	33,35	30,39	34,93
3,33	3,34	3,33	3,31	3,34	3,32
3,29	3,30	3,33	3,32	3,30	3,32
16,31	16,13	17,32	17,23	16,44	17,44
17,59	17,53	21,41	20,60	17,61	21,16
119 705	118 997	118 503	118 857	118 934	118 588
122 714	121 751	116 276	115 951	120 895	116 459
2 096	2 071	2 188	2 168	2 106	2 197
2 258	2 250	2 408	2 207	2 225	2 161

Table 7: Indicators results.

The analysis of table 7 shows that scenarios 13, 16 and 17 stand out due to the positive and more “relevant” impacts they include, with an emphasis on the last scenario (17), as it includes major impacts.

Scenario 17 has a decrease in the average indicators: about -6% and -12% in travel time, 14% and -24% in delay time, in the morning and afternoon peak periods respectively, and without a significant increase in average distance travelled in the morning (+0.3%), and even with a decrease of this value in the afternoon (-0.3%). With the general indicators, the travel distance increased by 2% and 4%, travel time decreased by -4% and -7%, and density decreased by 7% and -16%, in the morning and afternoon peaks respectively.

The decision which scenario should be studied in detail and serve as the basic support for preparing the “Asprela Mobility Plan” was a political one. The decision-maker was the City Hall of Porto, which based on the technical report opted for scenario 17 in the end.

3 NEW POLICY SCENARIOS

Since 2010 the Municipality has a new policy for the traffic lights at intersections, which avoids conflicts between pedestrians and cars, and improves the safety and mobility of pedestrians. The changes in the policy are: the minimum time of pedestrian green is calculated to allow crossing at a minimum speed of 0.4 meters per second, and the pedestrian green cannot be activated at the same time of car movement that would collide with crossing pedestrians.

The selected scenario was simulated again, including these changes in traffic light policy. The cycle time of the traffic lights increased by 31% on average the time given exclusively to pedestrians. In order to compare the baseline with the scenarios, the baseline too had to be simulated, taking into consideration this new policy, because the changes have quite an impact on traffic conditions.

4 RESULTS

The circulation scheme of the chosen scenario consists of the operation of each block as an independent system in a clockwise direction, reducing the conflicts between turning movement because these usually are right turns (scenario 17, Figure 6). The streets bordering the intervention area have a traffic collector and distributor function, while the streets inside the area have an accessibility function. A high number of trips use the area in transit. This traffic should be channelled to the ring road formed by highways (VCI, A3, N13 and N12).

The intersections controlled by traffic lights were optimized to achieve better performance results. The baseline versus the proposed scenario was analysed, using average indicators, at the level of traffic modelling and the intervention area, for morning and afternoon peak hours (see table 8).

Indicators	Traffic Modelling				Intervention Area			
	M		A		M		A	
	Base	Proposed	Base	Proposed	Base	Proposed	Base	Proposed
Density (veh/km)	17,6	15,8	21,0	16,8	31,7	29,4	37,4	17,9
Average Speed (km/h)	62,8	66,1	61,7	64,4	18,0	23,5	20,7	25,9

Average Travel Time (s)	76	72	85	74	266	215	265	164
Av. Travel Distance (km)	3,32	3,31	3,30	3,29	1,00	0,96	0,91	1,00
Average Delay Time (s)	35	31	44	33	210	161	212	109

Table 8: Baseline versus proposed scenario.

In order to analyse the robustness of the solution, the impact of the proposed scenario was studied at the microscopic level. For the sections and intersections within the intervention area the following performance indicators were defined: average travel time on each section and total delay at each intersection, for morning and afternoon peak hours respectively. According to the simulation's results, the proposed scenario decreases the total delay by about -20% in the morning peak hours and by about 30% in the afternoon peak hours. Average travel time decreases by -20% in the morning peak hours and by about 40% in the afternoon peak hours.

When the new policy for traffic lights in the intervention area is included in the simulation, the proposed solution results in a decrease of total delay by about -30% in the morning peak hours and by about -15% in the afternoon peak hours. Average travel time decreases by -13% in the morning peak hours and by -31% in the afternoon peak hours.

5 CONCLUSIONS

The AIMSUN modelling conducted for the CIVITAS demonstration area contributed considerably to gaining further knowledge and to become more consistent in the application of microscopic models in urban networks. The application of simulation models allowed testing different scenarios and consequently to find a solution that, according to the impact evaluation, improves traffic congestion levels during morning and afternoon peak hours, with no changes in the same demand because a modal shift was not taken into account.

The simulation model proved to be very useful for testing the new policy on traffic intersections concerning the safety and mobility of pedestrians, both for the actual and for the proposed traffic conditions.

The model has shown that the actual solution has more network capacity than the baseline scenario. The additional capacity becomes available due to more sustainable means of transport (public transport, walking and cycling) and due to a reduction of the traffic congestion levels. The exclusive public transport corridor has been extended by 1.1 km (= 150%). The proposed cycling network has a length of 7.7 km with double lanes, of which 5.8 km are lanes on the right side of the road and 1.9 km are within an urban park.

Pedestrians and cyclists were not considered in the simulation model due to time and data constraints hence a quantitative analysis about the benefits of the introduced changes cannot be conducted. Another limitation of the simulation model is the impossibility of modelling street parking, meaning that the impact of the new parking policy introduced in the study area cannot be derived from the model.

REFERENCES

Barceló, Jaume, Eric Bernauer, Laurent Breheret, Gianni Canepari, Carlo di Taranto, Jaime Ferrer, Ken Fox, Jean-François Gabard and Ronghui Liu. 1999. *Simulation Report: SMARTEST – Simulation Modelling Applied to Road Transport European Scheme Tests. SMARTEST deliverable D6*. Project funded by European Commission.

Barceló, Jaume. 2001. *AIMSUN Microscopic Traffic Simulator: a tool for the analysis and assessment of ITS systems*. Highway Capacity Committee, Half Year Meeting, Lake Tahoe.

Barceló, Jaume and Jordi Casas. 2004. *Methodological Notes on the Calibration and Validation of Microscopic Traffic Simulation Models*. 83rd Transportation Research Board Annual Meeting Washington D.C.: Paper #4975.

Barceló, Jaume and Maria Teresa Perez Prado. 2006. *Methodological note on the calibration and validation of Microscopic Traffic Simulation Models*. AIMSUN Training Course, 23rd and 24th November 2006.

Federal Highway Administration. 2004. *Traffic analysis toolbox* *volume III: guidelines for applying traffic micro simulation modelling software: FHWA-FRT-04-040*. Federal Highway Administration.

Her Majesty's Stationery Office. 1997. Traffic Appraisal Manual: Manual for Roads and Bridges. *Traffic Appraisal of Roads Scheme 12, Section 1, Part 1*.

Hoogendoorn, Serge P. and Piet H. L. Bovy. 2001. State-of-the-art of vehicular traffic flow modelling. Proceedings of the IMECHE Engineers Part I. *Journal of Systems & Control Engineering, Professional Engineering Publishing*: 283–303.

Hourdakis, John, Panos G. Michalopoulos and Jiji Kottomannil. 2003. *A Practical Procedure for Calibrating Microscopic Traffic Simulation Model*. 82nd Transportation Research Board Annual Meeting Washington D.C.: Paper#4167

Ortuzar, Juan de Dios and Luis G. Willumsen. 1990. *Modelling Transport*. West Sussex: John Wiley & Sons, Lda.

Tavares, José Pedro Maia Pimentel. 2003. *Aplicabilidade e Robustez de Modelos de Afectação de Tráfego em Redes Urbanas*. Dissertação de Doutoramento em Engenharia Civil, Faculdade de Engenharia da Universidade do Porto.

The Civitas Initiative. Cleaner and Better Transport in Cities. Available at: http://www.civitas-initiative.eu/index.php?id=4, 21. 10. 2011.

Transporting Simulation Systems. 2010. *Microsimulator and Mesosimulator AIMSUN 6.1. User's Manual*. Barcelona.

Van Vliet, Dirck and Mike Hall. 2004. *SATURN 10.3. User Manual*. The Institute for Transport Studies, University of Leeds.

PORTO I The Demand Responsive Transport service was available every Thursday, Friday and Saturday night, between 00:30 a.m. and 05:30 a.m., mainly targeting students.

PORTO I The ELAN activities have given mobility and transport issues a big push. Decision makers and citizens are now much more aware and the willingness of people to change their travel habits has increased.

PORTO | The infrastructure for non-motorised modes has been adapted to contemporary needs.

SPATIAL PREDICTION OF AIR QUALITY IN AN URBAN SENSITIVE AREA: A SEASONAL OVERVIEW

Tânia Fontes and Nelson Barros

1 INTRODUCTION

In most urban areas, as Porto, road traffic is the main source of ambient air concentration of pollutants such as nitrogen dioxide (NO_2), carbon monoxide (CO), benzene (C_6H_6), and particles (Alpopi, 2010; Keuken et al., 2004). In order to monitor this problem urban air quality monitoring and forecast has become an important issue for many environmental protection agencies around the world in the last decades (Horálek et al., 2005). To generate maps of concentrations means that interpolating and extrapolating methods have to be used.

Spatial prediction techniques, also known as spatial interpolation techniques, differ from classical modelling approaches in that they incorporate information on the geographic position of the sample data points (Cressie, 1993). The interpolation is the procedure of predicting unknown values using the known values at neighbouring locations which may be regularly or irregularly spaced. The values derived in this way are not necessarily the true value; they are a mathematical "best guess" based on the known values (Aranoff, 1995). Thus this method is necessary when the ground truth data does not cover the whole area. Demers (2005), classifies interpolation methods into linear and non-linear.

Usually, interpolation methods use the weighted average of nearby data to calculate the estimates. The weights could be assigned according to deterministic or statistical criteria. The quality of the interpolation results depends on the accuracy, number, and distribution of the known points used in the calculation and on how well the mathematical function correctly models the phenomenon (Aranoff, 1995). Also, the pollutants are governed by different mechanism, of acting on a different spatial scale: regional and local effects. Fluctuations in the concentration pattern are mainly driven by meteorological phenomena; however, air pollution can have a distinct local character due to local emission sources and their temporal variability. In the dense urbanized region of Asprela in Porto, the study area, the latter effects are significant. This is a sensitive area with several universities and two hospitals, with high traffic density and mobility problems, yet it does not have any air quality station within the national network.

Among statistical methods, geostatistical kriging-based techniques, including simple and ordinary kriging, universal kriging and simple cokriging have been used for spatial analysis. In the deterministic interpolation methods, inverse distance weighting method and its modifications are the most often applied. Kriging and Inverse Distance Weight (IDW) are the most commonly used methods when measuring air quality (Wong et al., 2004; Horálek, 2005; Mesquita, 2010; Sánchez, 2009). Both methods estimate values at unsampled locations based on the measurements at surrounding locations with certain assigned weights for each measurement. However, while kriging requires the preliminary modelling step of a variance-distance relationship, IDW does not require this step. Many studies have compared IDW and kriging, and the performance of kriging was generally better (Wong et al., 2004).

In this paper, two interpolation models have been used – IDW and Ordinary Kriging – which can incorporate both the regional and local aspects of the air pollution phenomenon. The main objective of this study was to describe and analyse the relative performance of these interpolation methods to predict the field concentration of air pollutants, such as benzene (C_6H_6) and nitrogen dioxide (NO_2), in Porto's Asprela area. This work summarised below was performed twice, once in winter 2009 and once in summer 2010.

The outline of this paper is as follows. In Section 2 the methodology is described in detail and in Section 3 and 4 model results are discussed and validated. A conclusion is presented in Section 5.

2 MATERIALS AND METHODS

The present study focuses on the atmospheric concentration of C6H6 and NO2 in Porto's Asprela area. These two pollutants are considered to be good indicators for pollution caused by traffic. Hence, they can be regarded as the most important emission source in the area. Measurement of these pollutants was conducted in the scope of the CIVITAS ELAN project (TREN/FP7TR/218954 - ELAN), co-funded by the European Commission between September 2008 and September 2012.

Statistical analyses were done in two stages. First, a geostatistical analysis was performed and then the distribution of data was described using conventional statistics such as mean, maximum, minimum and standard deviation (SD). In this second step the results were also compared with the annual limit value for the protection of human health defined in the Directive 2008/50/CE (5 µg.m^{-3} for C_6H_6 and 40 µg.m^{-3} for NO_2). Although these limits are linked to annual averages and the results are based on a relatively short measuring period (three weeks), this approach represents a good indicator for the potential impact of the air quality in Asprela (study area) on human health.

Regarding the first step, firstly the number of observation points needed for a correct spatial representation of atmospheric concentrations field in the area was defined. To do this, a statistic approach based on a screen run of a numerical dispersion model was used.

Due to its ability to reproduce mesoscale atmospheric circulations and photochemical production, the possibility to work with long data series, as well as its speed of data processing, the air quality modelling was performed using the TAPM model (Hurley, 2008). The model was applied using a three level nesting technique with 25 x 25 points, centred on the city of Porto (41°9'34, 94''N, 8°37'19, 32''W) and 25 vertical grid levels, between 10 and 8,000 metres. The larger grid uses cells of 30 km x 30 km, the intermediate grid, cells of 10 km x 10 km and the finer grid, cells of 3 km x 3 km (Figure 1). The synoptic forcing was done based on the ECMWF data for 2006, a year that can be considered a good approximation to the usual climatic conditions within the study region (Fontes, 2010). The simulation of air quality was made using CO and NO_2 UNECE emissions (Boavida et al., 2008) for the finer grid. Because the UNECE emission inventory does not include C_6H_6 emissions the TAPM was used to simulate, as a tracer of C_6H_6, the CO concentrations. Thus, two types of air quality simulations were done, one in non-reactive mode for CO concentrations, and another in reactive mode for NO_2. In the reactive mode simulation a value of reactivity pattern of VOC emissions (R_{smog}) of 0.0067 (Hurley et al., 2005) was considered. Additionally, in order to get a refinement of the concentration field over the study area, the output grid was processed to a sub-grid with cells of 300 m x 300 m. The simulation was performed for both measuring periods (winter 2009 and summer 2010).

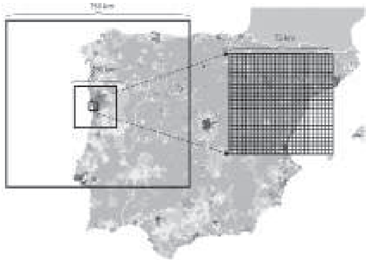
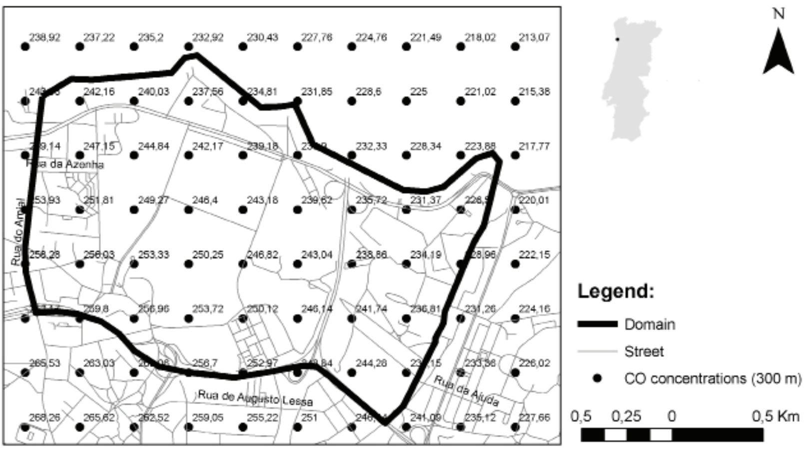


Figure 1: Meteorological areas considered in the air quality simulation using TAPM model in Metropolitan Area of Porto (MAO).

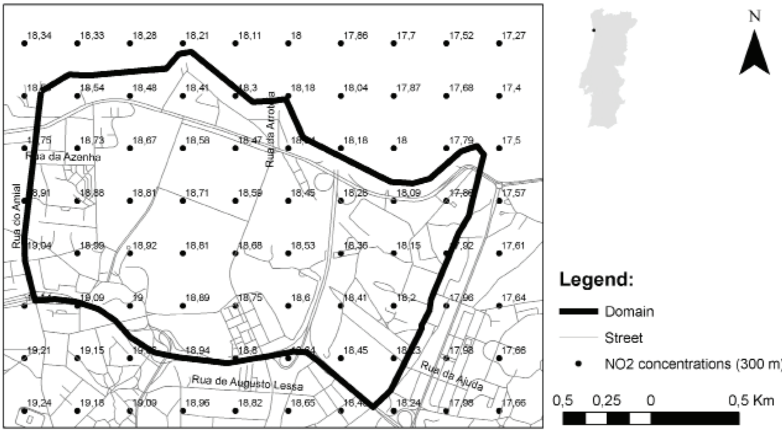
Using the estimate concentrations over the Asprela area (Figure 2), a CO average concentration of 241.86 ± 13.80 µg.m^{-3} and a NO_2 concentration of 18.43 ± 0.51 µg.m^{-3} was predicted. Based on these confidence intervals (S), the minimum number of observation points for each pollutant was estimated, considering that the confidence level (LC) has a significance level of 5% of the mean value (Eq. 1).

$$LC=\frac{s}{\sqrt{n}}t_{0.975} <=> n=(\frac{s}{LC}\ t_{0.975})^2 \quad \text{(Eq. 1)}$$

This approach resulted in an estimate of about six observation points for CO and two for NO_2 required for a representative description of the study area.



i)



ii)

Figure 2: Air concentrations (µg.m^{-3}) estimated by TAPM model in the Asprela area: i) CO; ii) and NO_2.

Based on these results two measuring periods were chosen (19 November – 16 December 2009 in winter and 28 June – 20 July 2010 in summer) using a diffusive sampler technique to monitor pollutants (PASSAM, 2010). In order to control deviations and diffusive samplers lost due to vandalism, 12 observation points were used. The diffusive samplers were placed on poles at a height of 3 m and evenly distributed within the area (Figure 3). Additionally, and in order to monitor the background concentration, measurements were also done at the top of four buildings of the city (height: 40–50 m): Antas tower, Burgos building, JN building and CMP building. At these locations replicas were used to control eventual deviations. Due to vandalism point number 4 of C_6H_6 was lost during the measuring period.

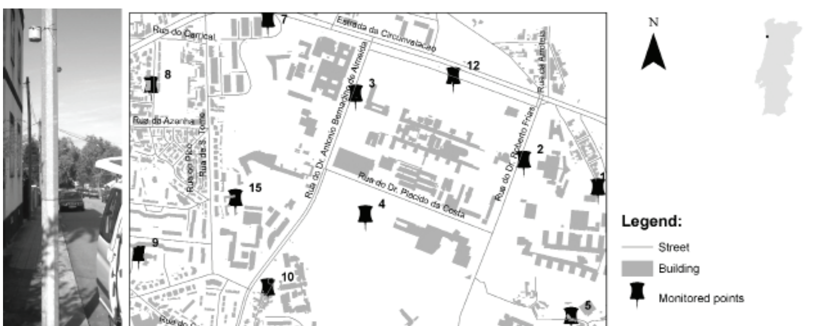


Figure 3: Location of the diffusive measurement points in the Asprela area (Porto).

To estimate the spatial distribution of C_6H_6 and NO_2 during the winter period, two interpolation methods were used: (i) a deterministic method, the Inverse Distance Weighting (IDW), (ii) and a geostatistical method, the ordinary kriging. These methods were implemented using the ArcGIS 9.3 software.

The IDW is a method often used to interpolate data from air quality, given its simplicity (Brigs et al., 2005; Keuken et al., 2005; Lindley and Walch, 2005). To predict a value for any unmeasured location, this method uses the measured values surrounding the prediction location. Closest values have more influence on the predicted value than those farther away, hence the name inverse distance weighted. The surface calculated depends on the selection of a power value and the neighbourhood search strategy. IDW is an exact interpolator, where the maximum and minimum values in the interpolated surface can only occur at sample points. The output surface is sensitive to clustering and the presence of outliers. IDW assumes that the surface is being driven by the local variation, which can be captured through the neighbourhood.

$$f(x,y)=\left[\frac{\sum_{i=1}^{n} w(d_i) z_i}{\sum_{i=1}^{n} w(d_i)}\right] \quad \text{(Eq. 2)}$$

Where z_i is an observed value i, d_i is the distance between the estimated point and the observed point i; $w(d_i)=1/(d_i)^p$ is the ponderation of the observation i; and p is the power function.

The IDW predictions were performed varying the number of power (0.5 and 3) and using different radiuses and neighbours.

The kriging method is similar to the IDW for considering the measured values in the neighbourhood to predict the concentrations in an unmeasured location. In ordinary kriging the weights depends on the model fitted to the measurement points of the local distance estimate, and the spatial relationships between the measured values around the local forecast (Johnston et al., 2001). Ordinary Kriging assumes the model:

$$Z(s)=\mu+\varepsilon(s) \quad \text{(Eq. 3)}$$

Where μ is an unknown constant.

The performance of each evaluation technique was assessed comparing the deviation of estimates using the cross-validation method. To use this technique, a point was excluded and then the model was applied to estimate the concentrations at this removed point. Therefore, the comparison of the performance between the different interpolation techniques was achieved using the average error (*ME*)(Eq. 4), the Mean Absolute Error (*MAE*) (Eq. 5), the Root Mean Squared Error (*RMSE*) (Eq. 6) and de Normalized Root Mean Squared Error (*NRMSE*) (Eq. 7), and the coefficient of determination (R^2) (Eq. 8) (Mesquita, 2010):

$$ME=1/n \sum^{n}_{i=1} E_i - O_i \quad \text{(Eq. 4)}$$

$$ME=1/n \sum^{n}_{i=1} \left| E_i - O_i \right| \quad \text{(Eq. 5)}$$

$$RMSE= \sqrt{1/n \sum^{n}_{i=1} (E_i - O_i)^2} \quad \text{(Eq. 6)}$$

$$NRMSE=\frac{RMSE}{\bar{O}_i} \quad \text{(Eq. 7)}$$

$$\mathrm{R}^2=1- \frac{\sum^{n}_{i=1}(O_i - E_i)^2}{\sum^{n}_{i=1}(O_i - O_i)^2} \quad \text{(Eq. 8)}$$

Where: *E* = Estimated value; *O* = Observed value; *n* = Number of cases; $\bar{O}$ = Mean of observed values.

All of these parameters have to be equal or close to zero, except the R^2 where the optimal value is 1.

To verify if the selected map can be considered from the legal point of view, the value of uncertainty was also calculated according to Directive 2008/50/EC:

$$Uncertanty=\frac{Observed\ value\ -\ Modelled\ \text{value}}{Limit\ value} \quad \text{(Eq. 9)}$$

The results were compared with the uncertainty of estimation, for both pollutants, defined by Directive 2008/50/EC, 100% to C_6H_6 and 75% to NO_2.

3 RESULTS AND DISCUSSION

Table 1 presents the results of the statistical analysis using cross-validation to the best interpolation map, by pollutant and interpolation method. The specifications are presented in Table 2. The comparison between the two methods of spatial distribution, IDW and ordinary kriging, shows that ordinary kriging is the best method to simulate the C_6H_6 but the differences to the IDW method are small. In the case of the NO_2 concentrations the IDW gives better results. This might be the case because of the different patterns of field concentrations for the study pollutants (different emission and reactivity pattern) and/ or due to the lack of one of the C_6H_6 control points (which was lost due to vandalism).

		C_6H_6		NO_2	
		IDW	Ordinary kriging	IDW	Ordinary kriging
ME		-0.0247	-0.0001	0.0164	6.8370
MAE		0.22	0.20	0.09	2.74
RMSE		0.30	0.29	0.11	3.69
NRMSE		0.24	0.23	0.002	0.078
R^2	All values	≈ 0.00	0.09	0.99	0.17
	Excluding the best and the worse case	0.55	0.32	0.99	0.78
Uncertanty		≈ 4.36%	4.00%	0.22%	6.85%

Table 1: Results of statistical analysis using cross-validation.

			C_6H_6		NO_2	
			IDW	Ordinary kriging	IDW	Ordinary kriging
Specifications	IDW	Output	5	-	5	-
		Power	3	-	1	-
		Search radius	Variable	-	Variable	-
Specifications	Ordinary kriging	Method	-	Spherical	-	Gaussian
		Lag size	-	500	-	500
		Major range	-	1000	-	1000
		Partial still	-	15	-	15
		Nugget	-	30	-	30
	Radius number of points		6	12	16	12

Table 2: Selected specifications by pollutant and method.

Figure 4 and 5 show the two best maps resulting from different simulations for C_6H_6 and NO_2 respectively using the IDW method and ordinary kriging for the winter measuring period. Figure 6 and 7 show the same results for the summer measuring period.

Although for all measuring periods the C_6H_6 maps record always low concentrations, the NO_2 map shows some areas with some critical points (hotspots). This is the case of sample 5 and 6 during the winter season (Figure 5) and sample 2 and 6 during the summer season (Figure 7) where the concentration values are high and are the main concern of the area. Due to this situation the IDW method can pick up these fluctuations better than the ordinary kriging method. Although the whole area is characterized by the presence of roads and car parks, this critical point (sample 4) was located in an area surrounded by vegetation and a sports park with low direct emission of pollutants. Due to the one measuring point that was destroyed by vandalism the C_6H_6 concentrations for this point were lost, but the records of NO_2 concentrations confirm that this is an area with less pollution. This fact can be decisive to show, in future measuring campaigns, that the IDW method may be the best interpolated method for the Asprela area.

