European Commission

Study on urban mobility – Assessing and improving the accessibility of urban areas

Final report and policy proposals

Ricardo Energy & Environment

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Executive summary

This study on urban accessibility was undertaken by Ricardo Energy & Environment (UK) and Transporti e Territorio (TRT, Italy) for the European Commission (DG MOVE). This study on urban accessibility has been designed to maximise the potential for useful outputs that will advance the understanding of urban accessibility in order to improve the functioning of urban areas and make the transport system in Europe's urban areas more efficient.

The study comprised five key tasks covering:

- Task 1 State of the art review – understanding and assessing urban accessibility
- Task 2 Estimation of European urban road congestion costs
- Task 3 Relative efficiency of urban passenger transport modes
- Task 4 Best practice examples – increasing accessibility
- Task 5 Policy recommendations

Individual detailed reports have been developed covering tasks 1 to 4. This is the fifth and final deliverable for the study, which provides an overview of tasks 1 to 4 but also includes policy proposals/recommendations for improving accessibility in urban areas (Task 5).

The state of the art review in Task 1 made clear that accessibility differs from mobility, which just refers to the movement of people and goods, in that it involves consideration of the opportunities enabled by mobility. It also identified four key dimensions of accessibility:

- *Transport* – covering the various aspects of transport options available for passenger or freight movement, and is essentially the mobility element of accessibility.
- *Land-use* – the distribution and quality of destinations that passengers and goods need to access;
- *Individual* – the personal needs in terms of travel options or destinations;
- *Temporal* – the time constraints in relation to when destinations are open or transport services operate.

The key dimensions that can be influenced by urban policy are the transport and land-use dimensions, which together can be considered the factors that should be integrated within a Sustainable Urban Mobility Plan (SUMP). Within the transport dimension the level of urban congestion and the efficiency of urban transport modes are key considerations in improving both mobility and accessibility. These two aspects are considered in a more quantitative assessment in Tasks 2 and 3, to provide data to help cities understand and improve these aspects of their urban transport system.

Tasks 4 and 5 go on to look at measures and policies that can help to improve accessibility. Task 4 considers the range of measures available at the city level and examples of best practice in applying them. Task 5 pulls together the lessons from all the other tasks and consider action at the national and European level that can support cities in delivering improvements to accessibility.

The aim of Task 5 was to recommend policies for improving accessibility in urban areas/European cities. We have therefore largely drawn upon the findings of all of the previous tasks with a particular focus on Task 1 (where we consulted policy makers, researchers, and associations in the form of interviews and stakeholder events) and Task

4 (where we identified best practice measures for increasing the accessibility of urban areas).

We have considered policy proposals at a higher strategic level – therefore the identification of policy proposals has been developed from a bottom-up approach, rather than top-down. That is, starting from root causes and problems, we have proposed policies that aim to address each issue at the local, national and European level.

A number of problems/issues were identified as a result of Tasks 1 to 4 and associated stakeholder engagement. These included a lack of:

- Common definition of accessibility
- Comparable and consistent monitoring data
- Understanding of measures to improve accessibility
- Interpreting accessibility as a main goal
- Understanding of congestion costs
- Financial resources and
- Consideration of accessibility in other policy areas.

Actions and potential policies to improve accessibility in urban areas were identified and described in more detail to address each of the issues/problems identified above. Potential policies were identified at the EU, national and local level and are summarised below.

Policy recommendations at **the EU level** include the following:

- Provide a common understanding and definition of accessibility and its relationships with congestion and Sustainable Urban Mobility Planning (SUMPS).
- Develop a set of comparable indicators.
- Promote consistent and comparable data collection to compute indicators.
- Include accessibility improvements as an explicit goal in policy assessment (at the same level of benefits currently estimated in Cost Benefit Analyses), within urban transport policy but also outside transport policy highlighting how accessibility can be promoted by non-transport policy.
- Support knowledge sharing and best practice between EU cities building on existing urban mobility programmes.
- Contribute to provide cities with the financial resources to implement policies to improve accessibility.

At the **national level**, authorities will have the role of linking EU level actions to the local level, where measures are implemented. Recommendations at the national level will therefore be as follows:

- Develop national guidelines, tailored for appropriate national/local context.
- Develop procedures and responsibilities to ensure data collection.
- Incorporate analysis of impacts on accessibility among formal procedures required to apply for public funding.

Local authorities and city organisations are responsible for implementing measures to improve accessibility. They will therefore take on-board any guidance or best practice developed at the EU or national level when considering how to assess accessibility and subsequently implement measures to improve it where necessary.

To some extent Task 4 considered the measures that could be implemented at the local level and their potential effects on accessibility. However, it is recommended that further research is undertaken in this area, particularly related to those measures not specifically linked to transport policy (i.e. social, land use, healthcare etc.). Recommendations at the local level therefore include:

- Adopt SUMPs and other policy guidelines developed at EU and national level concerning accessibility.
- Identify clear accessibility targets based on common definitions and considering that conflicts may emerge between alternative versions of accessibility.
- Involve citizens in the definition of targets and policy instruments.
- Define strategies based on integrated packages of measures rather than single measures.
- Consider linking congestion reduction objectives with wider accessibility improvement goals.

Résumé

La présente étude sur l'accessibilité urbaine a été entreprise par Ricardo Energy & Environment (UK) et Transporti e Territorio (TRT, Italie) pour la Commission européenne (DG MOVE). Elle a été conçue pour maximiser le potentiel de contributions utiles faisant progresser les connaissances de l'accessibilité urbaine en vue d'améliorer le fonctionnement des zones urbaines européennes et l'efficacité de leur système de transport.

L'étude comportait cinq tâches essentielles :

- tâche 1 : examen de l'état des connaissances – comprendre et évaluer l'accessibilité urbaine ;
- tâche 2 : estimation des coûts engendrés par les embouteillages dans les zones urbaines européennes ;
- tâche 3 : efficacité relative des modes de transport de passagers urbains ;
- tâche 4 : exemples de meilleures pratiques – accroître l'accessibilité ;
- tâche 5 : recommandations de politiques.

Des rapports détaillés individuels ont été élaborés concernant les tâches 1 à 4. Ceci est le cinquième et dernier livrable dans le cadre de l'étude, il donne un aperçu des tâches 1 à 4, mais inclut également des propositions/recommandations d'amélioration de l'accessibilité des zones urbaines (tâche 5).

Il est ressorti de l'examen de l'état des connaissances au titre de la première tâche que l'accessibilité est différente de la mobilité, qui se rapporte simplement au mouvement de personnes et de marchandises, en ce qu'elle suppose de considérer les occasions générées par la mobilité. Il a également identifié quatre dimensions clés de l'accessibilité :

- *transport* – couvre les différents aspects des options de transport disponibles pour le mouvement des personnes et des marchandises et constitue essentiellement l'élément « mobilité » de l'accessibilité ;
- *aménagement du territoire* – distribution et qualité des destinations auxquelles les passagers et les marchandises doivent accéder ;
- *individuelle* – besoins des personnes en termes d'options de déplacement ou de destinations ;
- *temporelle* – contraintes temporelles en lien avec les horaires auxquels les destinations sont ouvertes ou auxquels les services de transport fonctionnent.

Les dimensions clés qui peuvent être influencées par la politique urbaine sont celles du transport et de l'aménagement du territoire, qui ensemble peuvent être considérées comme les facteurs devant être intégrés dans un plan de mobilité urbaine durable. Dans le cadre de la dimension du transport, l'ampleur des embouteillages urbains et l'efficacité des modes de transport urbain sont des considérations essentielles