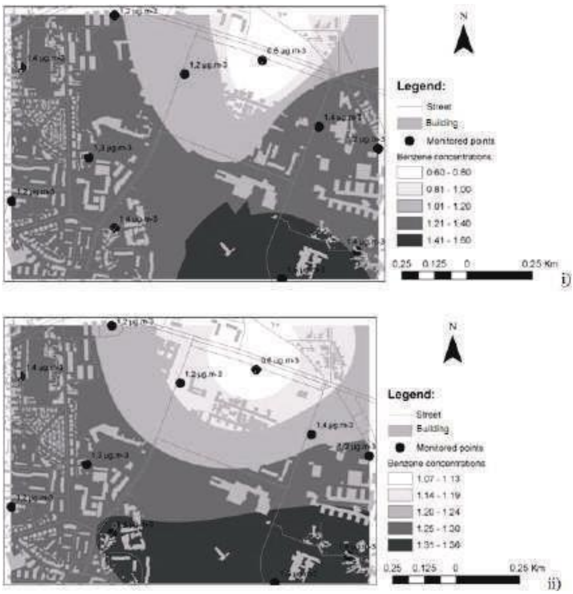


Figure 4: Average C_6H_6 concentrations (µg.m-$^{3)}$ in the Asprela area from 19/11-16/12/2009 using different interpolation methods: i) IDW, ii) Ordinary kriging.

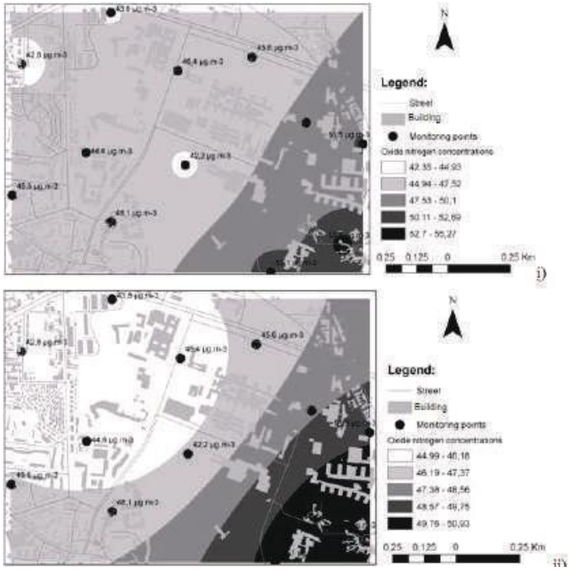


Figure 5: Average NO_2 concentrations (µg.m^{-3}) in the Asprela area from 19/11-16/12/2009 using different interpolation methods: i) IDW, ii) Ordinary kriging.

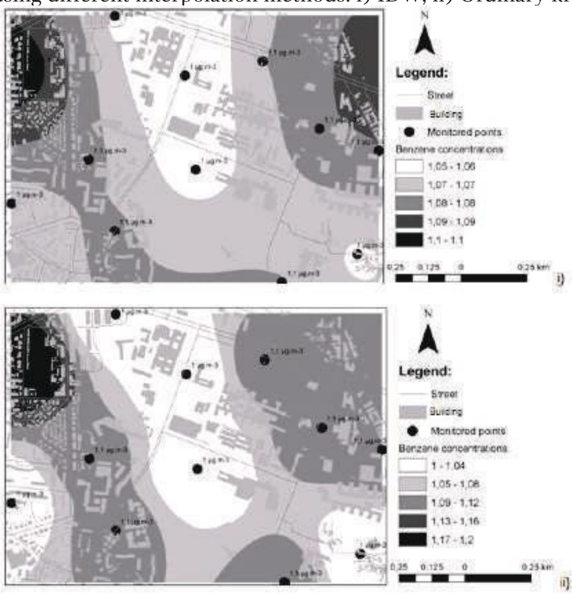


Figure 6: Average C_6H_6 of air concentrations (µg.m^{-3}) in the Asprela area from 28/06-21/04/2010 using different interpolation methods: i) IDW, ii) Ordinary kriging.

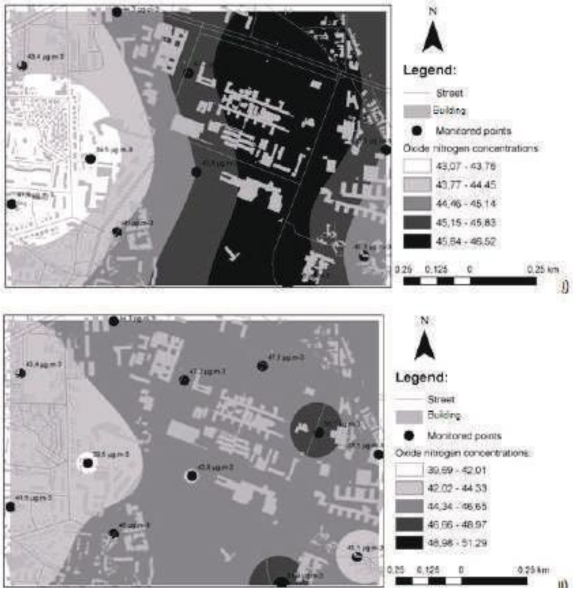


Figure 7: Average NO_2 of air concentrations ($\mu g.m^{-3}$) in the Asprela area from 28/06-21/07/2010 using different interpolation methods: i) IDW, ii) Ordinary kriging.

Once the best map for each pollutant had been validated and selected, the spatial analysis of the results took place as summarised in the next chapter.

4 DATA ANALYSIS

At a height of 3 m, the observed average concentrations of C_6H_6 are 1.25 ± 0.23 $\mu g.m^{-3}$ and 47.22 ± 4.18 $\mu g.m^{-3}$ of NO_2 in the winter period and 1.08 ± 0.06 $\mu g.m^{-3}$ of C_6H_6 and 44.98 ± 3.66 $\mu g.m^{-3}$ of NO_2 in the summer period. For the two pollutants the minimum values were recorded close to the “Estrada da Circunvalação” and the maximum values were recorded in the south close to the A3/ A4 motorway where the volume of traffic increases and traffic speed decreases causing an emissions increase. In the winter period the background average concentrations (observations in the top of the buildings) are 1.02 ± 0.11 $\mu g.m^{-3}$ of C_6H_6 and 34.86 ± 1.45 $\mu g.m^{-3}$ of NO_2, 18.4% and 26.2% lower than the average values recorded at 3 m respectively. Otherwise, in the summer period the background average concentrations (observations in the top of the buildings) are 1.07 ± 0.10 $\mu g.m^{-3}$ of C_6H_6 and 41.70 ± 2.02 $\mu g.m^{-}$

[3] of NO_2, 0.6% and 7.3% lower than the average values recorded at 3 m respectively, which may show a stronger atmospheric stratification situation during the winter measuring period when compared with the measuring period in summer.

The uncertainty of the estimates for both pollutants in winter is below the limits defined in Directive 2008/50/EC, 100% for C_6H_6 and 75% for NO_2 (Table 1). Thus, these maps are representative for the study area and are a good indicative tool to evaluate the results from the legal point of view. The comparison of C_6H_6 results with the human health protection value of 5 µg.m^{-3} defined by the Directive 2008/50/EC shows that, during the study periods, at all monitoring points, the C_6H_6 concentrations are lower than this limit value. Even considering the 23.0% of uncertainty of the C_6H_6 measurement method (PASSAM, 2010) the measured concentrations never exceed the average annual limit value for human health protection. On the other hand, the average NO2 concentrations are in the whole study area higher than the average annual limit value for human health protection defined by the Directive 2008/50/EC (40 µg.m^{-3}). However, considering the 18.7% of uncertainty of measurement method (PASSAM, 2010) for NO_2, 25% of these control points may not exceed the mentioned limit value.

5 CONCLUSIONS

The methods of spatial analysis used in this study do not render possible the definition of an optimal interpolation method for the winter and summer measuring period in the Asprela area. However, the analysis indicates that, in general, the IDW method should be the best method to be used for the study area. In order to confirm this, other tests have to be done for other periods and pollutants. Furthermore, other methods such as ordinary cokriging or multiple linear regression, using auxiliary variables to adjust the spatial interpolation, could be tested in order to minimize errors.

The results for both measuring periods show that, when compared with the Directive 2008/50/EC average annual limit values for the human health protection, the C_6H_6 concentrations are very low (lower during the summer when compared with the winter values), while the NO_2 concentrations present some values above that limit, in particular during the winter period. Even considering the uncertainties of the measurement methods, the C_6H_6 recorded concentrations are never above the annual average limit value for human health protection. Nevertheless, the NO_2 recorded concentrations are above the annual average limit value for human health protection at most of the control points of the analysed area during both measuring periods.

REFERENCES

Alpopi, Christina and Sofia Elena Colesca. 2010. Urban air quality, a comparative study of major European Capitals. *Theoretical and Empirical Researches in Urban Management* 6(15): 92–107.

Aranoff, Stan. 1995. *Geographic information Systems: A management perspective*. Ottawa, Canada: WDL Publications.

Briggs, David J., Hans Martin Seip, Chris Dore, Gerard Hoek, Michael Petrakis and Gavin Shaddick. 2005. *Air pollution modelling for support to policy on health and environmental risks in Europe. Final Report Section 6*. London: Imperial College.

Boavida, Filomena, Ana Teresa Perez, Pedro Torres, Teresa Costa Pereira, Vitor Góis, Tiago Seabra and Hugo Maciel. 2008. *Alocação espacial de emissões em 2005*. Lisboa: Agência Portuguesa do Ambiente.

Cressie, Noel. 1993. *Statistics for Spatial Data Revised Edition*. New York: John Wiley & Sons, Inc.

DeMers, Michael M. 2005. *Fundamentals of geographic information systems*. EUA: John Wiley & Sons. Inc.

European Commission. *Directive 2008/50/EC. Define the ambient air quality guidelines to avoid, prevent or reduce harmful effects on human health and the environment*.

Fontes, Tânia. 2010. *Impacto da qualidade do ar na saúde pública: O caso da cidade do Porto*. Thesis presented to the University of Aveiro to obtain a PhD on Environmental Sciences.

Horálek, Jan, Pavel Kurfurst, Bruce Denby, Peter de Smet, Frank de Leeuw, Marek Brabec and Jaroslav Fiala. 2005. *Interpolation and assimilation methods for European scale air quality assessment and maping Part II: Development and testing new methodologies*. Final draft, ECT/ACC Techical Paper 2005/8.

Hurley, Peter J.. 2008. *TAPM V4. CSIRO Marine and Atmospheric Research Paper Nº25*.

Hurley, Peter J., William L. Physick and Ashok K. Luhar. 2005. TAPM – A practical approach to prognostic meteorological and air pollution modelling. *Env. Modelling and Software* 20: 737–752.

Johnston, Kevin, Jay M. Ver Hoef, Konstantin Krivoruchko and Neil Lucas. 2001. *Using ArcGIS Geostatistical Analyst*. GISby ESRIS.

Keuken, Menno, Eric Sanderson, Roel van Aalst, Jens Borken and Jürgen Schneider. 2004. *Health effects of transport-related air pollution, contribution of traffic to levels of ambient air pollution in Europe*. Available at: http://www.bvsde.paho.org/bvsacd/cd63/e86650/cap2.pdf, 16. 4. 2010.

Lindley, Sarah and Tanya Walsh. 2005. Inter-comparation of interpolated background nitrogen dioxide concentrations across Greater Manchester. *Atm. Env*. 39(5): 2709–2724.

Mesquita, Sandra Maria Pereira. 2010. *Modelação da distribuição espacial da qualidade do ar em Lisboa usando sistemas de informação geográfica*. Instituto Superior de Estatística e Gestão de Informação da Universidade Nova de Lisboa. Master thesis in Geographical Information Systems.

PASSAM. 2010. Available at: http://www.passam.ch/, 16. 4. 2010.

Sánchez, Hermes U. Ramirez, Maria D. Andrare García, Rubén Bejaran, Mario E. García Guadalupe, Antonio Vallo Vázquez, Ana C. Pompa Toledano and Odila de la Torre Villasenor. 2009. The spatial–temporal distribution of the atmospheric polluting agents during the period 2000–2005 in the Urban Area of Guadalajara, Jalisco, Mexico. *J. Hazardous Materials* 165: 1128–1141.

Wong, David W., Lester Yuan and Susan E. Perlin. 2004. Comparison of spatial interpolation methods for the estimation of air quality data. *J. Exp. Analysis and Env. Epid*. 14: 404–415

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PORTO | The Porto Lightweight Bus Shuttle has been put in operation.

PORTO I The partner OPT has developed the mobile application MOVE-ME for Androids and iPhones. With an average of 1,000 requests per day, OPT has improved the application based on users' feedback.

PORTO I The Mobility Shop counted an average of over 100 visitors per day. The information provided is related to all the means of transport available in the city, advice services for better mobility management, and many others issues.

COMPOSITE MATERIAL-BASED LIGHT WEIGHT BUS

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1 INTRODUCTION

The fast globalization has made efficient and reliable transportation a key factor in the competitiveness of individual regions. At the same time, oil prices, CO_2 emissions and global warming constitute unprecedented challenges and an incentive to work towards a form of mobility that is sustainable, energy-efficient and respectful to the environment.

The context of mobility in Europe has changed considerably over the last years. In the wake of enlargement, mobility has now to be considered on a continental scale basis.

1.1 EUROPEAN TRANSPORT POLICY OBJECTIVES

The objective of a European Union (EU) sustainable transport policy is that its transport systems meet society's economic, social and environmental needs. Effective transportation systems are essential to Europe's prosperity. The objectives of EU transport policy, from the transport White Paper of 1992 via the White Paper of 2001 to today's communication, remain valid: to help providing Europeans with efficient, effective transportation systems, once having significant impacts on economic growth, social development and environment.

Mobility must be disconnected from its negative side effects using a broad range of policy tools, and the potential for technology to make transport more environmentally friendly must be enhanced, in particular with respect to greenhouse gas emissions (GHG).

1.2 TRANSPORT GROWTH IN EUROPE

Road transport is predominant in Europe, accounting for 44% of freight and around 85% of passenger transport. For the period between 2000 and 2020, forecasts establish the average annual GDP growth rate at 2.1%. Freight transport is expected to grow at roughly similar rates whereas passenger transport growth is expected to be lower in the order of 1.5% on average annually (European Commission, 2005). Modelling (European Commission, 2001) confirms that the modal split will be roughly stabilized in the long term.

According to data from the European Environment Agency, transport accounted for close to a quarter (23.8%) of total GHG emissions and slightly more than a quarter (27.9%) of total CO_2 emissions in the EU-27 in 2006. Compared to 1990 levels, the growth rate of GHG emissions in no other sector has been as high as in transport.

As the transport sector relies on fossil fuels for 97% of its needs, the fight against climate change in this sector goes hand in hand with efforts to improve security of its energy supply.

Moreover, urbanization has been a clear trend in the past decades and is expected to continue, with the proportion of the European population residing in urban areas increasing from 72% in 2007 to 84% in 2050 (United Nations, Department of Economic and Social Affairs/Population Division, 2008). Urban transport accounts for 40% of CO_2 emissions and 70% of emissions of other pollutants arising from road transport (European Commission, 2007). Congestion that is prevalent in agglomerations and in their access routes is the source of large costs in terms of delays and higher fuel consumption. As most freight and passenger transport starts or ends in urban areas, urban congestion also negatively impacts on inter-urban travel.

1.3 PORTO INTERVENTION AREA (CIVITAS ELAN PROJECT)

The scope of the project CIVITAS ELAN highlights the need for monitoring (environmental, energy, operational, etc.) the main impacts of measures sponsored and, therefore, it was decided that the area of intervention would be the area of Asprela – Paranhos. It is an area with high concentration of institutions of higher education (universities and polytechnics) and health-care facilities (S. João Hospital and the Portuguese Institute of Oncology). There is also the presence of consolidated residential areas and new ventures. These characteristics generate a concentrated demand, around the peak time at morning and afternoon, as well as variation over the school year periods.

In general, there are advantages of public transport over individual motorised transport, particularly with regard to efficiency of land use, since it can carry more people requiring less space, thus reducing congestion, but also in terms of energy and environmental issues (Institute of Highways and Transportation and Department of Transport, 1987).

Those reasons are strong enough to justify all the efforts to develop better and cleaner transports. Aligned to the growing need to reduce the consumption in urban public transport, the intention of developing a lightweight bus took place within the CIVITAS ELAN project in Porto.

Using new technology and new materials is expected to reduce the weight of vehicles without a decrease in the structural quality of their bodies. With the introduction of composite materials in the design of the bus bodywork it is expected to achieve a significant reduction of the weight of the bus body.

2 DESIGN CONCEPTS

It was decided to transform a Toyota Coaster minibus, reusing its frame and designing new and full composite materials bodywork. This solution results from a long process characterized by several evolution stages with advances and setbacks, essentially due to available budget and compliance with national laws.

The design concept, during the development process, took into account the following requirements:

- superior specific strength and specific stiffness characteristics,
- minimization of production costs and maintenance costs,
- reduction of the structural weight,
- development of a concept for the production and assembly of bodywork,
- definition of methodologies that reduce time manufacturing.

Two possible manufacturing processes, namely the vacuum infusion and the filament winding, were considered for the production of composite sandwich components.

2.1 CONCEPTS BASED ON PREVIOUS STUDIES

Three previous concepts were analysed so that the ideal structure could be designed to attend the objectives of the project, through several meetings with a few companies specialized in the manufacture of large parts in composite materials.

The first one (Figure 1) is a structure of sandwich skin rectangular tube being produced by lamination of the inner skin by filament winding over a removable (dismountable) mandrel, followed by placement and bonding of the sandwich core and lamination of the outer skin by filament winding.

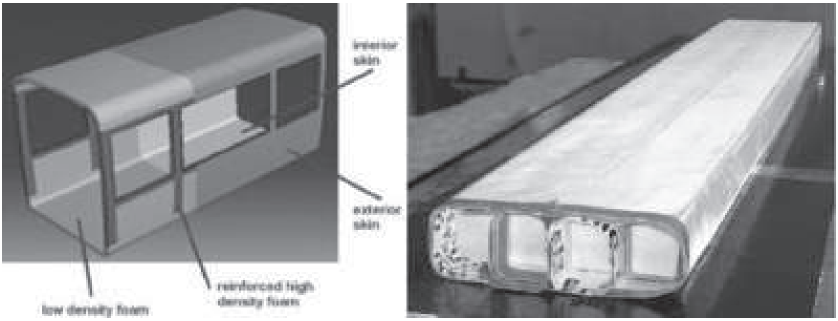

Figure 1: Previous constructive solution considering reinforced core.

This concept was abandoned because it would be necessary to build a large mandrel to produce only one prototype that would increase the costs too much.

In order to avoid the mandrel, the second concept considered a pre-form structure, sufficiently strong and stiff that would work as the main winding spindle. The outer skin would be laminated by filament winding, resulting in continuous shell, longer than the section. The extra laminate outside the length of the body would be necessary to enable the machine to correctly position the fibres. This extra length depends on the envisaged fibre orientations and laminate thickness. The extra areas must be cut off and only contribute to increase cost. This concept was also abandoned since the cut of the panels would bring to this process a big waste of material and would seriously weaken its structural strength.

The third concept considered an integrated mandrel, made by welded aluminium, and both the reinforced sandwich cores and the pillar cores would be completely assembled. The inner skins would be produced by vacuum infusion prior to mounting the structure in the spindle. The sandwich structure would be half produced before filament winding the exterior skin. The remaining steps would be equal to the second concept. Meanwhile, with the partnership with DesignStudioFEUP department and Estaleiros Navais de Peniche (ENP) shipyard, and after a few meetings, it was agreed by all stakeholders to waive this last concept due to budget and time constraints.

2.2 CONCEPTS BASED ON INTEGRAL STRUCTURE OF COMPOSITE MATERIALS

Other concepts were discussed just considering integral composite structures. First, a modular structure constituted in structural rings and concluded with flat glasses on rear and front allowing for different typologies of buses of different sizes. Second, a concept forming a Monobloc bodywork with panels attached based on sandwich structure type (strongly reflecting the traditional approach of a reticulated structure covered with metal panels- the usual manufacturing process in this business) but now with an integral composite structure.

The difference between these two concepts is that the first considers bonding panels into a main reticulated structure and the second considers bonding several parts/modules made in sandwich.

Despite the filament winding technology being a promising approach (Figure 2), the Institute for Mobility of Land Transports (I.M.T.T.) made it clear that it would be almost impossible to homologate the bus taking into account the national laws, without weakening the main structure (that must include large open areas for security reasons).

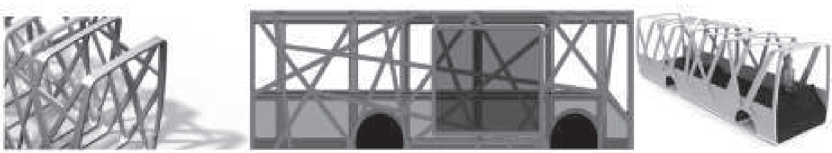

Figure 2: Reticulated structure concept.

The expertise of ENP shipyard in building parts with considerable dimensions through the vacuum infusion of resin technology made possible the progress on the concepts based on a truly monocoque structure in which the overall strength is mainly due to the behaviour of an unitary “shell” and no longer from a braced bone of filiform elements.

From this phase onwards, the panels were considered as structural ones, reinforcing the structure under the necessary openings (weakened sections), especially for the placement of “windows” with the dimensions imposed by existing regulations for this type of product. The floor was designed as a second part and welded to the bodywork (structural bonding) (Figure 3).

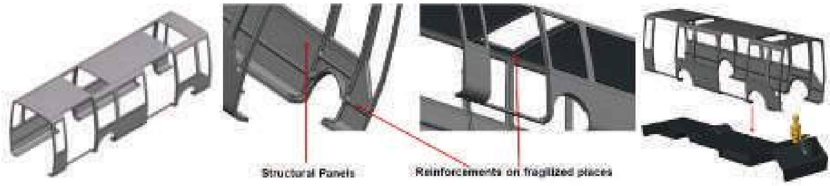

Figure 3: Monocoque concept.

However, the budget needed to spend for moulds would be unsustainable.

Taking in account the requests of CIVITAS project and considering the most recent technological approaches used in urban buses to improve mobility (low floor without steps, front wheel drive), it was agreed by all partners that another solution would be to transform a chassis-cab vehicle into a minibus, cutting the frame and allowing for an adaptation of an independent suspension on the rear axle, reuse the front axle (where the mechanical components are attached, as the wheel drive system and dashboard) and build a new bodywork (Monocoque and freestanding structure) with large and empty internal space, placing seats only at the rear (above the axle).

To reduce mould costs and to comply with the assembly technology used by ENP shipyard, the new bodywork concept foresaw smaller windows, the width of the pillars and the radii of curvature of the corners of windows increased to reduce stress concentrations looking like a structure of a “box”.

When discussing the viability of this concept with national transportation authorities, the huge difficulty imposed by its necessary future homologation became clear. A technical authorization from the frame manufacturer would be necessary so the cutting of the frame would be legal, which has discouraged any progress with this concept.

Finally, the team decided to keep the monocoque and freestanding structure, but returning to the Toyota Coaster frame as the mechanical base to new bodywork, assuming a high-floor bus. To that end, elevated platforms would have to be mounted at the bus stops to allow for an easy and fast access to inside/outside of the bus, and large internal and free areas.

3 TECHNOLOGICAL APPROACH

Once the design concept was approved, several meetings were held to select the manufacturing process, to define the first set of materials (its proportions and dimensions) which would constitute the sandwich, based on the project constraints (essentially budget and timeframe).

A pure composite material bodywork was decided to emerge from this measure, but given the low feasibility of using filament winding, the constructive technology SCRIMP was selected.

3.1 SCRIMP TECHNOLOGY

SCRIMP (an acronym which stands for Seemann Composites Resin Infusion Moulding Process) is a resin transfer moulding process that uses vacuum to pull liquid resin into a dry lay-up and is used to make very high quality, reliable composite parts with almost zero volatile organic compounds (VOCs) emissions.

In the basic SCRIMP process, fibre reinforcements, core materials and various inserts are laid up in a tool while dry, followed by a vacuum bag that is placed over the lay-up and sealed to the tool. The part is then placed under vacuum and the resin is introduced into the part via a resin inlet port and distributed through the laminate via a flow medium and series of channels, saturating the part (Seemann Composites INC – SCI, 2010).

The vacuum pressure compacts the dry fibres. For this reason, parts made with the SCRIMP™ process have high fibre volume contour, typically about 60–75% fibre by weight (50–65% by volume), depending on the type of fibre, the fibre architecture and the type of resin used. The vacuum removes all of the air from the lay-up before and while resin is introduced. The pressure differential between the atmosphere and the vacuum provides the driving force for infusing the resin into the lay-up (Bac2, 2001: 1).

4 BUS MANUFACTURING DEFINITION

Even with the manufacture process selected and the design concept established, a few revisions were done to promote the best quality of bodywork main structure, and anticipate future executing difficulties.

4.1 DESIGN REVISION

In order to produce the body parts by SCRIMP, it is required the construction of moulds. Great contribution was given by the ENP experience in manufacturing of composite parts to choose the most suitable type of mould to the intended technology, providing the required product of the physical properties necessary for their good performance, without compromising budgetary sustainability of the project (see details in Mould chapter).

A constructive parallelism was established, making an extrapolation of the construction of a cabin of a passenger ship (catamaran) to a body of a bus, without forgetting the different requests (loads) that the structures are faced in service.

This analysis led to the readjustment of the bodywork concept, and to build the bodywork in two parts, floor and bodywork properly, against the initial intentions to build it in one single part.

Specific geometries were predicted to improve the placement between the parts and make easier the bonding process. The floor part already includes the sills and includes metal inserts that allow screwing it to supports of the frame. The parts are bonded by structural adhesive and after that the main structure is clamped on top of the frame (Figure 4).

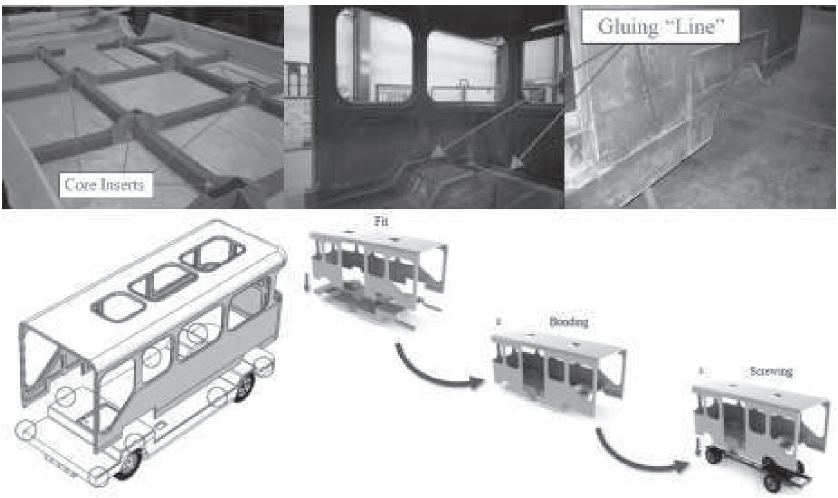

Figure 4: Inserts (floor), bonding areas, fit geometries and assembly sequence.

It was also discussed the possibility of manufacturing the part “bodywork” by bonding four different flat panels made independently from each other to finally form the “box” (multi-parts). Through this process it would not be necessary to build a mould. Panels would be executed by Vacuum Infusion too, manually stratified, with average times of 35 minutes each. ENP owns equipment to produce panels up to 15m x 6m x 2m (ENP SA, 2011). Thereafter the body would be assembled by vacuum assisted bonding the panels. Once more, for structural reasons it was decided to go for one single part.

4.2 MOULDS

The SCRIMP process requires moulds to produce the parts, which is the most expensive component of the construction budget. It was finally decided to build two open moulds, against the initial intentions to build it in a single closed one. These moulds are made of plywood for manual lamination and assured the critical dimensions of the project as well as stiffness and manoeuvrability of the model (Figure 5).

Figure 5: Moulds open type for extract floor and body parts.

This choice was also based on the fact that cold process of consolidation can be used, which uses low pressure, not requiring robust materials, heavy or expensive as the metallic to resist to deformations.

The external and internal flat geometries and constant bending radius made easier the lamination and the process of release parts from the mould.

To achieve structural parts with better properties (lower stress concentration) abrupt changes in thickness and parts geometry were avoided, as the composite nature does not allow for stress outflow (such as in metals that draining and absorb these stresses as permanent deformation).

Given the considerable size of the pieces to be extracted, this type of mould also enables a better control of the infusion process because it allows the access to all of the part points, as well as the detection and elimination of vacuum leaks, along with supervision of the flow of resin.

This choice has enabled lower cost in comparison with the execution of mould for extraction of the body in one piece, to form a continuous closed box (would need to be mould closed type) since it requires cheaper materials that involve less constructive rigorousness (easy to execute) (Composite One LLC, 2011).

4.3 COMPOSITION OF THE COMPOSITE SANDWICH

The initial set from structural dimensions of the sandwich was established such as the points/places where the bodywork should be reinforced.

Although the use of carbon fibre had been discussed, through computational analysis it was possible to predict that the ratio properties vs. costs would be worse than with integral fibre glass construction, for this shape. Even sacrificing the weight reduction (as the use of carbon fibre fabrics it would potentially reduce more weight), the significant costs increase turned out this solution not to be feasible.

The material base for the core of the sandwich is PVC foam, with 80Kg/m^3 of density (H80), and was involved by resin reinforced with fibre glass fabrics, mixing 0º-90º plies with random plies, on fibre orientation.

After the first approach, several tests to optimize the structure were done, which led us to make several modifications until the final solution.

4.4 CHARACTERIZATION OF THE USED FRAME

Simultaneously, the geometry of the Toyota frame was identified and a 3D model was created using SolidWorks software, to help providing the correct fit to the floor (avoiding geometrical interception between frame and floor and no mismatches on local provided for the screwing).

The best clamping solutions for each attachment place and the correct placement for the inserts into the floor part were determined.

5 STRUCTURAL CONCEPTION AND ANALYSIS

In order to guarantee the viability of the project, a few approximate structural conceptions were performed in parallel with the design conception. This dynamic process led to a stable and optimized conception.

The validity of the numerical models had to be guaranteed by laboratorial experiments.

Samples at 1:1 scale were built to be tested.

5.1 INITIAL STRUCTURAL CONCEPTS AND MODELS TESTS

Several numerical simulations and tests for the bus body were conducted for a few structures designed during the design concept evolution. For urban buses, which can only circulate up to 50 Km/h, it is not necessary to perform the rollover test in order to legalize the bodywork (United Nations, 2006), predicted in accordance to the European Regulations named “Resistance of the Superstructure of Oversized Vehicles for Passenger Transportation” (ECE R66).

ABAQUS software was used to do the simulations, in order to improve the designs and the mechanical properties of the bodywork. In this section, only a few examples will be reported.

On the first models a bending strength tests was conducted to understand its behaviour and help in calculation of its reference absorption energy. After that, rollover tests simulations were run, according to one of the predicted methods inside ECE R66. In these first models, the level of deformation was bigger than the acceptable values and these structures had to be modified/strengthened. Note that the residual space, according ECE R66, cannot be invaded in order to guarantee that the passengers are not injured.

The same process was executed with last model (chassis-cab), low-floor (real base of the actual) (Figure 6).

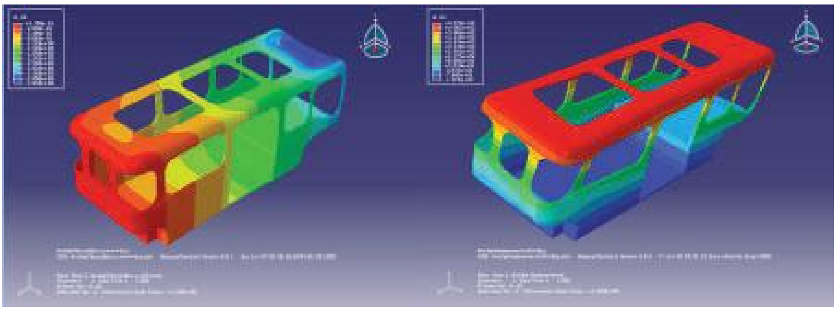

Figure 6: Bending strength test (left) and rollover test (right).

Even with a high percentage of satisfactory results, it was possible to observe that modifications could be introduced to enhance the structure.

The roof openings were reviewed and shortened and new static tests were performed considering a rigid body, placed on roof to simulate the air conditioner unit (100 Kg), and an uniformly distributed load, (passengers) 500 Kg/m2, applied in all parts of flat floor and considering the bodywork fixed on the predicted places on the frame. The stress value achieved 41.95 MPa, with 3.875 mm of maximum deformation (safe values for this construction).

5.2 VALIDATION OF THE MODEL

To validate the model, one sample of the column of the windows and two of the floor were developed.

A profile with one meter of length reproducing a pillar of the bus was developed by hand lay-up and consolidation with vacuum bag, with the dimensions shown in figure 7.

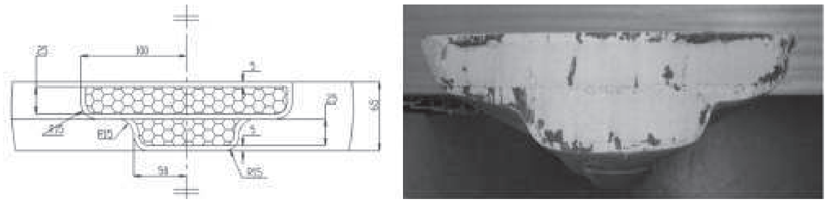

Figure 7: Window column geometry.

The column was tested by bending, simply supported, applying a load in it middle point, until rupture (ranging from 800mm), to know its stiffness. A maximum displacement of 40mm was obtained, under elastic conditions, for a load of 25000N. After the test, when unloaded, the pillar practically recovered the un-deformed initial configuration. However, a local crash damage was developed in the area were the load was applied.

For the tests two panels were also built, of 1:1 scale (1400mm x 1000mm) by hand lay-up and consolidation with vacuum bag (as the column). These panels included metallic inserts to assemble the floor on the frame.

The floor plates have the following composition:

- panels: upper skin (thickness 2.4 mm); PVC Core - 25mm; Lower skin (thickness 2.4 mm),
- reinforcements: PVC Core - 50mm; Skin strengthening -

3Combi (thickness 4.68 mm); Outer skin - 2Combi (thickness 3.38 mm).

The samples were tested under bending until rupture according to their longitudinal and transverse directions. For that, a beam was placed on top of the plate, applying the load evenly.

At the same time, a numerical model of a panel was developed with the lay-up specified in figure 8 below (reproduction of the same manufacturing process and solutions used in structural requirements to build the samples).

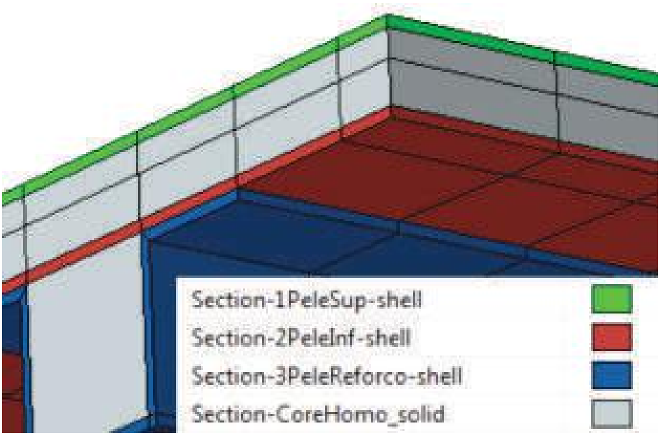

Figure 8: Lay up (modeled with the same characteristics of real floor plates.

The structural test was computer simulated by the finite element method, using the ABAQUS software. The properties for the materials considered in this simulation were estimated by the ESACOMP software.

Volume elements were used for the foam core and shell elements for the laminates and reinforcements in the structure of the bodywork and floor. A rigid plane simulated the support base and nodes were loaded prevented from carrying out horizontal displacements. The loading has been applied in the normal direction to the panel. Two tests were performed on each of the two main panel directions i.e. parallel and perpendicular to the floor rail.

Table 1 lists the values of stiffness obtained in the experimental and theoretical simulations.

	K1 - Stifness in direction (kN/mm)	K2 - Stifness in direction 2 (kN/mm)
Laboratory testing	2,892	5,189
Simulation	2,984	6,078
Error	3,18%	17,13%

Table 1: Comparison of results obtained for the stiffness.

Bearing in mind the uncertainties, and taking into account the simulation purposes, the error obtained (17%) was considered acceptable. This error results from the simplifications assumed, because variables such as void content and fibre volume fraction variation are not considered.

5. 3 OPTIMIZATION OF THE STRUCTURE AND COMPLEMENTARY REQUIREMENT VERIFICATION

Considering the results of previous simulations, ABAQUS software was used to create a finite element model of the bodywork and perform a structural simulation of the same. The mesh was built with elements of volume to the foam core and shell elements for the laminated (as in the simulation of the floor panels).

The bodywork has the following composition:

- panels: upper skin (thickness 1.7 mm); PVC Core - 25mm; Lower skin (thickness 1.7 mm),
- reinforcements: PVC Core - 25mm; Skin strengthening - 3Combi (thickness 4.68 mm).

The bodywork model was supported just in the joining areas with the floor and unsupported at the front sides. So, even if the connection to the chassis in front sides is insufficient, the necessary stiffness to prevent any large deformations can be ensured. The constitution of the floor was similar to the samples tested.

The applied loads on the roof were concentrated at points of the handrails used by passengers.

The following loads were considered in the simulation:

- dead weight,
- concentrated loads at points of support handrails according to

the direction of 1, 2 and 3 (F1 =10kN, F2 = 3.35 kN; F3 = 3.35 kN),

- weight of Air Conditioning equipment placed on the roof (0.5 kN),
- doors weight (2 x 1, 5kN),
- load distributed uniformly on the floor (7kN / m²).

The final results can be seen in figure 9.

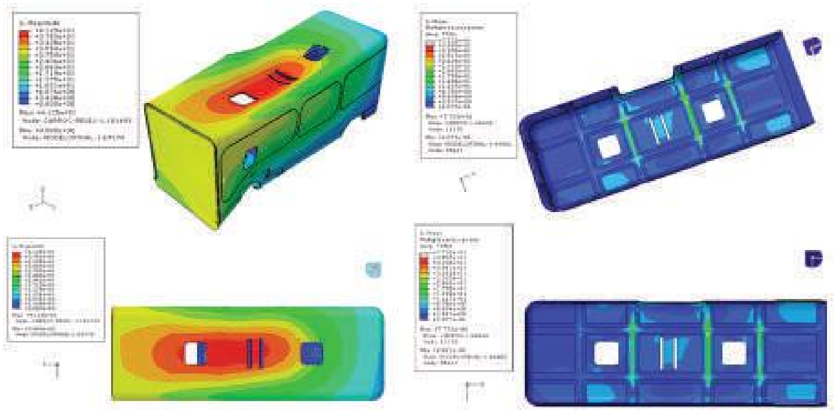

Figure 9: Displacements (mm) and equivalent stresses of von mises (MPa).

The maximum displacement value obtained (module value) was 41mm in the centre of the roof. The maximum displacement was 31mm in the floor and the higher stresses occur in the central reinforcements of the roof, with a maximum value of 77 MPa.

Again by ABAQUS software, it was estimated the weight of the main structure of the bodywork (including its two parts and the glasses mass), approximately 1,700 kg. The bodywork of the minibus, Toyota Coaster, weighs 2,370 kg. The proposed solution presents a weight reduction around 30% comparing with the original bodywork.

6 MANUFACTURE OF THE BUS PROTOTYPE

The process began with mould building. Once the external dimensions of the bus were established, its construction and improvements on the structures were done. With the discussions regarding the manufacturing strategy, it has been possible to refine the concept and introduce the relevant modifications to avoid future complexities.

With the validation of the model the several constructive solutions involved were applied and a few subprojects were conducted for the development of components essential to a bus performance (those for which the market does not have acceptable solutions for this specific bus; e.g.: handrails, wheelchair seat bracket, supplementary step, internal lamps, several covers, etc.), and its clamping solutions.

6.1 PARTS INFUSION BY SCRIMP

After conclusion of the shape design the moulds were finished and feed stocked.

The first infusion was the floor. First of all, it was necessary to fit and place the material inside the correspondent mould as planned. Then, the vacuum bag was placed and the vacuum pressure controlled, down to an acceptable value for that kind of infusion, below 100mbar.

The infusion was successfully done, but certain requirements had to be ensured before the start of the process, as it could not be stopped in case something went wrong. After curing time and verified the structure consolidation it was removed from the mould (Figure 10), and its bonding area to “bodywork” part was prepared.

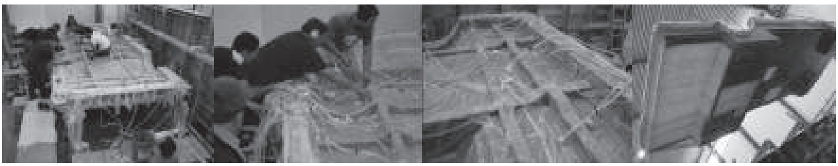

Figure 10: Floor part manufactured (infusion by SCRIMP).

To produce the part “bodywork”, the same procedures were followed.

That infusion was successful too and took 1h45m (part dimensions are 6220mm length x 2200mm width x 2300mm height) (Figure 11).

Figure 11: Bodywork part manufactured (infusion by SCRIMP).

6.2 ASSEMBLY

After producing both parts several adjustments were done to fit them and promote a correct bond. Structural adhesive was used on parts bonding and after the parts bonded, the main structure was transported from ENP shipyard to MOBIpeople (bodywork builder). A few adjustments were done on the main structure and on the frame to allow attaching them properly. The bodywork was fastened on top of the Toyota frame with M14 screws, using the metallic inserts (on the floor) like threaded nuts.

6.3 COMPONENTS DESIGNED

This bus has special features, which forced us to develop a few components, after a search on bus components market did not provide any existent solution to solve the needs. The majority of the covers were built after the bus arrived at MOBIpeople, even if some of them were projected before, to improve a perfect integration into the bus (e.g.: dashboard, doors mechanism and windshield wiper house covers).

Another challenge was the development of a legal sliding door for the vehicle. Metallic insets were foreseen, substituting the PVC foam on the bodywork sandwich core, allowing the fastening of a set of specific supports. The door panels were also specifically designed in order to fit the bodywork curvature.

According to the European regulation, a 3D modelling test device to define the handrail shape design was conducted.

7 COMPLETION AND TESTING

The bus was then painted, from inside and outside, and some of its components were attached on its servicing places. It has successfully gone through the homologation process and it is now being tested at the Asprela area in Porto (Figure 12).

Figure 12: Bus completion and testing.

8 CONCLUSIONS

This project aims to demonstrate the potential that the used composite technology has in the manufacture of high quality structural parts. Parts with curved surfaces, including complex forms that would be expensive if made on metal, are easily shaped in such composite materials, not just for aesthetical reasons but also for structural greater stiffness, relieving or minimizing the use of ribs.

The structure obtained is transparent, allows for a visualization of its interior easing the finishing work.

The SCRIMP manufacturing process has enabled parts of high surface quality with low roughness. It is a cleaner process, with no VOC´s release.

Using this technology the number of body parts is significantly reduced and consequently the production time. However, the composite structure requires special care in predicting the type of inserts to be used, taking into account the shapes, the nature of its material and the type of loads solicitation.

The main structure "bodywork" weighed after bonding, without components and glasses, 1139 kg. This result fits the anticipated bounds and allows for an effective bodywork weight reduction of around 30%. The structural behaviour of the bus can be predicted with some accuracy from numerical simulation, since the results in tests and simulations are in accordance.

The teamwork within the consortium has promoted the transfer and sharing of knowledge and technological development between partners. Conclusion of the bus assembly will enable performance tests on the fuel consumption and gaseous emissions.

REFERENCES

Bac2 – Bouwmeester Advanced Composites B.V. 2011. *An Overview of the SCIMP™ Technology*, 2001. Available at: www.sp-bac.nl/userfiles/scrimp%20_overview%20.pdf, 1. 10. 2011.

European Commission. 2001. *White Paper 2001. European transport policy for 2010: time to decide*. Available at: http://ec.europa.eu/transport/strategies/doc/2001_white_paper/lb_com_2001_0370_en.pdf, 1. 10. 2011.

European Commission. 2005. *Assessment of the contribution of the TEN and other transport policy measures to the mid-term implementation of the White Paper on the European transport policy for 2010*. Available at: http://ec.europa.eu/transport/white_paper/mid_term_revision/assess_en.htm, 1. 10. 2011.

European Commission. 2007. *Towards a new culture for urban mobility, Green Paper, {SEC (2007) 1209}, COM (2007) 551 final, 2007*. Available at: http://eur-lex.europa.eu/LexUriServ/site/en/com/2007/com2007_0551en01.pdf, 1. 10. 2011.

Composite One LLC. 2011. Available at: http://www.compositesone.com/process.php#openmold, 1. 10. 2011.

Estaleiros Navais de Peniche, S.A. 2011. Available at: http://www.

enp.pt/?lop=conteudo&op=c16a5320fa475530d9583c34fd356ef5&id=8f14e45fceea167a5a36dedd4bea2543, 1. 10. 2011.

Institute of Highways and Transportation and Department of Transport. 1987. *Roads and Traffic in Urban Areas*. London: HMSO books.

Seemann Composites INC – SCI. 2010. Available at: http://seemanncomposites.com/, 1. 10. 2011.

United Nations . 2006. *ECE Regulation 66, Agreement, E/ECE/TRANS/505, Rev. 1/Add. 65/Rev.1, 22 Feb 2006*. Available at: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r066r1e.pdf, 1. 10. 2011.

United Nations and Department of Economic and Social Affairs/Population Division. 2008. *World urbanization prospects — The 2007 revision*.

ZAGREB I 100 new PT buses on biodiesel and 60 on CNG, which emit less CO2, have been introduced.

ZAGREB I A new ticketing system has been introduced in Zagreb's PT vehicles.

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ON THE ATTRACTIVENESS OF USING PURE PLANT OIL AS FUEL FOR VEHICLE PROPULSION

Viktor Jejčič, Tone Godeša, Tomaž Poje,
Marko Gerbec, Davor Kontić

1 INTRODUCTION

Carbon dioxide produced from the combustion of biomass does not contribute to air pollution resulting in greenhouse gas emissions. Biomass produced in agriculture is used as a source of nutrition for humans and animals, as well as for processing different raw materials for clothes, other products, and fuels; one part of it, returns directly into the soil in the form of organic waste. Beside solid and liquid biomass products, biomass is a source for liquid fuels or biofuels. They can be used as a replacement or an addition to fossil fuels in transport and various other uses. Among liquid fuels obtained from biomass the following fuels are currently the most important: bioethanol, biomethanol, pure plant oil, and biodiesel. Recently, beside biodiesel (commonly used in diesel engines), pure plant oil in its refined (or non-refined form) can be used in modified engines, and as such has been gaining in importance.

Using pure plant oil in engines (diesel engines of working machines, tractors, trucks, municipal vehicles, cogeneration units for the production of electric and thermal energy, etc.) is an alternative for the current use of fossil fuels (diesel fuel of mineral origin). Pure plant oil as an energy source is becoming more and more interesting due to continuously growing fossil fuel prices and associated environmental issues. Pure plant oil is available practically all over Europe. The northern parts of Europe are more suitable for the production of oilseed rape, and the southern ones for sunflowers, soybean, etc. In other parts of the world palm trees, jatropha, etc. are used for pure plant oil production. There are more than 4,000 plant species in the world (Riva et al., 1999) from which plant oil can be produced.

Recently, Slovenia has witnessed increased interest in biofuels as a consequence of the obligation to achieve a certain degree of self-sufficient energy supply; this was accomplished by dedicating part of the agricultural land for biofuel crop production. In the framework of these strategic goals, biofuel field crop production plays an important role in alternative energy sources, especially in biofuels made from rapeseed.

1.1 DEVELOPMENT OF DIESEL ENGINES RUNNING ON PURE PLANT OIL AND PROBLEMS WITH PURE PLANT OIL

The diesel engine was named after its inventor (Rudolf Diesel, 1858 – 1913) who patented an engine with compression ignition of fuel in 1893. As a curiosity, it should be mentioned that he presented an engine which used peanut oil for propulsion as early as the 1900 World Fair in Paris. In the period between the two World Wars, when oil derivatives were cheap, the interest in plant oil as an energy source fell to its minimum (Mittelbach et al. 2005). The interest in pure plant oil as fuel increased again during World War II due to lack of mineral oil derivatives. After World War II the interest declined, only to increase again in the early 1970s, following the first oil crisis. In addition to the latter problem, scientists began to warn the public about the negative consequences of global heating due to the increasing use of fossil fuels for different activities.

Some enthusiastic users and researchers tried to use pure plant oil directly in diesel engines, without modifying them, in the early 1990s. In older construction types of diesel engines, especially those with indirect fuel injection (engines with IDI chambers – turbulence chambers) and high-pressure, inline piston fuel pumps, no special problems were noticed in the initial phases of use. However, after longer use of such engines major problems became evident. Investigation showed that even the simplest, robustly constructed engines broke down after approximately 500 hours of operation. The following problems were observed: plugging of fuel filters, build-up of carbon plaque in the combustion chamber and on the high-pressure injection nozzles, damaged pistons and piston rings, etc.

But what caused the problems? The answer lay in the construction of the contemporary diesel engines and the fuel. The development of modern diesel engines was logically directed towards these kinds of fuels due to the widespread availability of mineral diesel fuel. The combustion of plant oils is similar to that of diesel fuel but their viscosity is too high for modern high-pressure fuel pumps and other elements in the fuel supply system. High viscosity causes plugging of fuel pipes, filters and high-pressure injection nozzles. Investigation revealed that the high viscosity results in incomplete atomisation (dispersion of fuel drops) of the plant oil, thus preventing complete combustion of larger fuel drops, and causing carbon plaque to build up. Further research showed that plant oil caused a delay in the beginning of combustion as well as slower combustion, especially during low-load operation, causing later combustion and expansion stroke of the engine (corrections to the fuel injection time are the best solution for these problems). A part of the pure plant oil will be diluted into the engine oil. This results from the quality of pure plant oil, which has a lower burning rate than mineral diesel fuel, because pure plant oil cannot be atomised into very small droplets like mineral diesel fuel because of its high viscosity. Bigger droplets will not burn completely or will need more time, and a small part of the unburned fuel will be diluted into the engine oil. Diluted engine oil can affect the engine's wear rate. In this situation, some of the fuel will pass between the piston rings and cylinder wall to the crankcase, where it will be diluted or mixed with the lubricating engine oil. When mineral diesel fuel mixes with lubrication engine oil, the heat in the crankcase will evaporate mineral diesel fuel. On the other hand, biodiesel or pure plant oil will not evaporate easily and will therefore change the viscosity as well as other characteristics of anti-wear additives in the engine oil, if it comes into contact with it.

All this means that plant oils cannot be used in diesel engines without addressing the viscosity issues. The following three methods were developed to reduce the viscosity of pure plant oil: trans-etherification of oil (commercial name: biodiesel), mixing plant oil with mineral diesel fuel, and heating the oil to reduce its viscosity. The first two methods are quite demanding, but the last one has proved to be the most appropriate. Using pure plant oil in unmodified diesel engines is not recommended because it can cause damage to the engines. In order to ensure as complete combustion as possible in a diesel engine, the plant oil must be atomised just as finely as mineral diesel oil. To achieve this, the viscosity of the oil must first be adjusted to match that of mineral diesel oil. The viscosity of pure plant oil is strongly dependent on temperature: the higher the temperature is, the lower the viscosity becomes. Heating plant oil reduces its viscosity and prevents damaging the high-pressure pump during atomisation (highly viscous oil causes greater friction between pump's moving parts and consequently reduced efficiency). Heating pure plant oil also reduces the damages to the high-pressure injection nozzles and piston rings, resulting from incomplete combustion of highly viscous fuel.

1.2 ADVANTAGES OF PURE PLANT OIL AS AN ENERGY SOURCE

Considering the European and Slovenian conditions for producing liquid biofuel (climate, agricultural technology, biofuel production technology, the price of biofuels, etc.), the most suitable fuel to be produced from biomass is pure plant oil. The production of pure plant oil from rapeseed is the simplest of all available production chains/ technologies for biofuel production. In addition, the processing costs are lower compared to other biofuels. It is very important to point out that pure plant oil from rapeseed, sunflowers, soybeans, etc. can be used in converted diesel engines of vehicles and other machines that are used in various activities requiring fuel based propulsion. This gives pure plant oil a huge advantage over other energy sources, which often require a new generation of completely new engines to be developed.

The evaluation of biomass energy and biofuels is usually based on their energy balance ratios, a comparison of the energy stored in pure plant oil (the final product) to the energy required to produce it. Rapeseed oil has an energy ratio of 1:5.5 with straw included and 1:3.2 with straw excluded (straw calculated as fuel). These data show the high positive energy balance of pure plant oil. The production of pure plant oil requires fossil energy input in some phases of the production process: the production of mineral fertilisers (which can be replaced with organic fertilisers), use of agricultural machinery to grow oilseed rape, rapeseed drying, oil extraction from the seed by mechanical or chemical methods, etc. For some of these phases it is also possible to use energy from pure plant oil, mainly in the use of agricultural machinery and seed drying. If (edible) cooking oil is used, the energy ratio is even more favourable since the stage of oilseed rape and fertiliser production/ application can be omitted from the equation.

The mechanical extraction of rapeseed oil (with oil presses) yields approximately 40% pure plant oil, while more than 60% is a by-product used as animal feed in the form of oil-cake or pellets. The production of pure plant oil therefore also increases the feed supply for farm animals and reduces dependence on imports of high protein food from outside the European Union. This additionally means a decrease of energy consumption for transport.

1.3 PRODUCTION OF PURE PLANT OIL

The pure plant oil used for vehicle propulsion purposes may be produced/ extracted with a mechanical process, using oil presses, or industrially (chemically), using solvents. The pressing process does not require sophisticated machinery compared to the industrial process of using solvents. The outstanding features of the mechanical pressing process are low energy consumption and zero chemicals for extraction (the use of chemicals is environmentally controversial). Oil presses can operate continuously and do not require any special labour force.

Decentralised production of pure plant oil, intended for direct use in modified diesel engines or for further processing in biodiesel fuel, has recently spread around the world and in EU countries, as a result of oil production by means of mechanical pressing in small production units. Decentralised oil production means pressing from 0.1 to 5 tons of seeds per day (in some countries the production limit is a capacity of 25 tons of oil seeds per day). Such production units can work economically and environmentally friendly since their technological equipment and work process are very simple and require low energy use (up to 80 kWh per ton of processed oil seeds). On average, decentralised oil production uses six times less energy than industrial oil production. This type of oil production has other important advantages such as: (i) it is performed near the locations of agricultural production, (ii) it is directly or indirectly connected with agricultural production itself (no intermediaries), (iii) investment costs in equipment are low, (iv) there are no waste waters, (v) highly flexible production (quick transfer to pressing other types of oil seed, for example for consumer use, which increases the machinery's utilization rate), (vi) shorter transport distances (up to 30 km from the production site) resulting in lower costs, providing higher value added to the agriculture of the area, (vii) a by-product produced with mechanical extraction is oil-seed cake that is used as animal feed and has a high nutritive value (it contains 12 to 17 % oil compared to less than 1% oil in industrial cake).

1.4 THE QUALITY OF PURE PLANT OIL

Plant oil was standardised as fuel in Germany in September 2010 (Pure plant oil quality standard DIN 51605). This can also serve as the basis for an EU standard for pure plant oil quality in the future. Quality plant oil for diesel engines has to have the lowest possible content of phosphorus (below 10 mg/kg) and solid particles (impurities). Phosphorus is present in the form of phosphorus lipids. A higher quantity of phosphorus augments the risk of oil oxidation and water binding and, consequently, higher water content in the oil. A too high content of phosphorus in plant oil and biodiesel from plant oil negatively affects the combustion process in the engine (plaque builds up in the combustion chamber). The results of an experiment conducted in Germany indicated that the quantity of phosphorus in oil obtained with cold pressing ranges below 10 mg/kg oil (an additional advantage favouring decentralised oil production). In cold pressing, the majority of the phosphorus in the seed passes into the oil meal. This is the great advantage of cold pressing in comparison with the industrial process, where the high phosphorus content in the oil has to be reduced by expensive refinement. The reduction of the phosphorus content during the pressing process may be influenced by using the lowest possible number of rotations of the pressing parts as possible and a slightly higher temperature of the seed to be pressed.

Table 1 shows the physical characteristics of three different fuels used in testing vehicles and a laboratory engine. Mineral diesel fuel has the highest calorific value (MJ/kg) compared to pure plant oil and biodiesel. If the calorific value is calculated in MJ/l, then the calorific value of the rapeseed oil used for our tests was higher than that of mineral diesel fuel and biodiesel. And if we compare their viscosity at the same temperature, there are also differences between the fuels. The highest difference in viscosity at 20°C is between mineral diesel fuel and pure plant oil.

Parameter	Unit	Mineral diesel	Pure rapeseed oil	100% biodiesel
Lower heat of combustion	MJ/kg	42.96	39.4	40.5
	MJ/liter	34.44	36.14	35.84
Spec. density at 20°C	kg/dm^3	0.83	0.91	0.88
Viscosity at 20°C	mm^2/s	2-3	32	3.5-5
Flame point	°C	74	>220	>100

Table 1: Main characteristics of mineral diesel fuel, oil from oilseed rape and methyl ester of oilseed rape (100 % biodiesel).

2 DESCRIPTION OF THE METHOD

2.1 GENERAL

The work undertaken in the testing procedures involved a demonstration and field testing of converted diesel engines in order to use pure (100%) plant oil instead of mineral oil (diesel D2) or biodiesel (B100) fuels. The work involved the successful conversion of three vehicle engines (two tractors and one off-road vehicle) and one stationary laboratory diesel engine in order to use pure oil (in addition to conventional fuel), and was carried out in September 2009.

Field testing, subject to agricultural work seasons/ peaks, should provide practical insight into fuel consumption, engine wear and internal deposits, exhaust gas composition (pollution), reliability as well as maintenance costs – all related to actual "real life" exploitation (e.g. distances driven, working hours) comparing the use of conventional fuel (diesel – "business as usual") and that of various qualities of alternative fuel (pure plant oil).

No series of research activities on vehicle propulsion with pure plant oil has been conducted in Slovenia in the past. For this reason in-depth laboratory analyses were necessary in addition to testing the vehicles in real-life conditions. Therefore, within the ELAN project a stationary engine for use in the laboratory and three engines in vehicles for use in real-life conditions were modified and adjusted for the use of pure plant oil from rapeseed, produced in decentralized units.

Laboratory testing: The laboratory engine was converted so that every cylinder of the three-cylinder diesel engine ran on one type of fuel at the same time (the first cylinder on mineral diesel fuel, the second on pure plant oil, and the third on biodiesel). The load on the laboratory engine was the same for the purpose of tribology research (the influence of different fuels on engine wear and life).

Car testing: The car (with its engine converted to use pure plant oil) was tested in different transport activities (transport of persons and materials throughout the entire test period of approximately two years). It was used in different test cycles (driving short, medium, and long distances).

2.2 PRESENTATION OF THE APPROACH TO TESTING DIFFERENT TYPES OF FUEL IN A REGULAR CAR, OFF-ROAD VEHICLE, AND TRACTOR

Modification of the tested diesel engines for using pure plant oil

Using plant oil in an unmodified diesel engine is not recommended because it can cause damage to the engine (the viscosity of pure plant oil is too high compared to diesel fuel). In order to ensure as complete combustion as possible in the diesel engine, the plant oil must be atomised just as finely as the mineral diesel oil. To achieve this, the viscosity of the plant oil must first be adjusted to match that of diesel. Heating plant oil reduces its viscosity and prevents damages to the high-pressure pump, high-pressure injection nozzles, and piston rings resulting from incomplete combustion when highly viscous fuel is used.

The diesel engines in the test vehicles and the laboratory engine were therefore modified for the use of 100 % pure plant oil with an approach using a two-tank fuel system. To (cold) start the engine, mineral diesel oil from a small auxiliary fuel tank was used. When the engine was heated to regular working temperature, a valve switched the fuel supply from the auxiliary to the main tank containing pure plant oil. Heating fuel reduces its viscosity and allows better atomization of the fuel droplets during injection and prevents possible damage to the engine. The pure plant oil supply in the engine is fully automated (controlled by an electronic control unit) so that the user has not to be concerned about the proper use of the engine.

Functioning of the two-tank system used on the test engines

With a two-tank fuel system for starting the engine and just before stopping it, mineral diesel oil is used (biodiesel may be used as an alternative). An additional fuel tank, containing a small quantity of mineral diesel oil, is added to the engine's fuel supply system. Furthermore, an additional electric fuel heater and electrically heated fuel filter were built in. The engine was started using the mineral diesel fuel. When the water in the engine radiator is heated to working temperature, the thermostat switched on the electromagnetic valve for directional control of the fuels (mineral diesel fuel or pure plant oil) to start fuel supply from the main tank containing pure plant oil. With the help of a low-pressure fuel pump the pure plant oil is sent to the high-pressure fuel pump. The electric heater installed before the high-pressure pump heats the pure plant oil to a temperature of 85 –

95°C (at this temperature the viscosity of pure plant oil approximately matches that of mineral diesel fuel).

As mentioned above, starting the engine does not require any special procedures, but before stopping it, it must be switched manually to mineral diesel oil, so that the engine is ready to use mineral diesel fuel when it is restarted. The advantages of the two-tank system are that there are no problems with starting the engine at low winter temperatures and that mineral diesel oil can be used in case of a shortage of pure plant oil. The system is similar to that of driving a vehicle on liquefied petroleum gas (LPG) in which two fuels, gasoline and LPG, are used (Bi-Fuel System) – Figure 1.

The two-tank system used in the vehicles (Figure 2 shows an example of the conversion in a tractor; the same system modification was used in the test car). Details of the engine modifications in the converted vehicles are presented in Figures 3 to 5.

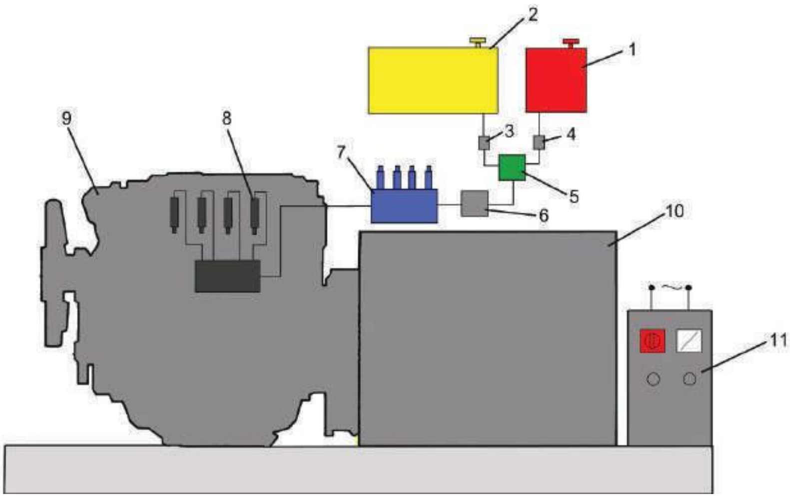

Figure 1: Conversion of the engine to a two-tank system in the laboratory Lombardini diesel engine with a power of 25.7 kW; (1 - fuel tank for mineral diesel fuel D 2, 2 - fuel tank for pure plant oil 100 %, 3 - fuel filter, 4 - fuel filter, 5 - (three-way) electromagnetic valve, 6 - (low-pressure) fuel pump, 7 - heating device with electronic control unit (12 V electrical system), 8 - injection nozzles with high-pressure fuel pump, 9 - diesel engine, 10 - brake dynamometer or electric generator (both for different load simulation), 11 - main control unit).

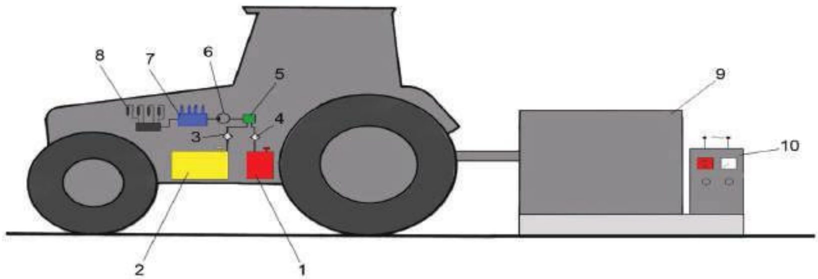

Figure 2: Conversion of the engine to a two-tank system used in vehicles (an off-road Land Rover Defender and two tractors, an AGT 835 and a Fendt Favorit); (1 - fuel tank for mineral diesel fuel D 2, 2 - fuel tank for pure plant oil 100 %, 3 - pure plant oil fuel filter, 4 - mineral diesel fuel filter, 5 - (three-way) electromagnetic valve, 6 - (low-pressure) fuel pump, 7 - heating device with electronic control unit (12 V electrical system), 8 - injection nozzles with high-pressure fuel pump, 9 - brake dynamometer or electrical generator (both for different load simulation), 10 - main control unit.

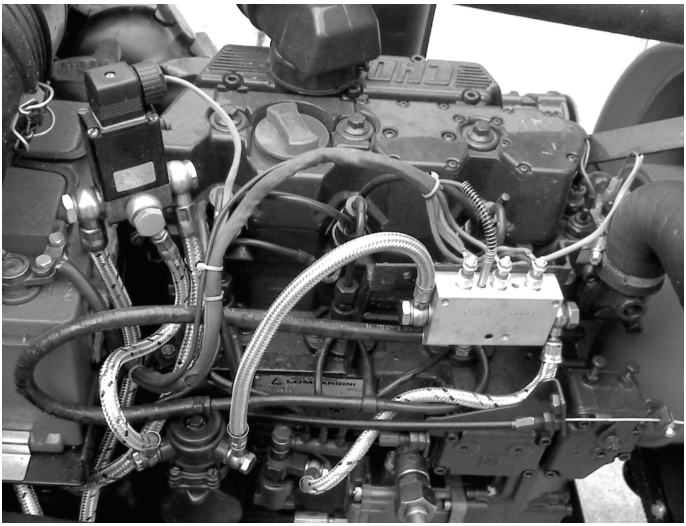

Figure 3: Modification of the engine (left of the diesel engine is an electromagnetic valve which switches the fuel supply between the mineral diesel tank and pure plant oil tank; to the right is an electric heater which heats the plant oil to a maximum value, adjusted by the electronic thermostat on the tractor's instrument board).

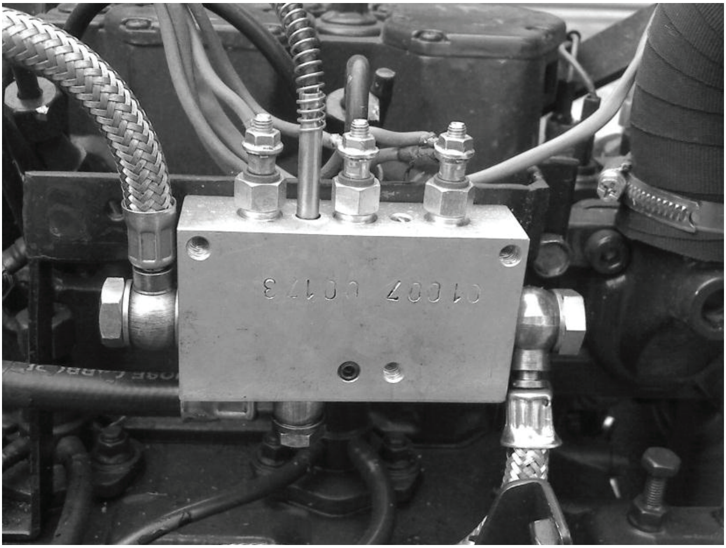

Figure 4: A detail of the electric fuel heater (the pure plant oil is heated to 80 – 95°C in order to reduce the oil viscosity to approximately that of mineral diesel oil).

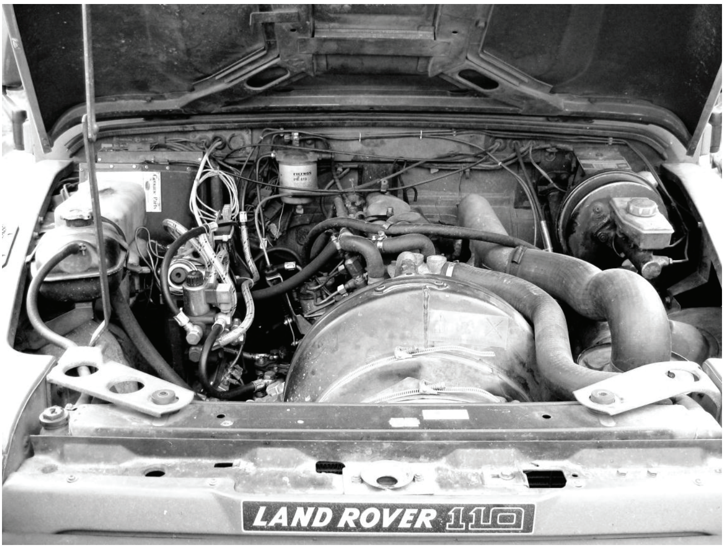

Figure 5: A detail of the converted diesel engine in the off-road Land Rover 110 (left of the engine is an electromagnetic valve which switches the fuel supply between the mineral diesel tank and the pure plant oil tank).

2.3 DESCRIPTION OF SELECTED MEASUREMENT INDICATORS

This section describes the approach to the selection of indicators and, in detail, the data collection/ measurement methodologies used for each indicator.

The evaluation of the effectiveness and suitability of using pure plant oil provided practical insight into fuel consumption, engine wear and internal deposits, exhaust gas composition (pollution), reliability, as well as maintenance costs – which are all related to the actual exploitation of the vehicles (e.g. distances driven, working hours) – of the fuels used. Finally, the economic benefits for the end user and the environmental impacts were assessed using an evaluation approach that consists of the following categories, sub-categories, impacts, and general indicators:

Evaluation category	Evaluation sub-category	Impact	Indicator - general.
ENVIRONMENT	Pollution	Emissions	CO levels
			CO2 levels
			NOx levels
			THC levels
			Particulate (PM10) levels
ENERGY	Energy consumption	Fuel consumption	Fuel consumption rate
		Fuel quality	Set of indicators *
	Maintenance costs	Cost benefit analysis	Deposits from fuel burning
			Preventive maintenance costs.
			Corrective maintenance costs.
			Engine oil quality

* includes the following indicators: combustion heat, phosphorus content, iodine number, water content, density, and kinematic viscosity.

Table 2: Overview of the evaluation and data collection approach.

The overall data collection plan consisted of 19 specific indicators, collected for all tested vehicles and all tested fuels and obtained either during operational service (e.g. fuel consumption, work done, distance travelled, etc.) or during measurement campaigns (e.g. fuel quality, emissions, engine oil quality, etc.).

3 RESULTS AND DISCUSSION

The results of the measurements are presented according to the evaluation categories.

The test periods refer to the following:

- start of the research – 15th September 2008 – month 1
- test period 1 – 15th June 2010 to 15th November 2010 – month 20 to 26
- test period 2 – 15th June 2011 to 15th December 2011 – month 32 to 39

3.1 RESULTS: ENVIRONMENT, POLLUTION, EMISSIONS

In terms of environmental pollution the emission concentrations of CO, CO_2, NOx, THC and particulates (soot) were periodically measured. Typical results as obtained for the Lombardini laboratory engine for three fuels and low and high engine speeds are presented in table 3.

Engine speed (RPM)	Fuel	CO [vol.%]	CO_2 [vol.%]	THC [ppm]	NOx [ppm]	Particulates Abs. Coeff. [min^{-1}]
Low (1300 min^{-1})	Diesel D2	0.006	1.14	11	70	0.00
	Pure Plant Oil	0.015	1.20	12	52	0.00
	100% Biodiesel	0.004	1.26	6	60	0.01
High (2600 min^{-1})	Diesel D2	0.007	1.62	9	50	0.02
	Pure Plant Oil	0.008	1.46	12	52	0.00
	100% Biodiesel	0.008	1.32	8	42	0.02

Table 3: Summary of the measured pollution emission concentrations in the exhaust gases for three fuels and two engine speeds for the Lombardini laboratory engine.

The results show that the pollutant emission concentrations are generally comparable for all three fuels. While CO and THC concentrations for PPO are slightly higher compared to D2 or B100, the NOx and particulate concentrations are lower. The overall conclusion is that the combustion of PPO in a modified engine is of a quality comparable to conventional D2 and B100 fuels.

3.2 RESULTS: ENERGY CONSUMPTION

Energy consumption was determined by measuring the fuel consumption of the test vehicles and laboratory engine. The fuel consumption of all included diesel engines was established by measuring the fuel volume consumed in a time unit by the tractor and laboratory engine, and for a distance unit for the off-road vehicle. Average consumption was calculated from the total volume of consumed fuel and total time or total number of kilometers covered over the entire measurement period. The fuel consumption of the laboratory engine was calculated daily. The laboratory engine was converted so that every cylinder of its three-cylinder diesel engine worked at the same time on a different fuel (the first cylinder on mineral diesel fuel, the second on pure plant oil, and the third on biodiesel).

The load on the laboratory engine was the same for the purpose of tribological research (the influence of different fuels on engine wear and life).

Presented are the results for the Lombardini laboratory engine. In terms of energy consumption, fuel consumption rates are presented in Table 4 and Figure 6.

Parameter	Fuel used		
	D2	B100	PPO
Average consumption rate [l/h]	1.38	1.3	1.47
Relative difference to D2 [%]		-5.67	6.65
Average consumption rate per work done [l/kWh]	1.44	1.35	1.53
Relative difference to D2 [%]		-5.04	6.05

Table 4: Summary of fuel consumption results for three fuels used in the Lombardini laboratory engine.

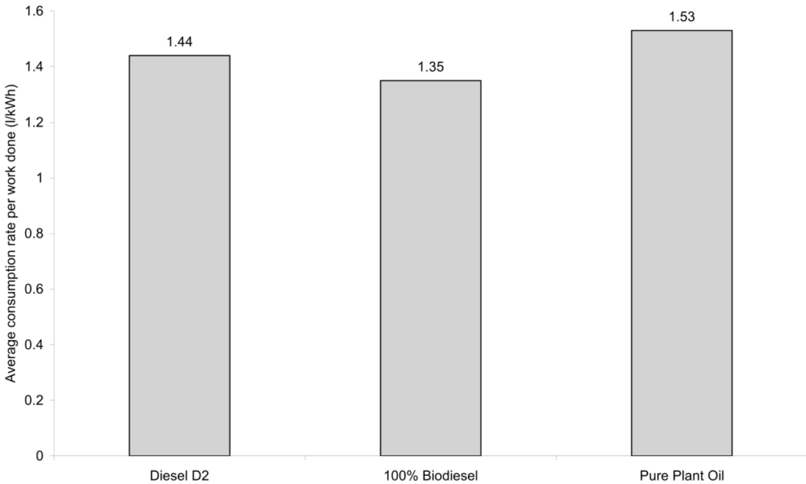

Figure 6: Graphical presentation of the fuel consumption rate per work done for the three different fuels used in the Lombardini laboratory/ stationary engine.

The results obtained show that pure plant oil consumption was higher by around 6 % in comparison to the conventional mineral diesel fuel D2. This is due to the lower energy stored in pure plant oil (PPO).

3. 3 RESULTS: ENERGY, MAINTENANCE COSTS, COST BENEFIT ANALYSIS

In terms of maintenance costs, the overall costs (referring to parts and work done) for all vehicles/ engines were considered in the test periods. Regarding pure plant oil (PPO) and B100 fuels, additional preventive maintenance work was carried out and the related monetary costs are presented in the following tables.

Parameter	Land Rover	AGT 835	Fendt 612 LSA	Lombardini Stationary engine
Costs of pure plant oil incl. 20 % VAT (€/l)	1.09	1.09	1.09	1.09
Costs of pure plant oil with added duty tax 0.43 €/l	1.52	1.52	1.52	1.52
Fuel consumption (20 - 26 month) (l/h)	-	3.0	8.33	1.39 l/kWh

Fuel consumption (32 – 39 month) (l/h)	-	1.27	7.89	1.04 l/kWh
Fuel consumption (20 – 26 month) (l/100 km)	13.18	-	-	-
Fuel consumption (32 – 39 month) (l/100 km)	12.18	-	-	-
Costs of fuel (20 – 26 month) (€/h)	-	4.56	12.66	2.11
Costs of fuel (32 – 39 month) (€/h)	-	1.93	11.99	1.58
Costs of fuel (20 – 26 month) (€/100 km)	20.03	-	-	-
Costs of fuel (32 – 39 month) (€/100 km)	18.51	-	-	-
Costs of fuel (20 – 26 month) (€/100 h)	-	456	1266	211
Costs of fuel (32 – 39 month) (€/100 h)	-	193	1199	158
Overall maintenance costs (€/km) Campaign involving 5504 km [number of exchanges]	0.0320 [2]	-	-	-
Overall maintenance costs (€/km) Campaign involving 5298 km [number of exchanges]	0.0332 [2]	-	-	-
Overall maintenance costs (€/h) Campaign involving 153 hrs [number of exchanges]	-	-	-	1.047 [2]
Overall maintenance costs (€/h) Campaign involving 627 hrs [number of exchanges]	-	-	-	1.534 [12]
Overall maintenance costs (€/h) Campaign involving 419 hrs [number of exchanges]	-	1.412 [8]	-	-
Overall maintenance costs (€/h) Campaign involving 963 hrs [number of exchanges]	-	1.382 [18]	-	-
Overall maintenance costs (€/h) Campaign involving 324 hrs [number of exchanges]	-	-	1.343 [2]	-
Overall maintenance costs (€/h) Campaign involving 390 hrs [number of exchanges]	-	-	1.116 [2]	-

Table 5: Summary of overall fuel costs (100 % pure plant oil) and maintenance costs for all vehicles and the laboratory engine in the test periods.

Parameter	Land Rover	AGT 835	Fendt 612 LSA	Stationary engine Lombardini
Pure plant oil price incl. 20 % VAT (€/l)	1.09	1.09	1.09	1.09
Pure plant oil price incl. VAT & duty tax 0.43 €/l	1.52	1.52	1.52	1.52
Fuel consumption rate (l/100 km)				
Campaign from month 20 to month 26	13.18	3.0	8.33	1.39
Campaign from month 32 to month 39	12.18	1.27	7.89	1.04
Fuel costs (€/h)				
Campaign from month 20 to month 26	-	4.56	12.66	2.11
Campaign from month 32 to month 39	-	1.93	11.99	1.58
Fuel costs (€/100 km)				
Campaign from month 20 to month 26	20.03	456	1266	211
Campaign from month 32 to month 39	18.51	193	119	158
Overall maintenance costs[1] (€/km) [number of exchanges]				
Campaign involving 5504 km [2]	0.0320	-	-	-
Campaign involving 5298 km [2]	0.0332	-	-	-
Overall maintenance costs[1] (€/h) [number of exchanges]				
Campaign involving 153 hrs [2]	-	-	-	1.047
Campaign involving 627 hrs [12]	-	-	-	1.534
Campaign involving 419 hrs [8]	-	1.412	-	-
Campaign involving 963 hrs [18]	-	1.382	-	-
Campaign involving 324 hrs [2]	-	-	1.343	-
Campaign involving 390 hrs [2]	-	-	1.116	-

[1] includes consumables (oil, filters) and work, considering the number of oil exchanges indicated for each campaign.

Table 6: Summary of overall fuel costs (pure plant oil 100 %) and maintenance costs for all vehicles and the laboratory engine in the test periods.

The values for pure plant oil consumption were estimated in the everyday use of the vehicles (table 5).

The values for the pure plant oil consumption of the laboratory engine were estimated in laboratory conditions, loading the engine with a brake dynamometer or DC generator.

	Overall maintenance costs in €			
Fuel / Vehicle	Land Rover	AGT 835	Fendt 612 LSA	Stationary engine Lombardini
Diesel - D2	87.51	295.81	217.4	80.1
Diesel - D2	87.94	665.57	217.62	481.29
Pure Plant Oil - PPO	176.12	591.62	435.13	160.35
Pure Plant Oil - PPO	175.89	1331.14	435.24	962.58
100 % Biodiesel - B100	176.12	591.62	435.13	160.35
100 % Biodiesel - B100	175.89	1331.14	435.24	962.58
Index PPO/D2	2.01	2.00	2.00	2.00
Index PPO/D2	2.00	2.00	2.00	2.00
Index B100/D2	2.01	2.00	2.00	2.00
Index B100/D2	2.01	2.00	2.00	2.00

Table 7: Overall maintenance costs for three fuels.

The results show that the use of PPO and B100 fuels causes some additional preventive maintenance costs. This is mainly due to more frequent preventive exchanges of the engine oil and filters to assure good lubrication in the engine's internals. The changing intervals for engine oil had to be halved for all tested engines compared to normal intervals for engine oil, when mineral diesel fuel was used in the tested engines. Furthermore, when the engine oil was changed, oil and air filters had to be changed as well. However, overall costs were relatively low.

3.4 CO_2 EMISSIONS OF THE VEHICLES AND LABORATORY ENGINE

Methodology

CO_2 emissions were determined on the basis of the measurement of fuel consumption (pure plant oil) of the three vehicles and laboratory engine (the engine operated simultaneously on pure plant oil, biodiesel, and mineral diesel, with each of the three cylinder engine operating on one and the same fuel) in a given period. The calorific value (MJ/kg) and fuel density kg/m^3 were determined for mineral diesel fuel, biodiesel, and pure plant oil in a laboratory that researches the physical and chemical properties of fuels (Petrol d.d., Zalog laboratory).

For biodiesel and pure plant oil the emissions of CO_2/MJ were determined on the basis of calculating the CO_2 generated in the production of rapeseed, its transport and processing into fuel (the value of 36 g CO_2/MJ for pure plant oil is taken from: Approaches for optimising the greenhouse gas balance of biodiesel produced from rapeseed, German Biomass Research Centre, 2010). In our production conditions, the emissions of CO_2/MJ from the production of rapeseed oil are 24.2 g CO_2/MJ (data from the Department of Agricultural Engineering, Agricultural Institute of Slovenia). For example, in Germany the emissions of CO_2/MJ from the production of rapeseed oil are 25 g CO_2/MJ.

The difference between the emission of 24.2 g CO_2/MJ from growing rapeseed and the final pure plant oil emission of 36 g CO_2/MJ (data in Tables 1 to 4) is the additional energy consumed for transporting and processing rapeseed into fuel – pure plant oil (in the case of biodiesel the energy consumed for the esterification of pure plant oil into biodiesel is added). The emission of CO_2/MJ of mineral diesel fuel is determined in accordance with the EU Directive on the promotion of renewable energy from renewable resources, 2009/28/EC from 23 April 2009.

Findings

Parameter/indicator	Mineral diesel fuel	Pure plant oil
Calorific value (MJ/kg)	42.96	39.69
Calorific value volume (MJ/l)	35.65	36.5
Density (kg/m^3)	833.2	921
Emissions CO_2 (g)/MJ of fuel	83.8	36

Fuel consumption (l/100 km), 20 - 26 month	13.18*	13.18
Fuel consumption (l/100 km), 32 - 39 month	12.18*	12.18
Emissions CO_2 (g) for fuel consumption, l/100 km (20 - 26 month)	39,374.85*	17,318.5
Emissions CO_2 (g) for fuel consumption, l/100 km (32 - 39 month)	36,387.38*	16,004.5

* If we assume that the consumption of mineral diesel is about the same as the consumption of pure plant oil, then the CO_2 emissions of mineral diesel in the measurement/ test period 1, month 20 to 26, amounted to 39.37 kg/100 km and 36.38 kg/100 km in period 2, month 32 to 39.

Table 8: Emissions of CO_2 for the off-road Land Rover Defender 110.

The emissions of CO_2 for pure plant oil in the measurement test period 1 from month 20 to 26, were 17.3 kg/100 km and 16.0 kg/100 km in the test period 2, month 32 to 39.

After subtracting the CO_2 emissions of pure plant oil from those of mineral diesel fuel, the difference represents the reduction in CO2 emissions when pure plant oil was used. In the test period 1, the savings from the use of pure plant oil were 22.0 kg CO_2/100 kilometers and in period 2 they amounted to 20.3 kg CO_2/100 kilometers travelled. A vehicle averaging a mileage of 10,000 km per year could save up to 2.2 tons of CO_2 yearly compared to one using mineral diesel fuel.

Parameter/indicator	Mineral diesel fuel	Pure plant oil
Calorific value (MJ/kg)	42.96	39.69
Calorific value volume (MJ/l)	35.65	36.5
Density (kg/m³)	833.2	921
Emissions CO_2 (g)/MJ of fuel	83.8	36
Fuel consumption (l/100 km), 20 - 26 month	3*	3
Fuel consumption (l/100 km), 32 - 39 month	1.27*	1.27
Emissions CO2 (g) for fuel consumption, l/h (20 - 26 month)	8,962.4*	3,942.0

Emissions CO2 (g) for fuel consumption, l/h km (32 - 39 month)	3,794.0*	1,668.7

* If we assume that the consumption of mineral diesel is about the same as the consumption of pure plant oil, then the CO_2 emissions of mineral diesel in the measurement/ test period 1 (month 20 to 26) were 8.9 kg/h and 3.7 kg/h in test period 2 (month 32 to 39).

Table 9: Emissions of CO_2 for tractor AGT 835.

The CO_2 emissions for pure plant oil in the measurement/test period 1 (month 20 to 26) were 3.9 kg/h and 1.6 kg/h during test period 2 (month 32 to 39).

After subtracting the CO_2 emissions of pure plant oil from those of mineral diesel fuel, the difference represents the reduction in CO_2 emissions when pure plant oil was used. In test period 1 the savings from the use of pure plant oil were 5 kg CO_2/h and during period 2 they amounted to 2.1 kg CO_2/h. A tractor running on pure plant oil for 500 working hours/ year, could save up to 2,500 kg of CO_2 compared to one running on mineral diesel oil.

Parameter/indicator	Mineral diesel fuel	Pure plant oil
Calorific value (MJ/kg)	42.96	39.69
Calorific value volume (MJ/l)	35.65	36.5
Density (kg/m^3)	833.2	921
Emissions CO_2 (g)/MJ of fuel	83.8	36
Fuel consumption (l/100 km), 20 - 26 month	8.33*	8.33
Fuel consumption (l/100 km), 32 - 39 month	7.9*	7.9
Emissions CO_2 (g) for fuel consumption, l/h (20 - 26 month)	24,885.6	10,945.6
Emissions CO_2 (g) for fuel consumption, l/h (32 - 39 month)	23,601.0	10,380.6

* If we assume that the consumption of mineral diesel is about the same as the consumption of pure plant oil, then the CO2 emissions of mineral diesel in test period 1 (month 20 to 26) were 24.8 kg/h and 23.6 kg/h in test period 2 (month 32 to 39).

Table 10: Emissions of CO_2 for tractor Fendt Favorit 612.

The emissions of CO_2 for pure plant oil in the measurement/ test period 1 (month 20 to 26) were 10.9 kg/100 km and 10.3 kg/100 km in the period of month 32 to 39.

After subtracting the CO_2 emissions of pure plant oil from those of mineral diesel fuel, the difference represents the reduction in CO_2 emissions when pure plant oil was used. In the measurement/ test period 1 (month 20 to 26), the savings from the use of pure plant oil were 13.9 kg CO_2/h and in test period 2 (month 32 to 39) 13.3 kg CO_2/h. A similar tractor, running on pure plant oil for 500 working hours/year, could save up to 6,950 kg of CO_2 compared to one running on mineral diesel oil.

Parameter/indicator	Mineral diesel fuel	Biodiesel	Pure plant oil
Calorific value (MJ/kg)	42.96	40.06	39.69
Calorific value volume (MJ/l)	35.65	35.25	36.5
Density (kg/m^3)	833.2	883.1	921
Emissions CO_2 (g)/MJ of fuel	83.8	52	36
Fuel consumption (l/100 km), 20 - 26 month	1.31	1.26	1.39
Fuel consumption (l/100 km), 32 - 39 month	1.00	1.1	1.04
Emissions CO_2 (g) for fuel consumption, l/h (20 - 26 month)	3,913.5	2,309.5	1,826.4
Emissions CO_2 (g) for fuel consumption, l/h (32 - 39 month)	2,987	2,016.3	1,366.5

Table 11: Emissions of CO_2 for the laboratory engine.

The CO_2 emissions for pure plant oil in measurement/test period 1 (month 20 to 26) were 1.8 kg/kWh and 1.3 kg/kWh in test period 2 (month 32 to 39) (one cylinder of the engine was fuelled with pure plant oil).

The CO_2 emissions for biodiesel in measurement/ test period 1 (month 20 to 26) were 2.3 kg/kWh and 2.0 kg/kWh in test period 2 (month 32 to 39) (one cylinder of the engine was fuelled with biodiesel).

CO_2 emissions for mineral diesel in the measurement/ testing period 1 (month 20 to 26) were 3.9 kg/kWh and 2.9 kg/kWh in the testing period 2 (month 32 to 39) (one cylinder of engine fuelled with mineral diesel).

After subtracting the CO_2 emissions of pure plant oil from those of mineral diesel fuel, the difference represents the reduction in CO_2 emissions when pure plant oil was used. In measurement/test period 1 (month 20 to 26), the savings from the use of pure plant oil (one cylinder of the engine was fuelled with pure plant oil) were 2.1 kg CO_2/kWh and in test period 2 (month 32 to 39) 1.6 kg CO_2/kWh. At 100 kWh, the savings in CO_2 emissions amounted to 210 kg and 160 kg respectively. The laboratory engine, using pure plant oil and operating at 500 kWh, could save up to 1,050 kg of CO_2 (one cylinder of the engine was fuelled with pure plant oil) compared to mineral diesel fuel.

In test period 1 (month 20 to 26), the savings from the use of biodiesel (one cylinder of the engine was fuelled with pure plant oil) were 1.6 kg CO_2/kWh and in test period 2 (month 32 to 39) 0.9 kg CO_2/kWh. At100 kWh, the savings in CO_2 emissions amounted to 160 kg and 90 kg respectively. The laboratory engine, using biodiesel and operating at 500 kWh, could save up to 800 kg of CO_2 (one cylinder of the engine was fuelled with biodiesel) compared to mineral diesel fuel.

From the results obtained, it is evident that the reduction of CO_2 emissions using biodiesel in the laboratory engine was lower than that when pure plant oil was used.

Using pure plant oil can generate substantial savings in CO_2 emissions. In the case of tractor AGT 835 with 500 working hours/ year, savings of up to 2.5 tons of CO_2 compared to using mineral diesel fuel are possible. For Tractor Fendt 612 with 500 working hours/ year the use of pure plant oil can save up to 6.9 tons of CO_2 compared to using mineral diesel fuel. For the off-road Land Rover Defender with a mileage of 10,000 km/ year, the use of pure plant oil can save up to 2.2 tons of CO_2 compared to using mineral diesel fuel. All vehicles together can annually save up to 11.6 tons of CO_2, which also means lesser impact on the atmosphere with greenhouse gases.

4 CONCLUSIONS

The energy use of plant oil in engines (diesel engines in different road and off-road vehicles, cogeneration units for the production of electric and thermal energy, ships, railways, etc.) is a real alternative to fossil fuels/ mineral diesel oil. For driving modified diesel engines, beside pure plant oils, waste edible/ cooking oil may also be used. This is due to the characteristics of the combustion of plant oils, which are very similar to those of mineral diesel fuel, but their viscosity is the only significant limiting factor, in terms of being too high for the fuel supply systems in modern diesel engines. The high viscosity of pure plant oil causes plugging of fuel pipes, filters and high-pressure injection nozzles because of the incomplete atomization of the fuel drops of plant oil during the fuel injection, preventing complete combustion due to large fuel drops and causing carbon plaque to build up. As a result, pure plant oil cannot be used directly in diesel engines – a modification of the engine is required. An efficient way to accomplish this is to use a two-tank system. The two-tank system requires mineral diesel fuel (instead of mineral diesel oil biodiesel may be used) to start and heat up the engine and to use it before engine stop. The results of using such a modified engine yielded a significant reduction of CO_2 emissions, but also showed slightly higher energy/ fuel consumption and higher maintenance costs.

Another important issue that should be mentioned is the duty tax. In Slovenia, the use of pure plant oil is permitted for vehicle propulsion and cogeneration of electrical and thermal energy. In these cases the same duty tax applies as for mineral diesel fuel – 0.43 €/l plus 20 % VAT. This also applies for the self-produced pure plant oil of farmers, but they are entitled to an end-of-year reimbursement of paid taxes – i.e. part of the duty tax (for either bought or self-produced fuel). This is deemed extremely unfair with respect to the promotion of renewable fuel sources. It is understood that the current national duty tax policy is one of the serious obstacles to wider production and use of pure plant oil as fuel in Slovenia, and it appears as if the national authorities currently do not regard this as an issue that needs to be addressed.

REFERENCES

Godeša, Tone, Viktor Jejčič and Tomaž Poje. 2010. Characteristics of a tractor engine using mineral and biodiesel fuels blended with rapeseed oil. Scientia Agricola 67: 510–516.

Jejčič, Viktor, Tomaž Poje and Tone Godeša. 2008. Possibilities of running tractor and vehicles by plant oil, Actual tasks on Agricultural Engineering. Proceedings of the 36th International Symposium on Agricultural Engineering, Opatija.

Kitani, Osamu (ed.). 1999. CIGR Handbook of Agricultural Engineering, Volume V - Energy & Biomass Engineering. American Society of Agricultural Engineers. Available at: http://www.cigr.org/documents/CIGRHandbookVol5.pdf, 21. 8. 2012.

Knuth, Hans Walter and Markus Winkler. 2009. Implementation of a 500 h engine test cycle and field testing of Deutz Common-Rail Engines in Heavy Duty Euro IV Truck Applications for Release of Biodiesel. Final report. UFOP Project No. 540/080. Köln: Deutz AG.

MAN B&W Diesel AG. 2004. Bio fuels for Diesel Engines.

Mittelbach, Martin and Claudia Remschmidt. 2004. Biodiesel, The comprehensive handbook, Graz.

LJUBLJANA | The public bike-sharing system Bicike(LJ) has made cycling increasingly popular.

ZAGREB I ELAN activities have promoted tolerance and understanding among all groups of traffic users.

LJUBLJANA I Public transport users are able to plan their trips more efficiently with the help of 58 real-time information displays at bus stops and the Google Transit portal with a route planner for the entire PT system.

A DISCUSSION ABOUT THE DIFFERENT MODAL SPLIT METHODOLOGIES USED IN CIVITAS ELAN

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1 INTRODUCTION

The main objective of the CIVITAS initiative is to support cities to introduce ambitious transport measures and policies towards sustainable urban mobility, achieving a significant shift in the modal split towards sustainable transport.

In this context it is crucial to have a good understanding of the transport term “modal split”, which is an important indicator of the efficiency of the implemented strategies. In this way the evolution of the modal split can be used for various purposes, e.g.:

- to determine actual use of transport modes and travel habits at the urban and suburban levels,
- to test the quality of service satisfaction on public transport modes,
- to analyse differences between urban and suburban population concerning their use of transport modes and travel habits,
- to adequately present and interpret the socio-spatial trends,
- to plan transport infrastructure and related investments within cities and surrounding suburban areas,
- to identify important themes, vulnerable groups, potential conflicts that may arise, etc.

Especially for CIVITAS ELAN, the modal split indicator brings together the impacts of all implemented measures, which is an important aspect of the integrated approach envisaged by the CIVITAS initiative.

Having a look at the wide range of evaluation studies and policy documents, we notice that we have a wide range of definitions of “modal spilt”. The main interpretations are the following:

- modal split as the share of each mode in the number of trips done by citizens,
- modal split as the share of each mode in the number of trips done by people going to work,
- modal split as the share of each mode in the number of kilometres travelled by citizens.

Additionally, we see a lot of minor differences in the types and definitions of trips and modes taken into account, the analysis group, and the way the data is collected. As most of the measures are implemented only in a specific area, instead of in the entire city, the modal split is often only measured in this “corridor”. All these aspects have a larger or smaller impact on the modal split figures.

For this reason the ELAN evaluation managers initially had the idea to define one unique approach on modal split and to organise identical surveys in the different cities. In practice this was not possible for obvious reasons. Such surveys would require much higher resources than available and would make it impossible to refer to historical data series. Some cities carry out the modal split survey for ELAN-specific purposes, but others have carried out modal split surveys before. For this reason the modal split surveys conducted in ELAN cities were usually organised in a way consistent with existing surveys and optimised for specific target groups.

However, in this context the CIVITAS ELAN evaluation managers are fully aware of the importance of high transparency and the need for further harmonisation in the modal split approach. This article aims to contribute to these objectives. Since other research on transport behaviour is done in a complementary way, we do not aim to give a comprehensive overview of all surveys in the ELAN cities, but to describe in a critical way the main modal split surveys that were used for the evaluation of the CIVITAS ELAN measures.

Further a comparative interpretation is made by indicating some key differences and their related impact on the modal split figures. Finally, the importance of the different choices in the modal split approach is synthesised, contributing to future optimisation of the modal split analyses.

2 DIFFERENT METHODOLOGIES OF MODAL SPLIT SURVEYS IN THE ELAN CITIES

This chapter contains information on how the modal split surveys are conducted in the five cities of CIVITAS ELAN. The differences between the cities are summarised in a comparative table (table 1).

2.1 LJUBLJANA

In Ljubljana, two different surveys on modal split were carried out, one within the context of changes in the public transport system arrangement, and one on the travel habits of the inhabitants of the Ljubljana region. Both surveys were carried out in 2009, before the implementation of the CIVITAS ELAN measures. A second one is planned in 2012, and there is a possibility that it will be repeated in 2013.

The survey "Changes in the public transport system in Ljubljana and the Ljubljana region" consisted of 12 thematic sections (over 47 questions). The questions regarding the modal split were included in the section "Transport and functionality", in which the use of various transport modes by the respondents were surveyed. Specifically, the questions addressed the type/kind of transport mode respondents usually used for various activities, use of car pooling, frequency of public transport use, and the average travel times to work/school.

The survey aims at two target groups: inhabitants of the CIVITAS corridor and commuters along the corridor. For the inhabitants, a random sample was selected, ensuring a high level of representation and even distribution of social groups by selecting the person in the household who last celebrated his/her birthday at the time of the interview and who was over 18 years old. The area of the corridor was divided into several sample areas. For each, a specific share of surveys took place. In order to gather information about daily commuters using the corridor, the survey sample was extended to the outskirts of the city (regional level), to establish the travel habits outside Ljubljana.

The population of the corridor and the number of commuters in the corridor is estimated at approximately 60,000. The sample size was set to 1,000, which is considered to be a statistically representative size (1.5% of the corridor population). Due to an expected response rate of 0.65, the sample was increased to 1,350 (the confidence interval for the sample was 95%, the error rate 3%).

In the first phase of the survey, the questionnaire was delivered to 1,350 statistically selected potential respondents (inhabitants of Ljubljana and the Ljubljana region), with a letter describing the purposes of the survey and the details concerning the interview at their address. Afterwards, the face-to-face interviews were conducted by the University of Ljubljana. During the two weeks period between the delivery of the questionnaire and the interviews, at least one member of the survey team was periodically available at a special telephone number and e-mail address to respond to any questions from the respondents.

In the "before" survey, the response rate was over 80%, relating to a total number of 1,081 questionnaires, of which 12 questionnaires were excluded due to various reasons (missing data, incorrect input of data into questionnaire, etc.). In the final phase, a total number of 1,069 questionnaires were included in the further processing of data. 901 responses were obtained from the corridor, while 168 responses were obtained from the regional level (daily commuters).

The survey "Travel habits of the respondents in the Ljubljana Urban Region" aimed at determining the actual use of transportation and travel habits at the urban and suburban (regional) levels, and the relation with the services satisfaction with public transport modes and demographic characteristics. Therefore, besides questions on the transport mode usually used for various activities, also questions such as the frequency of public transport use, transport mode in relation to distance/travel time, service satisfaction of PT and demographic characteristics were addressed.

Based on a sample of landline telephone subscribers in the Ljubljana Urban Region, 1,111 adults were selected through random telephone numbers for a telephone interview using a standardised questionnaire. The confidence interval for the sample was 95%, the error rate 3%.

Data analyses were based on a system of sample weights which reduce bias and errors in the results deriving from the sampling method used. The sample weights were created on the basis of the variables of gender, education and age.

The results revealed the connections between the views expressed by the respondents and their status or socio-demographic characteristics. In addition to gender, age, and education, the analysis thus included the occupation or employment status, type of settlement, and local affiliation of the respondents. The analysis further included variables revealing specific features of the use of public transport by individuals. The illustrations and data analysis were based on a system of sample weights, which reduced bias and errors in the results deriving from the sampling method used.

For both surveys, the paper versions of the questionnaires/notes needed to be transferred to the SPSS (Statistical Package for Social Sciences) computer database before statistical analysis. The data was then cleaned, decoded, and prepared for further statistical analysis. The answers were cross-examined to obtain additional information about multimodality, the modal split for various groups of respondents and various purposes of the journeys. During the data analysis, no additional demographic of other methodologically relevant pondering was applied.

2.2 GHENT

The department "Data analysis and GIS" of the city of Ghent collects modal split data for the citizens, residents of Ghent, at the city level on a 5-year basis Ghent. The latest survey, done in spring 2009, will be used as "before "data. The modal split is only reported for the main transport mode used on journeys to work or school and during leisure.

To analyse significant differences in the modal split between the city and corridor levels, the same indicators and survey methods were used for the modal split analysis within the CIVITAS corridor. This additional "before" survey within the CIVITAS corridor was organised in spring 2009 as well.

The survey at the corridor level was based on a postal survey sent to all citizens between 10 and 79 years of age, residing in the corridor. Taking into account the number of inhabitants in the corridor (29.525) and that a confidence interval of 95%, as well as representativeness of age and gender had to be reached, at least 380 filled out questionnaires had to be received from the CIVITAS corridor. Therefore, taking into account a response rate of 30%, the questionnaire was sent to 1.018 inhabitants of the corridor. Also, the Dillman method was used (reminder letters were sent to all selected citizens who did not yet fill out the questionnaire).

Especially for the CIVITAS project, additional mobility related questions were included in the questionnaire distributed at the corridor level:

- average length of trip to work or school,
- average time of trip to work or school,

- several questions related to bicycle thefts in Ghent,
- satisfaction with communication and participation strategies,
- quality of different types of infrastructure such as cycle lanes, footpaths, traffic guidance system, etc.,
- knowledge about several mobility services such as bicycle route planner, cycle website, rental bikes, etc.

The "after" survey within the CIVITAS corridor was started in March 2012. To make sure that an impact analysis at the corridor level could be conducted in proper way, the same indicators and survey methods were used as in the "before" corridor surveys. To increase the efficiency of the work of Ghent's evaluation team, the questionnaire of this survey was extended with additional questions needed for the evaluation of the impact of a range of measures on "Stimulating Cycling and Walking". Additional questionnaires were distributed in the area of the main train station to make sure that the results of the "after survey" were representative at this lower level. The "after "survey at the corridor level was also based on a postal survey sent to all citizens between 10 and 79 years of age, residents in the corridor. Taking into account the representativeness at the level of the number of inhabitants in the corridor, and at the level of the number of inhabitants in the area of the main train station, and that a confidence interval of 95%, with representativeness of age and gender had to be reached, a total of at least 700 filled out questionnaires had to received. Therefore, taking into account the response rate of the "before" survey, 46%, 1512 questionnaires were sent. The Mobility survey at the city level is planned in early May 2012. Here too the survey methods are similar to the "before" survey. To get trip-based modal split figures, a trip diary will be added to the questionnaire. This trip diary is based on the trip-based modal split surveys organised by the Flemish Government. Extra attention is given to the quality of this modal split survey, as this study will be repeated on a 2 to 3 year basis in the future.

All modal split surveys were carried out by a subcontractor, Market Analysis & Synthesis (MAS) consultancy. Data entry into the SPSS (Statistical Package for Social Sciences) computer database before statistical analysis was done by the subcontractor, using standard procedures to prevent input errors. The answers needed to be coherent. For this reason, data cleaning is done using e.g. cross tabulations. From the analysis of the survey done at the corridor level, the ratios we find in the population by sector, age, and gender are also well respected in the realised sample compared to the statistical figures. Although deviations between the sample and population were restricted, it was decided to increase the representativeness of the satellite results by weighting the functions of sector, age and gender. Finally statistical analyses were done. The results and technical report of the survey were delivered to the city of Ghent by the subcontractor.

2.3 ZAGREB

In Zagreb, citizens were interviewed face-to-face on their mobility behaviour before the implementation of the measures. The survey design was carried out by the Faculty of Transport and Traffic Sciences (ZFOT) of the University of Zagreb, a partner of CIVITAS ELAN. The survey will be repeated after the implementation of the measures. It is unsure if it will be repeated after the project as well.

First, sample size, i.e. sampling fraction, was determined in order to meet the requirements of the possible use of a particular sample, whose answers truly reflect the population. The sample was derived by dividing the population into seventeen non-overlapping classes (there are seventeen districts in Zagreb). A second stratification was based on dividing every defined class into four subclasses (there are statistical data for the population, divided into four age groups in Zagreb and its districts). This technique allowed the predetermined sample size of 500 citizens of Zagreb to result in a correctly differentiated view of travel behaviour in Zagreb. For each district, the sample was selected from a given percentage of citizens from different age groups. The calculation of the required number of citizens of a particular class or subclass was based on the statistical data for Zagreb.

Data was collected by employees of the partners of CIVITAS ELAN in Zagreb. They were asked to fill out the questionnaire for themselves and their family, neighbours and relatives. Beside employees, students of the Faculty of Transport and Traffic Sciences were asked to fill out the questionnaire for themselves and their family (if they lived in Zagreb) and for their neighbours and relatives as well. Apart from that, some questionnaires were filled out by citizens who visited the CIVITAS ELAN Info Point during a determined time period. Furthermore, 10 students of ZFOT were trained to collect the rest of the questionnaires, in case the data collected by the previously described methods were not satisfactory. For a few questionnaires, personal interviews and telephone surveys were used to collect the data.

The questionnaire was in the form of a table containing a range of multiple choice questions on the following indicators:

Transport mode*	Purpose of the journey**	Respondent information	Journey/Trip information
1. Walking	1. School/Faculty	1. Age group	1. Origin
2. Cycling	2. Work	2. Gender	2. Destination
3. Motorcycle	3. Business (hospital, bank)	3. Occupation	3. Purpose
4. Car (driver)	4. Shopping	4. Level of education	4. Transport mode used
5. Car (passenger)	5. Leisure	5. Address	5. Departure time
6. Bus	6. Home	6. Driver's licence (Yes/No)	6. Arrival time
7. Tram	7. Other	7. Car ownership (Yes/No)	7. Length
8. Train		8. Bicycle ownership (Yes/No)	

* For each trip several choices were possible.
** Each journey had to have a purpose.

A purpose was assigned to each journey, as distance and duration. Each journey was then divided into trips. For each trip a transport mode, origin and destination, distance and duration had to be filled out.

The answers from all questionnaires were entered manually into MS Excel. Data analysis was conducted manually as well; data were derived about the modal split for unimodal journeys, multimodal journeys, and for different groups of respondents and different purposes. Moreover, average trip distances and durations were determined for each transport mode which we analyzed.

2.4 BRNO

In Brno, a modal split survey was carried out before and after the implementation of the ELAN measures. The sample was composed of two groups, residents of the city and commuters who enter the city, in a 70/30 proportion. The age group was defined as 15+ and only respondents above this age limit were interviewed. Other stratifications were gender and residence in a city district; the 29 city districts were divided over 14 areas of the city to achieve the required quotas.

The sample was set at 1,000, which means a confidence interval of 95%. 20 people were interviewed in a pilot survey, but no major changes were made to the questionnaire afterwards; therefore these 20 questionnaires were included into the total of questionnaires that were analysed.

The data collection itself was carried out by 20 interviewers from 22 June to 9 July 2010. Respondents were approached face-to-face in the streets at various collection points across the city, both in the city centre and various city districts to meet the set quotas for the defined 14 areas of the city. It usually took around. 20 minutes to fill out a questionnaire.

The key information that was collected concerned the modes of transport used for regular trips to work/ school, trips during work/ school time, and trips respondents made in their free time. The modes of transport used on weekends, to travel outside Brno, or for various kinds of activities (services, leisure, shopping, and meeting friends) were also included in the questionnaire. Information on the accessibility of various modes of transport, apart from public transport, and people's options to use them was collected together with information on user satisfaction with the different facilities and the ease to park a car in or outside the city centre.

The collected data was transferred to a computer and processed with IBM SPSS software. The scope and contents of the questionnaire, as well as the sample size, allowed the use of simple statistics (descriptive statistics), but also sophisticated analytical methods (such as correspondence analysis). The next survey is planned for June 2012 (two years after the first data collection).

Biannual use of this tool will be possible after the end of the project.

2.5 PORTO

To measure the modal split in Porto, two separate campaigns were carried out, one for modal split of students/ workers and another for the inhabitants of Porto's CIVITAS demonstration corridor (the Asprela area). This data collection was performed before and after the implementation of the CIVITAS ELAN measures.

The Transport Infrastructure Division of the Faculty of Engineering, University of Porto, organised the mobility home survey to establish the mobility of Asprela's inhabitants on a regular working day. This was done by face-to-face interviews in people's homes. The following variables were collected:

- the number of trips,
- origin,
- destination,
- departure time,
- arrival time,
- travel reason,
- mode of transport,
- place of interchange and
- characterization of the person inquired.

A sample's size depends on the city's size and the level of statistical accuracy required. For this survey, the size of the sample was estimated for a population of 12,000 inhabitants, with a 95% of confidence interval and 5% error rate. This implied that 376 households in the Asprela corridor were selected to be interviewed through a random generation of coordinates using Microsoft Office Excel.

The company OPT and the City Municipality is in charge of planning the mobility survey for students and workers in the Asprela area. Data was collected by an online survey that was disseminated by e-mail to workers and students, and by face-to-face interview for visitors in several Asprela institutions (companies, university, hospital). The following indicators were selected:

- travel reasons,
- travel frequency,
- origin, destination,
- transport mode and
- departure time.

1,434 valid answers were collected for an estimated population of 42,500, with a 95% confidence interval and 2.5% error rate.

The data treatment considered only the means of transport used within the corridor, and walking was considered as a mean of transport if the travel time on foot was more than 15 minutes.

For both surveys the data was exported to Excel files and data analysis was manually performed using Excel tools and macros. A general characterization of the data sample was performed (age, gender, level of education, occupation) and mobility patterns established (purpose of the journeys, uni/multimodal journeys) and, finally, the modal split results, taking into account the number of trips. Data analysis was performed for the total sample and separately for residents and commuters.

Summary table	Ljubljana	Ghent	Zagreb	Brno	Porto
	1: inhabitants and commuters in the corridor; 2: all inhabitants of the Ljubljana region				1: households; 2: workers/ students
Method of data collection	1: Face-to-face interviews at home 2: Telephone interviews with standardised questionnaire	Postal survey (Dillman method: reminder letter sent to all selected citizens who had not filled out the questionnaire)	Face-to-face interviews (and supplementary personal interviews and telephone surveys by students if necessary)	Face-to-face interviews in the street	1: Face-to-face interviews at home 2: Online questionnaires by mail

Summary table	Ljubljana	Ghent	Zagreb	Brno	Porto
Analysis area - target group	1: inhabitants of the corridor and commuters (estimated total of 60,000) 2: Inhabitants of the urban and suburban areas (total population of 400,000)	Inhabitants of the corridor between 10 and 79 years of age (29,525 in total)	Inhabitants of the city (estimated total of 779,000)	Inhabitants of the corridor (319,000) and commuters (143,000)	1: Inhabitants of the corridor (total of 12,000) 2: Workers/ students/ visitors of several institutions in the Asprela area (estimated total of 42,500)
Types of trips included (trip purpose or travel reason)	One question addresses only work/ school trips Another question addresses other activities: visits to the historical centre of Ljubljana, downtown shopping, shopping on the city's outskirts , visits to the city's parks and green areas, using the city's sports facilities a, official errands, visiting friends	Main trips to work or school	All trips made in one day: school/ faculty; work; business, services (hospital, bank); shopping; leisure; home; other.	Work, school, services, leisure activities, shopping, friends	1: All trips that start/ end in the corridor 2: work/ school/ hospital

Summary table	Ljubljana	Ghent	Zagreb	Brno	Porto
Data collected	1: Average travel times, transport mode usually used for various activities, use of car pooling, frequency of public transport use, etc. 2: Transport mode in relation to distance/ travel time, transport mode usually used for various activities, frequency of public transport use (bus, train),	Average length of trip to work or school, average time of trip to work or school, questions related to bicycle thefts in Ghent, satisfaction with communication & participation strategies, quality of different types of infrastructure like cycle lanes, footpaths, traffic guidance system, knowledge of several mobility services, e.g. bicycle route planner, cycle website, rental bikes ...	Number of trips, origin, destination, departure time, arrival time, travel reason, mode of transport, place of interchange and characterization of the person inquired	Regular mode of transport used, frequency of use of various modes in free time, in the weekends	1: Number of trips, origin, destination, departure time, arrival time, travel reason, modes of transport, place of interchange and 2: Travel reason, travel frequency, origin, destination, mode of transport, departure time characterization of the person inquired

Summary table	Ljubljana	Ghent	Zagreb	Brno	Porto
Sample size	1: 1,000 interviews needed for confidence interval of 95% and error rate of 3%; 1,069 valid answers received 2: 1,111 interviews (representative sample of LUR landline telephone subscribers), stratification in subsamples based on demographic characteristics	At least a total of 380 filled out questionnaires needed for a confidence interval of 95% with representativeness of age and gender.	500 interviews needed (derived by stratification of the population, based on age groups and districts) Non-random selection (relatives and neighbours of partners' employees and students, and visitors of ELAN Info Point)	20 pilot + 1,000 = total 1,020; 70% residents and 30% commuters, 99% confidence level and 1% margin of error	1: 376 interviews needed for 95% level of confidence and a 5% error rate (households were selected through random generation of coordinates using Microsoft Office Excel) (406 questionnaires/ forms and 385 validated). 2: 1,500 interviews needed for a 95% confidence interval and 2.5% o error rate
Modes included	1: Car Taxi Train Bus Motorcycle, scooter Bicycle By foot Combined modes 2: Car Public transport Bicycle/ motorcycle On foot Others	Car driver Car passenger Train Bus/ tram Motorcycle Bicycle On foot	Car driver Car passenger Train Tram Bus Motorcycle Bicycle On foot (more than 100m)	Car (no distinction between driver and passenger) Train Tram Trolleybus Bus Motorcycle Bicycle On foot In-line skates	Car (no distinction between driver and passenger) Taxi Bus Metro Motorcycle Bicycle On foot (only if the travel time on foot was more than 15 minutes)

Summary table	Ljubljana	Ghent	Zagreb	Brno	Porto
Combination of modes included?	1: It is possible to treat the information in order to obtain the combination modes 2: no	For trips by train, also the transport mode that is used to go to the train station is surveyed	Unimodal and multimodal journeys measured separately	multimodal for travels to work/ school; the rest unimodal	It is possible to treat the information in order to obtain the combination modes
Periodicity	Before and after the implementation of ELAN measures: 1: 2 weeks in January 2009; 2 weeks in April 2012 2: between 30 September and 6 October 2009; April 2012	3-yearly (2009 and 2012)	before and after the implementation of ELAN measures	Biannual: June 2010 & June 2012	before and after the implementation of ELAN measures: April-June 2009 & March/ April 2011

Table 1: Key characteristics of the modal split approaches in the CIVITAS ELAN cities.

3 COMPARATIVE INTERPRETATIONS

The above descriptions of the approaches in the ELAN cities provide a view of the variation of approaches in the different cities. To allow a structured discussion on the theme, the key aspects were brought together in the above summary table (Table 1). Making up this table resulted in a first important observation: different terms are used in the description of the characteristics of the modal split approach between the cities and research institutes. Some examples are:

- trip purpose or reason of travel,
- modes of transport or main mode of transport,
- the mode “on foot” has different meanings.

3.1 ANALYSIS AREA AND TYPE OF TRIPS

A basic aspect of any modal split analysis is the definition of the area in which we want to gain insight in travel behaviour. In most surveys, the analysis is made for the city area (the municipality) or the metropolitan area. For the CIVITAS ELAN cities a more limited area is important as well: the corridor or area in which most of the measures are implemented and for which we expect a significant impact of the integrated implementation of these measures. Most surveys focus on the travel behaviour of the citizens living in analysis area. It is important to realize that this approach covers only a part of the trips in the analysis area. Two extreme situations are typical. On the one hand, there is the large metropolitan area around a city area, in which most of the trips to and from the central city occur. A survey of the citizens will give a quite complete view of the travel patterns of all movements in the analysis area. On the other hand, we have the small area of, e.g., a city centre. In this case, only a small part of the trips in that area will be included in the area’s modal split analysis, since both commuters and transit traffic are excluded.

Other surveys focus on specific activities (based on the trip purpose) in the analysis area, e.g. working, going to school or visiting the city’s commercial and tourist centres. Although the first two activities are in many cases the main type of activities, an analysis of the modal split for these activities is not representative of the general travel behaviour in the analysis area. A specific analysis of this e modal split can, of course, be of high interest, but its results are not comparable with a general modal split survey of the citizens.

From this perspective, a citizen-focused survey of a limited corridor or area in the CIVITAS ELAN cities should be interpreted with care.

3.2 DATA COLLECTION

The method of data collection is important to guarantee the quality of the results. The selected method strongly depends on the analysed target group. In many cases the necessary choice is to use a sample of this target group as representative of the whole target group. The size and the selection of the sample are not discussed here as this is common statistical knowledge. Recently, surveys on travel behaviour of citizens have been able to use a much wider range of techniques such as e-mail and the Internet. Traditional surveys by phone or letter are used less and less. The representativeness of the latter is even doubted as fewer citizens communicate in this way.

3.3 TYPE OF DATA COLLECTED

A detailed modal split survey will collect all the data describing all trips and modes used by a person during one or more days, or in relation to the specific analyzed activity (e.g. work). This gives a full view of a person's travel behaviour; it also includes the variation in choices over the week days (e.g. going to work on Mondays by car, but by bus on Tuesdays). If the relevant characteristics of the respondents are collected as well (e.g. age, gender, car availability, etc.), such a survey will allow an in-depth and differentiated understanding of mode choice.

A "minimum" modal-split survey will ask for the mode that is mainly used in general or for a specific trip purpose. Such a survey can show evolution in travel behaviour and in this way it will give an indication on the effectiveness of measures, but it does not allow for a detailed analysis of travel behaviour. We have to be aware of the fact that in such a "minimum" modal-split survey the modes used most will be normally overestimated in the modal split figures.

A survey on modal split is also a good opportunity to ask about other characteristics of people's mobility behaviour. The survey can include questions on the reasons for using or not using certain transport modes, the perception of the quality of modes, travel times, etc.

3.4 MODES INCLUDED AND COMBINATION OF MODES

The modes included in all surveys were car, public transport, and bicycle. Most surveys now also include going on foot, and occasionally less common modes like ship or airplane. Since the latter generally have only a very limited share in a city environment, they seem less important. On the contrary, going on foot seems crucial to be included (this was done in all CIVITAS ELAN surveys) as an important sustainable mode. Here we see differences in the minimum distance of the trip on foot that is included. In many cases 100m is taken as a minimum to avoid any discussion on trips inside buildings or complexes of buildings. In some cases, the walking distance is counted in minutes rather than in metres.

As indicated above, some surveys include a detailed logging of all trips and modes used, ensuring that detailed analyses can be made of all combinations of modes used by the target group. Some surveys also try to have collect information on this aspect by allowing combined answers, or by asking specifics about n the main mode and the “before” and “after” mode. This type of analysis is crucial for arriving at conclusions about ”park and ride” systems or the importance of integrated information systems.

A further important element seems to be the distinction between car driver and car passenger. Not all surveys include this distinction, making it impossible to have a view of the success of carpooling. On the other hand, some surveys go even further here, using different categories for car passengers – driver’s family members or not.

Finally, the identification of different sub-modes such as train, bus, or tram for public transport, and different minor modes like motors and motorcycles, can make the surveys more interesting, but also more difficult to compare.

4 CONCLUSIONS

The CIVITAS ELAN cities are using a wide range of techniques to collect modal split data. The use of effective and appropriate methods, depending on the interviewed target group, guarantees the quality of the data.

However, the results of the surveys can hardly be compared because of the differences in survey area and target groups, types of trips analysed, and modes or sub-modes included. All this calls for caution in interpreting the results: which modal split should be analysed?

Any modal split analysis, and especially a more general interpretation involving different cities, should start with a clear understanding – or, if possible, a well-considered decision on the methodology in advance – of the following elements:

- the analysis area in relation to travel patterns,
- the trips included in the survey: trips by the inhabitants of that area and trips by people coming from neighbouring zones,
- modes included.

Further research seems necessary to develop a structured scheme of different modal split analyses in which all these aspects are combined and linked to policy issues.

For the CIVITAS evaluation – where we are interested in the impact of an integrated package of measures, which are mainly aimed to effect travel behaviour for trips in a specific area or corridor of the city – it seems important to have a layered analysis. On the one hand, a survey of the citizens of a specific area will provide insight into changes in the travel behaviour of these citizens. On the other hand, a survey of the trips coming in or going out the area or corridor will give us complementary information on the impact of the measures on commuters and visitors. Since both groups are influenced in different ways by the measures adopted in the area, this distinction seems relevant. An overall survey for the whole city or metropolitan area will give the best global view of travel behaviour in a city. For the CIVITAS evaluation, the data can be processed into differentiated figures for both citizens and non-citizens.

To account for the long term impact of the measures implemented during CIVITAS ELAN and to make the evaluation of mobility measures more structural, it is important that performing modal split surveys is continued in the future as well, on a regular basis, and with a standardised approach to ensure comparability.

ZAGREB I Public transport drivers have received special training to raise their awareness of the needs of older passengers and increase their safety in PT.

ZAGREB I 47 bio-diesel waste-disposal and street-cleaning vehicles have been introduced in the public fleet.

GHENT | Free loading spots provide easier access to delivery trucks and ensure quick handling.

THE PERPLEXITY OF ACTANTS: SELF-EVALUATION OF THE SCIENTIFIC COORDINATION OF THE CIVITAS ELAN PROJECT

Franc Trček

1 INTRODUCTION

This chapter presents a self-evaluation of the scientific coordination of the CIVITAS ELAN project. Although officially designated as a demonstration project, it is based as a whole on the application of scientific and research findings, and solutions deriving from them, from a wide range of natural science and sociological disciplines to which the partners in the project belong. To understand the scientific coordination therefore requires understanding and evaluation of the project as a whole. In the self-evaluation of our joint efforts in the field of RTD improvements in the complex system of public transport in the five partner cities I draw on the findings I acquired not only as the project's scientific coordinator, but also as a spatial sociologist, who has been dealing with urban technologies, new socio-spatial implications, and local/regional development for two decades. I observed and analysed these findings as part of the work on the project. This means that I arrived at my conclusions, as termed in sociological methodology, through research with observation.

The evaluation of our joint efforts points out not only common successes, but also the difficulties and, in particular, the many bottlenecks, that emerged in the execution of the project, and specifically in its scientific coordination. Its intention is, of course not to point a finger at an individual partner in the project or a group of partners, where these concrete difficulties emerged. Quite the contrary. The intention of my analysis is to show how we managed, in spite of many discipline-derived, administrative/bureaucratic, and cultural differences, to successfully execute this, to date biggest, CIVITAS project, which will have long-term effects improving public transport. Through the transfer of the acquired knowledge and the territorial expansion of the measures the results of our numerous successful measures will contribute to improvements, not only in the partner cities and beyond the corridors included in the CIVITAS ELAN project, but in the entire regions where the project's participants are based.

In a project's final phase its successes are usually highlighted in glossy brochures, but my professional deontology requires me to draw particular attention to the difficulties. These derived on the one hand from the project's scope and nature and, on the other hand, in terms of the actor-network theory, from the properties of the numerous actants included in the project. The perplexity of actants, as indicated by the articles' title, is one of the project's strengths, but at the same time its limitation. The intention of this article is not only to point out the difficulties brought about by this kind of perplexity. Its intention is rather to explore our common findings and draw conclusions for future CIVITAS projects. This is after all my duty after four years of dealing with the project's scientific coordination. I freely admit, of course, that many partners included in the project with different tasks and responsibilities, will from their different points of view perceive matters in different ways, but this does not mean that either my findings or theirs are necessarily wrong or less important. They are merely different.

Below in this chapter I will first provide a brief history of how the scientific coordination was included in the CIVITAS ELAN project, because this is necessary to understand both the scientific coordination and my entire evaluation. This will be followed by a subchapter on the conceptual and theoretical premises that form the basis for my analysis.

Improvements to public transport constitute an exemplary field where numerous users and service providers, each with their own wishes and needs, become intertwined with the complexity and variety of technological issues, the technical solutions derived from them, and the simultaneous political/developmental decision-making process. For this reason I considered it logical to use a conceptual-theoretical background for reflecting on the RTD activities of our project and chose as starting point for the evaluation of the scientific coordination the actor-network theory, as it often goes beyond the outdated division into people and other (technical) artefacts. In this analysis I will use my own findings and the meta-methodological dyadic model of four spheres, which I developed for studying the development of the information society (see Trček, 2003). In reflecting on the dynamics of the project

I also consider the findings related to the focus group method; this is explained in detail in a subchapter.

The core of this chapter will use the storytelling method to analyse and evaluate our project through the prism of the three above mentioned conceptual-theoretical bodies. The conclusions contain recommendations and guidelines, which I hope will contribute to even better outcomes of future CIVITAS projects.

2 THE INCLUSION AND ROLE OF THE SCIENTIFIC COORDINATION IN THE CIVITAS ELAN PROJECT

As an autonomous part of the project, scientific coordination had to be conducted in a very specific way in order to meet the expectations and completely fulfill its purpose, with the requirements and imperatives constantly increasing over time, along with the amount of work done within the project. Even though CIVITAS projects are not scientific projects in the narrow sense, but demonstration projects for which European cities apply as key organizers, the very concept set by the European Commission foresees the inclusion of scientific coordination, as an instrument with a purpose to introduce additional dimension and increase overall amount of relevant inputs to be further processed. However, just like any other serious work, the introduction and conduction of scientific coordination had to have a dynamic of its own, constantly encountering new challenges and requiring lots of hard work and good coordination in order to cope with them.

The RTD and scientific coordination were planned as part of one of the horizontal workpackages and gradual increase of their importance had been anticipated in the preparatory phase of the project. Along with its importance, its quality was also expected to increase during the course of the project implementation. There were several reasons and one of them, if not the basic one, certainly was the fact that the initial phase of the project involves, among others, that the partners get to know each other and find forms and ways of communicating and cooperating, as well as whole range of more critical and urgent tasks, e.g. getting familiarized with the FP7 administrative and financial rules. These urgent tasks were largely related to the financial construction of this very complex project, which includes over 40 partners from seven countries and often also very different (organization) cultures. The two other horizontal workpackages, i.e. evaluation and dissemination, have external monitoring partners to advise and evaluate them, contracted by the CIVITAS consortium. Involvement and contribution of these partners, combined with those from the European Commission, largely influenced the nature of organization and (joint) management of all the currently running CIVITAS projects in their first year, as well as later. This issue will be addressed in detail in the evaluation analysis.

One of the strengths of the CIVITAS ELAN project was the organization of essentially similar measures, which are implemented in the partner cities. This is a platform of common measures that was to establish a discussion space for the exchange and transfer of specific knowledge acquired by the partners in solving similar problems. In that sense, the experience gained through previous CIVITAS projects had served as a precious input in an effort to design and implement a successful scientific coordination.

As deducted from the evaluation of already implemented projects and considering the significance of the issue, there has been a general recommendation that optimization of scientific coordination should be addressed somewhat more carefully in the future. Following that conclusion, among the first major tasks of the Centre for Spatial Sociology and one of the first so-called deliverables in general, was the "Methodological Background Paper". With the exception of the chapter on interviewing methods, this important document, aimed at presenting a broad selection of methodological approaches to studying the issues involved in the project, especially in the light of greater inclusion of many groups of stakeholders in planning future transport policies. The document started with deducting some upsides and related downsides from the experiences of previous endeavors and envisaged common methodological approaches to common measures, which would facilitate comparisons between the cities.

After consulting the partner responsible for the overall project management, the future role of WP 11 has been envisaged as a combination of methodological and advisory support to all partners, identification and opening up of conceptual and theoretical difficulties related to public transport development and situating transport policies in local/ regional spatial development policies.

Further consideration has resulted in defining the twelve conceptual-thematic areas to be discussed among the partners within the CIVITAS ELAN consortium. These themes, deriving from the extensive research experience of the researchers in the Centre for Spatial Sociology of the Faculty of Social Sciences of University of Ljubljana, address many critical areas from the field of urban mobility that the project was certain to encounter (Consuming Places and Urban Mobility, Alternative

Urban Mobility as a Lifestyle, Urban-Rural Partnership and Mobility, City or/ and Regional Mobility Planning, Influence of Institutionalized Individualization on Mobility Patterns, Who are critical users – better targeted marketing, Disabled and Mobility – Social Model of Urban Mobility, Social Innovations in Urban Transport, Mobility of Rich vs. Mobility of Poor Stratus – Social Exclusion, How Will the Aging of the Population Influence Urban Mobility, Influence of Economic Crisis on Mobility ((re)localization of production and consumption, public funding problems, social exclusion…), What is "Safety and Security of Urban Public Transport" for Users). After a careful consideration and thorough harmonization, these topics have been incorporated into a final decision about the issue.

The final decision was inclining towards an approach that assigns somewhat different role to the scientific coordination, as it was not to directly support common measures but rather to monitor them in detail. The key role of the scientific coordinator and the Centre for Spatial Sociology was to closely monitor the implementation of the measures and offer every necessary help and scientifically based second opinion, in cooperation with the partners responsible for evaluation. Scientific support was also to be provided to the internal evaluators, coordinated however with the support all CIVITAS projects are provided by the external contract partner POINTER. The scientific coordination retained the dissemination of the scientific findings acquired in the project and the preparation of a scientific monograph. The monograph, including this chapter as its part, was envisaged from the beginning in the form of a final scientific report about the project. In addition to that, besides all the support to the project, science had found its own way to benefit from all the things done within CIVITAS ELAN, with a most notable piece of added value found in the innovation regarding the search for the reliable indicators of mobility changes.

3 THE COMPLEX NETWORK OF ACTANTS AND THE QUESTION OF THE SIZE OF FOCUS GROUPS

Before turning to the self-evaluation, we have to outline its conceptual, theoretical premises. As mentioned in the introduction to analyse the performance of the scientific coordination and RTD of such an extensive project – which involves natural science and sociological disciplines, democratic (co)decision-making processes, administrative-bureaucratic procedures and monitoring, and the interests of numerous groups of users and service providers – a very adequate reflection and approach is that taken by the actor-network theory (ANT). It is a theory first developed in the sociological study of science and technology (STS – Science and Technology Studies) in the 1980s and 90s, when the foundations of ANT were laid by, in particular, Michel Callon, Bruno Latour, and John Law. We can agree with Crawford (Crawford, 2004: 2) that ANT can be perceived as both a method and a theory. In our case it will serve especially in the first sense, i.e. as a method that will facilitate our evaluation analysis. Why do I consider the ANT approach to be a suitable method for self-evaluation?

ANT is an "anti-essentialist movement" (Crawford, 2004: 1) for theoretical reflection, aimed at overcoming classical sociological divisions like agency-structure, nature-culture, context-meaning, micro-macro levels, etc. Because it developed as part of STS, its adherents have mainly addressed the research of socio-technical processes and networks from the initial phase of the method's development. In their researches ANT adherents are especially critical of social constructivism on the one hand, and techno-determinism or realism on the other hand.

In its early researches of "science in action" they established that often the assumed default autonomy and objectivity of (laboratory) science essentially does not exist, because it involves laboratory work in a network that also includes cultural norms, fights between scientists and groups of scientists over funding and research equipment, state research programmes, cancelled projects, the cost of research equipment, educational institutions, professional associations and their norms, charismatic persons, etc. All these are internal forces operating within a STS network, and they may either help to create stability or cause the network they belong to to implode. The topology of the temporal-spatial network emerges from the network of relationships between the system's elements.

The key element of ANT for our analyses is the innovative answer to the question who exactly operates and who exactly is (can be) an actor. In their conceptualisation the adherents of ANT ignored sociology's dominant anthropocentric model to introduce the concept of an "actant", borrowed from semiotics. Any active part of a network can turn into an actant and, of course, it is not necessarily a person or a group of people. Though ANT is often criticised for being an "inhuman" theory, because actants can be non-humans as well, the emphasis on the "agency of things" seems to us to be ANT's essential contribution, and Bruno Latour fittingly demonstrated this in his analysis of public transport systems (Latour, 1997).

Slightly simplified, because the aim of this article is not an in-depth theoretical (re)conceptualisation of ANT, ANT adherents ignore the divisions between nature and society, people and things, hard scientific facts and, as has recently become popular to say, soft power. A processual network of actants exists, which combines and mixes social, technical, conceptual, and textual elements. Through processes of translation such a concrete network of heterogeneous and irreductionist elements attempts to achieve stability and (at least medium-term) durability. The translations are thus simultaneously practices, occurring in the network, as well as the results of these practices, whose conditions the actants making up the concrete network understand and accept. The nature of the internal network's hegemony of course changes through these processes, which are, among others, attempts at simplifying irreductionist complexities (see Latour, 2005; Law, 2003).

The concept of actants and the analysis of a concrete network as a whole is the element of ANT that has proven to be suitable for analysing socio-technical systems, something CIVITAS ELAN certainly is. We are of course aware of the ANT's defects, which show in particular in the limit to which we can go in enumerating actants relevant to our analysis. To avoid this, I will enhance the conceptual/methodological usefulness of ANT with a more classical sociological approach that derives from an attempt to solve the basic sociological dilemma of the relationship between agency and structure. It involves a dyadic mode of four spheres which I developed for the needs of studying the information society.

In this model I start from the dyadic relationship between the social system and the actors on the one hand, and the infrastructure's properties and social action on the other hand. The decision to use such abstraction of social practices is based on an attempt to synthesise and overcome the "micro-macro" and "objective-subjective" dichotomies. In spite of the often assumed objectivity of social systems and structures, facilitating the very existence of systems through structuration processes, social systems nevertheless are not ontologically separated from the actors' operation and daily practices. Using their emancipatory capital the actors help to create and adapt the structural conditions, aiming at usefulness and practicality in everyday activities and living. In these transformations the actors go to the limit of their own competitiveness, as well as to the limit of a concrete system's carrying capacity. The carrying capacity of a system shows above all as the gap between the range of the actors' needs and wishes and the options to realise them, largely through systemic development policies. I tried to capture this didactics of practice and policy in the widest sense in a dyadic model with four spheres in which two spheres refer to the properties of the system (the technical and political spheres), and two to the properties of individuals and collective actors (the social and information spheres). This is of course a cognitive aid that facilitates mastering the complexity of social practices in concrete analyses (see Trček, 2003).

The technical sphere refers to the infrastructural development level of concrete social systems, in our case to the mobility/transport public infrastructure, which is a key development issue of our technical sphere. Even though from a classical sociological point of view it is at first glance the least interesting sphere, it is a necessary infrastructural condition. The political sphere refers to the field of regulation by the holders of political power. In our case it refers at the external level to public socio-spatial development transport policies, which are formed in a (co)decision-making process that includes a whole range of actors with different and often contradictory interests. At the internal level it refers to the project's regulation and management and the powerful influence of external factors on our self-regulation. Changes in the balance of social power, which basically determine new policies of urban mobility, depend on the competences and emancipatory potential of the actors. The social sphere is the field where the actors' social capital reveals itself. It is of course connected with their infrastructural level of equipment and with the democratic level of the (co)decision making process. The development question of the social sphere concerning changes in mobility patterns is the question how well equipped individuals and groups are at the level of mobility. The information sphere is the field where innovations occur in a perplex network of actors – innovations deriving from the initial competences of the social actors.

In the final reflections on the approach to self-evaluation, some essential methodological starting-points and recommendations have to be addressed regarding the use of the focus group method. The focus group method, while common in marketing research, is particularly successful in the evaluation of projects and planning public (development) policies. A focus group can be defined as a group of individuals who have common interests or similar properties. It is useful for understanding why and how people form their views and opinions on themes under study. In particular for the analysis of "common sense" views, the formation of new ideas and concepts, the evaluation of existing programmes and public policies, gathering proposals before taking decisions, accurate operationalisation of development strategies, and improving the elaboration of new programmes and policies.

The method is based on the fact that we usually form meanings and opinions through interaction with other people and/ or under their influence. It is further based on group dynamics about a concrete research theme and in accordance with the principle of similarity of connected individuals; therefore, the results must be analysed at the group level, not the individual level, because the method provides us with answers about the views of relatively homogeneous groups on the researched theme, not about the views of the individuals in them. Because it involves small groups (usually 7 to 10 members) of voluntarily included interviewees, the research findings obtained with the focus group method cannot be generalised to other and different groups, or to the entire population.

The method's essential qualities are also its weaknesses. A key condition is the presence of an experienced moderator. The moderator must guide the group dynamics towards the focused theme. There is always a great risk that some members of the focus group will monopolize the group interaction. For successful performance of focus groups the conceptual phase is of key importance, because we have to define the reason and content of the research and also who will be the users of the research's results. Only when it is based on a defined and essential focus we can answer questions on the composition of our focus groups. The method's name indicates that the group has to focus on a concrete theme and address it through 5-6 questions. In the further phases of the analysis we use a comparative analysis of the focus groups, aiming to find common and meaningful classifications of the researched themes. It is a methodological approach that provides us with information in a live, usually colloquial language (on the focus group method see Barbour, 2007; Greenbaum, 2002; Hennink, 2007; Krueger and Cassey, 2009).

This brief summary of the essence of the focus group method was necessary for the self-evaluation that follows, as it starts from the opinion that most of the group work in the CIVITAS ELAN project was actually a series of (quasi-)focus groups. Together with the moderation of the partners responsible for the project management, we used evaluations of existing transport policies, researches into new ideas and concepts, attempts to operationalise them, inclusion in future development strategies and new programmes and transport policies; the latter should give more sensitive consideration to changes in urban mobility and attempts to improve and enhance the existing mobility options in the partner cities. While aware of the importance of non-human actants, which also influence the translation and durability of the CIVITAS ELAN network, and using the model of four spheres for the self-evaluation analysis of our activities, we have to be aware of the nature of our joint work, especially the exchange and transfer of knowledge, which largely occurred in the form of expert focus groups including a wide range of experts dealing with the concrete research subject.

4 SELF-EVALUATION – THE PERPLEXITY OF ACTANTS OR TRANSLATION CAPTURED IN REPORTING

Below I will use the storytelling approach for the promised self-evaluation. Storytelling is an established methodological approach in poststructuralist sociology (Antonino, 1991), borrowed to some extent from psychotherapy practices, where it was first developed. The storytelling method is common in the field of narrative analyses in many fields of sociology and other human sciences (see Nash ed., 1990). It is often used in attempts to reach a deeper understanding of many socio-spatial issues (see more on the use of the method in Barber et al., 2007; Miller and Zachary, 2007; Pollette, 2006).

Through the (micro) story of the project's temporal progress I wish to point out in particular how difficult it is to achieve changes in fields with so many different interwoven interests of the kind transport systems and transport and mobility policies certainly are. This approach involves references to often problematic examples from our concrete project practices, through which I want to draw attention to the complexity of the researched theme and to the fact that it is impossible to be aware in advance of all the consequences of envisaged interventions. However, the names of the cities or concrete partners, who dealt with a specific measure, will not be mentioned, because our intention is not to provide internal criticism, but rather a message for future similar projects. The reader can learn about examples where our solutions for sets of problems were particularly successful in other chapters of this monograph.

4.1 THE TECHNICAL SPHERE – INITIAL DIFFERENCES IN INFRASTRUCTURE

For the purpose of our analysis, the technical sphere is defined as a complex transport/ technical system of infrastructures: a public city transport infrastructure and the services it provides. Together with a whole range of concrete infrastructural/ developmental problems, which differ between the partner cities and are related to changed mobility patterns, this systems consist of numerous actors, where translations between them are hard, if not impossible.

Let us look at the example of a very banal problem in one of the partner cities. Searching for a way to optimise traffic flows, they faced the problem that their traffic lights belong to three generations of different and not entirely compatible series, making it practically impossible to manage them efficiently and simultaneously: a traffic light from the first generation could simply not communicate with one of the third generation. This is of course about an inherited situation of incompatible actants, which will have to be solved in the long term with technological standardisation and the elimination of incompatible actants from the network.

We often face a situation where an improvement that is obvious to everybody, for instance the introduction of a technically more sophisticated actant in the technical sphere, does not yield only positive effects. A quick sociological response would be that this is of course a Beckian accepted social risk, but it is essentially more about people's unawareness of all the consequences the introduction of a new actant will have on the entire technical sphere.

Take, for instance, the introduction of new, more comfortable tramcars to replace old "mechanical" and technologically less complex ones. The introduction of new computer-supported "intelligent" means of transport of course brings about a range of improvements, benefiting not only people, i.e. human actants, but indeed most actants and the network/ technical sphere as a whole (e.g. air-conditioned, comfortable tramcars, easier use for handicapped people, an information system announcing arrivals, incorporated CCTV reducing vandalism, higher energy efficiency). Used in practice, however, the new tramcars – an attractive actant for the needs of the PR project and introduced to stimulate the use of the public transport system – prove to a greater burden on the tracks and cause more damage to them then the old and lighter "unintelligent" tramcars. And the energy savings are not as high as was initially anticipated.

This of course does not mean that the partner who promised more than was realised deceived the city. The matter primarily results from the unawareness of all the possible multiplication effects that are caused in the network by the new actant. And, regarding the energy savings, also because people were not aware that what was introduced instead of the old actant was a micro-network of new actants, not just a substitute mono-actant. The new tramcars indeed contain either a series of previously absent systems or updated old systems with much more complex and information/ communication supported systems. Though these do indeed enhance the comfort in the tramcars and the efficiency of our technical sphere, they are of course not a perpetuum mobile, since they require energy for their operation. Technologically more complex tramcars also mean a higher risk of defects in the individual non-human actants they consist of, and that the human actants (drivers, maintenance teams) have to be resocialized to adapt to the new actant in the technical sphere. It would be a premature and superficial conclusion to say that the introduction of new tramcars did not contribute the anticipated energy savings and caused additional cost for maintaining the system and vehicles; this incorrect assessment derives from unawareness of the changes in complexity.

Easier to understand and more simple in the analysis of the technical sphere is the story that involves a city's relief and which we can perceive as an important actant in our analysis of RTD performance. The issues may range from problems with the groundwater in the partner cities to questions how to introduce cycling to a city that is situated on hills above a river and has neither a relevant cycling tradition nor a well developed network of cycle lanes. If we want less fit citizens and visitors to join the cyclists, the city faces a presently insolvable financial challenge at the level of mass use, because electric bicycles are too heavy on account of their battery packs. By engaging all the cities of the CIVITAS consortium in a joint order of a series of lighter, more suitable, but also more expensive electric bicycles, it may be possible to substantially reduce the price per bicycle, but that is a question which in our dyadic model belongs to the political sphere.

The domain of the technical sphere is immanently a field on which spatial sociologists, unlike other CIVITAS ELAN partners from the technical academic sphere, have the least to contribute to. It is, however, necessary to take into consideration the important surge in complexity of the socio-technical system that is usually brought about by improvements in the technical sphere in the form of the infrastructural consequences of new strategies of urban and regional transport policies. This increasing complexity and the increasing numbers of actants included in the technical traffic infrastructure also heighten the immanent probability of interference in a much more complex system. As I have continued to point out in my role of scientific coordinator, this interference, which often cannot be anticipated at all until it emerges in practice, is a partial correlation that we have to take into consideration before judging too harshly the results of our highly accurate series of indicators by individual measures.

4.2 THE POLITICAL SPHERE – THE COMPLEXITY OF THE DECISION-MAKING PROCESS AND POWERLESS REPORTING

For the analytical needs of the CIVITAS ELAN project the political sphere can be divided in an external and an internal one, although they are of course interwoven in practice. The external political sphere is the field of public socio-spatial development and especially transports policies where a wide range of human actants and their often contradictory interests, wishes, expectations and opposition meet. For instance: in the attempt to obtain more active engagement from taxi drivers in some of the measures introduced in one of the partner cities, they did not perceive the project as an important means for realising their personal and legitimate interests, and consequently were disinclined to cooperate.

At the internal level we understand the political sphere as (self) regulation, project management, and the powerful influence of external factors on our self-regulation. The projects of the CIVITAS consortium are co-funded over 50% by the European Union. This means that the European Commission, the evaluators and external evaluation and dissemination advisors constitute a key (co)decision-making partner, acting within the project's balance of social power from the position of a legitimate hegemon, to use the language of classical sociology. In attempts to objectivise, the key actant proves to be the rules of the game, contained in the public tenders of CIVITAS and in the forms and contents of reports at the time of execution and conclusion of projects. The logic and dynamics of reporting is the meta-actant that to the greatest extent determined the behaviour of the entire CIVITAS ELAN network.

Here an urgent remark must be made: our project was put together in the application phase before the outbreak of the present global financial and economic crisis, and this quickly – as soon as the project started – became an unanticipated actant, whose power only increased in the course of the project. In all the countries of the five partner cities anti-crisis measures have been adopted at the national level, usually meaning reduced funding for investment in infrastructure. In one of the countries a decision was adopted that very explicitly reduced the funds from the national budget for the big (biggest) cities, obviously based on the logic that in the spreading crisis these cities would find it easier to draw on internal resources than other, smaller towns and non-central regions, which often depend on a single economic branch. This external decision from the higher territorial level means for our partner city that it must conclude the project in line with the prevailing logic that more services must be provided with a lower budget, and that more efficient transport policies have to be elaborated and developed.

If we now return to the position of the meta-actant and address the self-evaluation of the internal political sphere, I can conclude – after four years of observation with participation – that reporting was the essential bottleneck that often drove the partners in the project to despair. I am of course aware of the legitimate need for optimal use of public funding, the monitoring this involves, and the required transparency of such project co-funding by the European Commission. With reporting exposed as a meta-actant, defined by the European Commission and the external dissemination and evaluation meta-actants, divisions consequently emerged within the CIVITAS ELAN project.

On the one hand, certain difficulties occurred, typical for those situations marked by the multi-actant interdependence, regarding the level of their familiarity with the specific terminology of the EU reporting procedures. A division emerged into partners, who based on their responsibilities in the project, were forced to accept and understand this specific language, the reporting code, and others, who understood it only partly. Within the project a discourse soon prevailed that consisted of a series of acronyms and EU reporting expressions. For actants who had no such previous experience, this created difficulties, in some cases causing frustrations and additional distress about the reporting logic. Overcoming the possible stalemate regarding the issue required additional efforts put in order for the optimal coordination and task division to be secured. Given the pace of semi-annual reports and regular intermediate teleconferences, reports on the conditions in the city, the measures taken and horizontal workpackages, reporting proved to be a very time-consuming task. It indeed absorbed more time than the partners had perceived when the project started.

However, there have been certain differences also among those on the same side of the language barrier. Namely, the complexity of the relations and the tasks assigned caused the emergence of a group with the very delicate mission to coordinate the demands of the external partners and the internal actants. Most of all, those in charge of project's management, dissemination, and evaluation had to bridge the gap that appeared due to certan differences between the workplan of the project and the agenda and priorities of the European Commission and the external consulting partners for the evaluation and dissemination, who strove towards utilitarian unification of the five contemporarily running CIVITAS projects. And while this tendency could be considered well justified if understood both in the sense of practicality and as wishing comparability, such unifying measures often conflicted with the agenda of the project itself. Reflected on the inner structure of the project team, this discrepancy created an atmosphere of pseudo conflict among the aforementioned group and the rest of the project team. The reporting subsystem thus established itself in the project as a higher-level system, leading to a situation where reporting at certain times during the project became a dominating aspect. Far from being destructive, this situation emerged as yet another challenge to be overcome.

Besides the divisions within the project, resulting from the reporting-discursive competences, where the latter often acted as the key matrix in the (re)production of the balance of power between the human actants engaged in the project, similar replications occurred at the level of the cities, as well as the level of the horizontal workpackages. In these replications the actants who performed the tasks of project management, evaluation and dissemination at the level of the partner cities, assumed the role of mediators and transmissions of the reporting logic provided by the external meta-actants. In some cases this led to frustration among the project partners from the local urban subsystems.

As the project is of a demonstration and implementation nature, another difficulty emerged within the political sphere at the level of the external urban political spheres. As mentioned in the introduction this is a field of perplex contents, where a wide variety of needs and interests intersect. Through (co)decision-making processes they are translated into long-term urban development strategies and concrete policies, as well as legally enacted implementation plans resulting from them. The content of the project and the perplexity of the field proved to be the two critical actants, causing lower political support to the CIVITAS ELAN project than was expected in the decision-making processes at the level of professional associations and complex public organisations, as well as at the municipal, regional, and national political levels. The project aimed at introducing rather ambitious changes and improvements in selected corridors within the five cities, causing the professional collaborators as well as politicians, including the so-called significant others in the local communities, to be sceptical about the proposed measures and their (envisaged) effects.

A good example is the experience with a new priest in one of the cities. The priest was newly appointed in a local community on the fringe of a selected corridor. He considered the envisaged change in the traffic regime as a threat that would hinder the believers from attending holy services. As he proved to be an important political actor in the local environment, our partners were forced to look for an alternative solution. The newly arrived priest thus made use of the project and its criticism to gain greater influence and respect in his new environment. This example is a perfect illustration how difficult it is to foresee all the external actants that are connected with the project and have an impact on its course and performance.

Considering the field of RTD in the narrow sense at the end of this analysis of the political sphere, I can say that while the partners had a high level of autonomy in the RTD activities, the field was not immune to the balance of political power. On the one hand, the project and its innovativeness clashed with the dominant views in the disciplines related to the themes (e.g. giving priority to public transport over car traffic) and, on the other hand, it ran into a range of difficulties deriving from the organisation cultures and organisation structures of the numerous partners. Given the modest number of civil society partners in the project and the moderate-sized consulting organizations, most CIVITAS ELAN partners were complex, large organizations. First the cities with their public administration, then numerous large public-private infrastructure companies with concessions for providing public transport, and finally a series of research institutes and centres, which are (usually) part of universities.

These complex organisations and their key actants – organisation structures, latent vs. manifest and formal vs. informal balances of social power, differences in organisation culture, significant others in the decision-making process, involvement with politics in the narrow sense, etc. – constitute the field in which RTD occurs. Many partners joined the project with high expectations and because of possible multiplication effects. The financial and economic crisis then emerged as a key actant, affecting the viability of their expectations. As is usually the case, a whole range of unforeseen actants emerged in the realisation of the planned RTD activities, causing a number of difficulties which influenced the temporal and cost aspects of concrete RTD measures.

Such a complexity of the internal structure and relations inevitably produces certain lack of tacit knowledge, as tacit knowledge is the experience related category. However, a multitude of stakeholders has the inexhaustible capacity to produce new and unknown types of situations with an obvious imperative for applied thinking outside the box. Therefore every expertise has to be relative and a subject to a further upgrade. In practice this meant that numerous, professionally excellent partners had to put additional efforts in order to optimize their own capacities to suitably perform the reporting part of the project's cooperation. Furthermore, a very demanding nature of the project caused some additional difficulties due to its prolonged implementation, as many of the project executives had to cope with their daily duties as well, occasionally being forced to neglect the projects increasing demand for attention.

We must point out that numerous organisations instrumental to the execution of the measures were public service offices and largely funded by the city or national budget. The funds of CIVITAS ELAN, i.e. the part funded by the European Union, constituted a minor share in their annual financial plans. This had an important impact on the attitude of administrations, department heads and other (important) decision-makers with the partners to the project. If we take the example of the partners from the public transport field – while acknowledging the high engagement of the staff included in the project – we must say that they often met with numerous difficulties in the implementation of RTD measures within their own organisations. As sociologists we know all too well that such difficulties are often related to the internal balance of power and to Weber's iron law of bureaucracy.

At the end of our analysis of the political sphere we must draw attention to the fact that the issue of changes to our daily mobility patterns, which result from the spatial temporal organisation of how we live and work, are a field that is connected with many sectors and their policies. A British researcher with forty years of experience in the field recently told me an illustrative example. When they started to engage in detailed planning of mobility in the UK in the 1980s, they found out that no less than 11 ministries and government offices were involved in the issues. Such sectoral and territorial-level dispersion of authority and responsibilities is equally evident in our project.

The partner city with the longest transparent policy of democratic (co)decision-making is from a country that is ethnically and regionally divided into two parts and has to cope with a complex system of territorial-level decision-making at the local/municipal regional and national levels. In another partner city, where the responsible ministry was to decide on the integration of two types of e-tickets into a single one, something that would of course make intermodal transport friendlier and more efficient, this decision was not made. Though this chapter does not allow for a detailed discussion of the (in)adequacy of sectoral approaches, the field of mobility illustrates quite well that reflection is required on supra-sectoral and other organisational challenges and problems in planning transport policies, mobility, and socio-spatial development in general.

4. 3 THE SOCIAL SPHERE - MOBILITY CAUGHT BETWEEN WISHES AND OPTIONS

Changes that thoroughly define new policies of urban mobility depend on the competences of the human actants. The social sphere is the field where the social capital of the actors manifests itself (on the concept of social capital, see Halpern, 2005 in Fine, 2001) and defines their emancipatory potential. The latter is of course connected with their level of infrastructural equipment and with the democratic nature of the (co)decision-making process.

If I try to first analyse the social sphere within the project, I can say that our network consists of a range of experts from different organisational environments who deal with common issues. Most of us have many years of experience and a well-established formal and informal network of cooperation at different levels, including supranational ones. The cities that applied for the CIVITAS ELAN project selected quality partners at the internal city level in their preparations for the project. Over forty organisations, meaning that over three hundred human actants were involved in and working on the implementation of the project, constituted a large pool of behaviours and a mixture of diverse, but synergetic social capitals.

What became obvious quite soon, at least in the field of RTD and the scientific coordination connected with it, was that there was no lack of professional knowledge, but above all a gap between people's wishes and the available options. On the one hand, of course, between the wishes incorporated in the project's contents and the options to implement them, which were connected with a whole range of actants, including often unforeseen ones. These ranged from difficulties and problems in the socio-technical (sub)systems to difficulties in the (co) decision-making processes. An additional difficulty was the fact that the human actants with the biggest pool of social capital became key mediators or key nodes in the project's network, where we were often drawn into a discourse on reporting rather than deal intensively with RTD.

The external social sphere, the key field and communication space for the project's implementation, was of course much more diverse and chaotic. Moreover, this sphere was often not aware of its (hidden) potential. Certain important nodes in this sphere were composed of a handful of human actants, who through civil society initiatives succeeded (or halfway succeeded) in questioning old, inadequate solutions, demonstrating and introducing new forms of mobility. Despite of their dedication to the activities and their vigorous approach, these pioneers, heralds of change, were at times simply not able to translate the project's logic. A good example is the civil-society cycling network in one of the partner cities. It is driven by a single person, who however was not able to join the planned cooperation due to constraints in terms of time and money.

Similarly to the political sphere, the social sphere demonstrated that the field of mobility is a problematic development field par excellence, where a wide range of very diverse groups of actants intersect, and where translation and searching for a common communication code becomes the essential issue, i.e. a code that would enable the actants to understand the complexity of the issues at hand, because this a necessary condition in the search for future optimal solutions. We can say that the CIVITAS ELAN project functioned as an important catalyst and that it enabled at the level of the partner cities the development of a meta-social sphere where many previously unconnected actants met (for example the cooperation on hybrid and CNG buses between three partner cities) . And this new social sphere facilitated a range of innovations. Those will, however, be elaborated in more detailed form in one of the final chapters of this publication.

4. 4 THE INFORMATION SPHERE – FROM INNOVATIONS TO INNOVATIVE NETWORKING AND CAPILLARY EFFECTS

Turning to the information sphere in concluding the evaluation of the project and RTD activities, I can say that based on the dyadic model of four spheres the success of our innovative measures depended on the above addressed (analytical) spheres. The term "information sphere" refers to the field where innovations occur in the network of actants, innovations deriving from the enhancement of their initial competences. In a project with 68 measures, divided over eight policy fields, it is impossible to list most, let alone all the innovations, which were either direct effects of concrete measures or stimulated by them. Some of them are described in the other chapters of this book; others will be featured in the planned publications on the project and in the scientific articles of the collaborators of the CIVITAS ELAN project. I therefore wish to point out in particular the long-term effects CIVITAS ELAN made possible in the partner cities and between the partners in the project.

Although CIVITAS projects are not scientific projects in the narrow sense, it is nevertheless a fact that understanding changes in the field of (daily) mobility and searching for new, more adequate policies of mobility is not possible without conceptual-theoretical and methodological approaches from a wide range of sciences and disciplines connected with these issues. In spite of the fact that the key focus of CIVITAS projects is on public policies and users, innovative solutions emerge within the information sphere in a mixture of scientific findings, civil society initiatives, the interests of service providers, (new) public development policies and, of course, better solutions for old needs, as well as efficient solutions for the new needs and interests of the users. Starting from these facts, I see the innovativeness of the CIVITAS ELAN project not so much in the results of concrete measures, innovative in local urban environments, but above all in the fact that CIVITAS ELAN triggered in the partner cities a process of trans-sectoral linking up of actants who before the start of the project usually acted each in their own network.

Moreover, the project and its innovative approach of common measures offered a platform for discussion between the human actants from all five cities engaged in trying to solve similar issues. The innovativeness of networking enabled by CIVITAS ELAN lies also in the fact that it is a platform offering equal communication to actants from different fields of the social regulation of urban practices. In spite of all the difficulties that are typical of cooperation based on different values and organisation cultures, different professional languages of individual fields and disciplines and, last but not least, different fashionable or popular concepts and solutions in individual fields and disciplines – in the language of ANT these are referred to as difficulties in translation – the long-term result of CIVITAS ELAN is that the discussion on mobility and transport, with a strong emphasis on ecological and energy-friendly public transport, has moved in the partner cities from the margins to the attention of the wider public and the centre of the social developmental political debate.

Personally, I view and understand the project above all as a series of mutually connected focus groups. These are mixed internally and at the intercity level. It is a fact that people usually form meanings and opinions, and change their behavioural patterns, through interaction with other people and groups. Project brought together a whole range of actants in a series of focus groups, where we dealt with concrete thematic fields. Many of our groups, though not really homogenous, were professionally dedicated to concrete problems. And many brought together experts, providers, mediators, and users who endeavoured to understand the changes and sought to find answers to the challenges these changes would bring about.

Most of our joint work in the project, especially the exchange and transfer of knowledge, largely occurred in the form of expert focus groups. These included a wide selection of experts who deal with the concrete issues at hand. In the four years of the project this among others meant that obstacles between different groups of experts were eliminated. In a retrospective view of the attitudes between the partners from the technical disciplines and sociologists in the discussions on RTD, I can say that we found a common language and understood that the work involved socio-technical networks with complex series of actants, where we have to enter inter- and trans-disciplinary cooperation, not because this is a popular phrase, but because the info-urban habitats of techno-cultures in which we live are structured in such a way that they make cooperation necessary. In the case of the repeated rejection of a joint methodological approach to study modal split we gradually arrived at joint key conclusions, which consequently and in spite of the specifics and differences between the individual cities and approaches, led to a condition where comparisons between the cities concerning modal split were made possible.

Developmentally equally important are the networks that were established through the activities of our dissemination networks. One of the basic focuses of CIVITAS ELAN was taken into consideration: widest possible citizen engagement, with a special emphasis on the inclusion of the marginalized groups. The socially marginalised are less visible in transport, and users who are less mobile for a variety of reasons had the opportunity to become visible and to be heard in a series of thematic workshops. Their needs were incorporated in numerous measures in the partner cities. And even if their implementation was not possible, at least information was collected for future improvements. Take for instance the above mentioned new tramcar: it is more punctual, provides more comfort and is safer because of the use of CCTV monitoring, but proved to be problematic because of the layout of its interior. A new problematic actant thus emerged: the narrow space for moving down the tramcar.

How can we make our networking and numerous (focus) groups more successful? Although I am aware that in the described cases quasifocus groups were involved, we can nevertheless use the instructions for successful performance of the focus group method. In the CIVITAS ELAN project the content matrix of the project, organised around concrete measures and connected series of measures, proved to be fairly challenging.

In addition to the reporting system, the number of measures and the quite big differences between the numbers of measures in the individual partners affected our search for common answers. Some measures have proved to be fairly demanding and massive and it would be recommendable to consider putting some of them into a separate framework in order for a proper treatment to be provided in accordance with their features. In that sense situations regarding reporting, that have been occurring occasionally, can be transferred into valuable lessons with a great capacity to contribute to a substantial improvement in the future project and CIVITAS follow-ups.

In spite of the fact that in the course of the project a range of anticipated as well as unanticipated difficulties and problems arose, which resulted in some measures not being implemented to the planned extent, CIVITAS ELAN (co)created new information spheres which go beyond the former forms of dealing with the contents in the participating cities. From the position of a spatial sociologist this is the project's essential long-term innovative contribution, which will trickle down further when CIVITAS ELAN has ended, through a capillary effect, to the numerous fields in our cities that are connected with mobility and the temporal-spatial organisation of working and living.

5 PROPOSALS FOR FUTURE CIVITAS PROJECTS

In my reflections, which are not an evaluation in the way of an "objectivised" and quantified evaluation as it is performed by the colleagues from the evaluation network, I tried to provide my own view of the quality contribution of the CIVITAS ELAN project, as well as the difficulties we had in the implementation of the contents. Coming to the end of this chapter I now briefly list proposals and recommendations for future CIVITAS (and similar) projects.

- Greater emphasis should be given to similar contents and common issues the partner cities try to solve.
- As reporting is the most time-consuming activity, it would make sense to consider reducing its quantity. Reduction of resources

and time dedicated to reporting could greatly strengthen those available for the other, core parts of projects.

- The form of the reports should remain uniform during the entire four-year course of the projects and focus on the quality of the information and innovations, not on the quantity dimension of the reports.
- It seems useful considering the comparability of the concrete project with the other ongoing CIVITAS projects, as well as that among cities of the same consortium, within the preparatory phase, and incorporate conclusions in a working plan from the very beginning.
- Greater emphasis should be given to the exchange of experiences between the actors in the cities who deal with similar issues (in the form of joint workshops and longer, 2-3 month exchanges between the cities).
- The external evaluation and dissemination actants proved to be not sufficiently synergetic and productive, especially because of their levelling down approach. A more adequate solution would be for every CIVITAS project to have besides internal consultants an external consultant for evaluation, dissemination, and scientific coordination. These consultants would actively and regularly participate in the meetings of the project consortiums since this would be the only way for them to remain abreast of the project's dynamics.
- As collaborators in the project we acquired substantial tacit knowledge that deserves to be passed on to future partners in new CIVITAS projects. In particular the partners who dealt with project management, evaluation, scientific coordination, and dissemination, could act as external consultants in future CIVITAS projects, point out difficulties and help solve them, based on their similar experiences.
- Selection of the cities included in the project consortium should be conducted in a way that would provide the highest possible level of institutional and political support. CIVITAS ELAN has, among other things, pointed out at the significance of that factor.
- In future it would make sense to direct CIVITAS projects towards mid-size and small towns and regions, which have fallen into a long development crisis caused by deindustrialisation. These crisis regions would certainly provide more support to the projects, as they would be more interested in their success.

- In the socio-technical improvements of mobility greater emphasis should be given to the social actants, especially marginalized groups who normally are not included in the selection of “usual” special groups in transport, and the concept of mobility challenged and handicapped groups has therefore to be widened.
- It would make sense to consider new funding shares because cities and regions will find it hard to gather financial means in the current development crisis.

REFERENCES

Antonino, Robert J. 1991. Postmodern Storytelling versus Pragmatic Truth-Seeking: The Discursive Base of Social Theory. *Sociological Theory* 9(2): 154–163.

Barber, Kirsten et al. 2007. Narrating the Storm: Storytelling as a Methodological Approach to Understanding Hurricane Katrina. *Journal of Public Management & Social Policy* 13(2): 99–120.

Barbour, Roslaine S. 2007. *Doing Focus Groups*. London: Sage.

Crawford S., Cassandra. 2004. *Actor Network Theory. In Encyclopaedia of Social Theory*, ed. George Ritzer, 1–3. London: Sage Publications.

Fine, Ben. 2001. *Social Capital versus Social Theory*. London: Routledge.

Greenbaum, Thomas L. 2002. *Moderating Focus Groups: A Practical Guide for Group Facilitation*. London: Sage.

Halpern, David. 2005. *Social Capital*. Malden: Polity Press.

Hennink, Monique M. 2007. *International Focus Group Research*. Cambridge: Cambridge Uni. Press.

Krueger, Richard A. and Mary Anne Cassey. 2009. *Focus Gropus: A Practical Guide for Applied Research*. London: Sage.

Latoru, Bruno. 1997. *Aramis, or the Love of Technology*. London: Routledge.

Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Law, John. 2003. *Notes on the Theory of the Actor Network: Ordering, Strategy and Heterogeneity*. Lancaster University: Centre for Science Studies. Available at http://www.comp.lancs.ac.uk/sociology/papers/Law-Notes-on-ANT.pdf, 12. 3. 2012.

Miller, Stephen K. and Michael Jack Zachary. 2007. *Storytelling as Narrativity: Rural Life through the Prism of Social Tensions*. Southern Rural Sociology 22(1): 15–27.

Nash, Cristopher (ed.). 1990. *Narrative in Culture: The Use of Storytelling in the Sciences, Philosophy, and Literature*. London: Routledge.

Polletta, Francesca. 2006. *It Was Like a Fever: Storytelling in Protest and Politics*. Chicago: The University of Chicago Press.

Trček, Franc. 2003. *Problemi informacijske (ne)dostopnosti*. Ljubljana: Center za prostorsko sociologijo/Fakulteta za družbene vede (Zbirka Kiber, 1).

GHENT I The Civitas school competition resulted in real hands-on solutions for mobility problems in school environments.

ELAN Youth Congress I On the last day of the ELAN Youth Congress the students presented fresh ideas on how to improve PT in the cities.

Up: ELAN Youth Congress | The winning team of the Mobility Treasure Hunt solving the last riddle.

Down: GHENT | Enthusiastic teenagers performing in the Civitas school competition.

SOME SOCIOLOGICAL CONSIDERATIONS ON URBAN CHANGE AND SUSTAINABLE MOBILITY

Pavel Gantar

The following contribution does not aim to be a comprehensive reflection on the entire CIVITAS ELAN project – a multiannual project on sustainable mobility carried out in five European cities[1],– as its author did not have complete insight into all the project's phases, procedures, operational and technical details in the cities and their urban agglomerations. It is quite obvious that the issue of urban mobility is of critical importance to the endeavours to achieve a higher level of sustainability for modern urban living. From the sociological point of view, the mobility issue is connected to spatial access to the various public and non-public goods that sustain people's daily life. Differences in the spatial accessibility of institutions providing different public goods (among others education, health, work, recreation, etc.) have been identified as an essential component of social inequality in modern, urbanised societies. Therefore, the aim to increase citizens' mobility is still one of the most distinctive and recognisable features of various urban policies in different social and political contexts of the modern urbanised world. Closer insight into such policies would likely detect two main goals: to increase the competitiveness of the cities and to provide to the inhabitants better access to institutions and facilities necessary for daily life.

This paper is based on reading the collection of papers on the researches carried out as part of the CIVITAS ELAN Project. The papers address a great variety of subjects and approaches and accurately reflect the scope of the project, which includes measures ranging from such "soft issues" as influencing people's behaviour to

1 For a detailed description of the project and the cities involved see: http://www.civitas-initiative.org/index.php?id=69.

very technical issues like, for instance, using new, more sustainable fuel. It is actually impossible to cope with such diverse approaches and I closely considered only two issues: the interconnectedness of mobility and urban change, and the issue of the public legitimation of mobility policies and participation in changing them.

1 MOBILITY AND THE URBAN CHANGE

One cannot overlook the enormous impact of the development of transport on the transformation of urban structures and the spatial patterns of urban growth throughout history. Urban researchers and historians have described in great detail the impact of the railway on urban forms in the 19th and early 20th centuries, and this was followed by the no less enormous impact of automobilization on the transformation of urban forms and the spatial distribution of work, housing, public and private services. The Athens Charter, edited and published by Le Corbusier, codified the conclusions of the IV. Congress of CIAM (Congrès International d'Architecture Moderne) and elevated the idea of adapting inherited urban forms to the requirements of automobilism to the level of an urban planning doctrine. In addition to urban housing and renovation projects, the history of urban reconstruction has been narrowed, so to speak, to adapting urban forms to the demands of personalised "door-to-door" transport. Highway construction, transformation of public spaces into parking lots, street widening projects, promoting suburban housing, building commercial centres on the outskirts of the cities: all these developments served to promote the main imperative of automobility – increase traffic flows. This development has produced self-perpetuating effects: more space for cars creates additional transport flows and thus congestions. At the end of such circulos vitosus effective mobility tends to decrease and contribute to the general deterioration of the quality of urban life. Since the 1960s the negative and partially devastating effects on urban life have become increasingly evident and have given rise to various forms of public discontent, leading to a quest to change mobility policies. The lessons learned from the past nearly one hundred years of conflicts between the urban form and structures on the one hand and (automobile) mobility on the other hand, show that fundamental changes to urban mobility are not possible unless they target adapting and changing the urban structure and form to redefine the relations between the different various spaces and structures in the cities and their wider agglomerations.

These changes to the urban structure should encompass:

- a gradual transformation of mono-functional urban areas to mixed spatial use, reducing the distances between residence and work, education and services,
- reclaim public spaces occupied by cars for other forms of mobility and for public use,
- adapt the street and road infrastructure, now completely adjusted to car traffic, to other forms of mobility. e.g. by constructing more cycle lanes, etc.,
- readjust modal split preferences in favour of public transport.

Some of these changes are, of course, already under way in our cities, taking into consideration the specific mobility problems of each individual city and its urban agglomeration. In doing so, they face mixed responses from their citizens and users of transport facilities. This is normal and expected, since even minor changes (i.e. changing traffic signalisation) effect the habits of the users. In the CIVITAS ELAN project, 14 measures out of 68 directly addressed the travel habits of the citizens. Such measures can be successful only if they are accepted by those who are affected by them.

2 TOWARDS PUBLIC CONSENT ABOUT CHANGES TO URBAN MOBILITY: SOME OPEN QUESTIONS

The CIVITAS ELAN project was conceived from the onset to focus on citizen engagement and participation, as stated in the description of the project: "The starting point for CIVITAS ELAN is to 'put citizens first' in the dual sense of:

- considering citizens not only to be "the problem" in creating a sustainable transport system, but to "mobilise" them by letting them become part of "the solution" through,
- dedicated participation and consultation processes in many aspects of the project, and by,
- giving priority to the needs and expectations of citizens in the "ELAN cities" - difficult to achieve or contradictory as they may sometimes appear to the transport practitioner. Throughout the project this will be communicated with the citizens by using five characters, representing not only the five

ELAN cities, but the citizens of Europe".

(The Civitas Initiative, http://www.civitas-initiative.org/index.php?id=69)

The above cited orientation towards citizens and transport users is certainly one of the project's major strengths, since it does not consider users as objects of transport planning but as active participants in changes designed in a joint communicative process. From words to deeds is, however, a long and often conflict ridden process. Not only because of a certain degree of "distortion" in the communication, which seems to be unavoidable, but because of the simple fact that people have different value orientations, interests, and above all different expectations about changes in urban mobility. What will these changes bring to them, how are they going to affect their daily life, do they perceive themselves as "victims" or "benefiters" of the changes?

The researchers who scientifically evaluated some of the project's distinctive measures devoted considerable attention to this issue, because it seems to be critical to greater public acceptance of the proposed changes in urban mobility.

Drago Kos, for example, addresses the legitimation issues of urban mobility changes, emphasising consensual legitimation "through a transparent information process and participatory decision-making process". He tackles the problem of the inconsistency between the factual (empirically observed) situation and the normative (desired) situation in facilitating changes. He describes and analyses in depth the various modes of the deliberation processes that would bring about consensus, but concludes "that it is difficult to establish an operational institutional framework representing all the interested parties (residents, visitors, car users, public transport users, real estate owners, employees, and people with special mobility needs) in the city or even the whole metropolitan region". Obviously, his final conclusion opens the question whether the legitimation process is based on procedural rules or on the substance or content of the issues deliberated? The author is inclined to search for the solution in the self-organisation of the people concerned (civil society). Nevertheless, when there is a conflict of different views, let alone interests, the decision makers face the following dilemma: if they adopt only changes that enjoy wide public support, they might not be incremental, i.e. they may only slightly, if at all, improve the mobility situation; but if they opt for more substantial changes, which split public opinion, they may face the project's collapse.

The second issue that needs closer or even alternative elaboration is raised by Matjaž Uršič in a paper analysing people's attitudes towards possible changes to Ljubljana's transport and mobility system. The article reveals so-called "passive activism", an attitude observed also in studies on environmental values and behaviour. The main feature of "passive activism" is that people's actually observed mobility behaviour does not correspond with their professed mobility values. People tend to put a high value on more sustainable modes of mobility (cycling, walking etc.), but on the other hand they nevertheless tend to oppose measures that would restrain car use in congested urban areas. Such discrepancy between mobility values and actual behaviour is, of course, understandable if no alternative modes of mobility such as public transport are available, or at least not at a comfortable level, and users therefore have no alternative. Matjaž Uršič understandably and convincingly analyses the discrepancies between people's values on sustainable mobility on the one hand, and their "professed attitudes" towards limiting car use deriving from their cost-benefit analysis. He also explains the respondents' strong opposition to restricting car use with a "deep-rooted 'car culture' and a value system and lifestyles that strongly depend on the use of cars." This is certainly a viable interpretation.

However, in my opinion, another dimension of the problem deserves further elaboration. From a game theory perspective, the problem of the traffic behaviour of a large number of mutually unconnected car users can be seen as the problem of a non-cooperative game, in which every user tries to maximise his/her own benefits with no regard for others. The obvious result is congestion and all participants are off worse. The issue of mobility policies affecting car users is therefore how to change a non-cooperative game into a cooperative one and improve traffic flows. Put very simply, how to avoid the "free rider" dilemma when changing mobility policies and setting restrictions on car use, including, for instance, payable access to the city centre, high parking fees, traffic limitations, etc. Of course, the free rider dilemma can be simply eliminated by imposing heavy fines on car users who break the new rules, but this would likely cause massive discontent and resistance to the measures and eventually cause the measures to be alleviated or even abandoned. In circumstances where access to certain urban areas by car is increasingly restricted, the individual car user has the following options in the implementation of the changes:

a) he will cooperate even if others do not cooperate (altruism),
b) he will cooperate if all others cooperate too (cooperation)
c) he will not cooperate even if others do cooperate (free rider, egoism), and
d) he will not cooperate if others do not cooperate either (non- cooperation).

Obviously, options a) and c) do not tend to be realistic. Altruistic behaviour can be expected only from a minority of participants and egoistic behaviour is likely to be sanctioned with fines. Option d) actually changes nothing and is unsuccessful by definition, and therefore only option b) remains viable. To change a non-cooperative game into a cooperative one is actually based on this question: what are the benefits for traditional car users if they change their mobility mode? This brings us back to Uršič's initial investigation of people's cost-benefit calculation. There are, of course, still unexplored and unrealised opportunities for increasing walking and cycling, but it is unrealistic – taking into consideration the specific geographical conditions and existing urban structure of the cities - to expect them to substantially improve sustainable mobility in our cities. For the cities involved in the CIVITAS ELAN project (with the exception of Brno), the solution towards more sustainable mobility lies in changing the relations between private and public transport. However, conflicts seem to be inevitable in the elaboration and design of such policies.

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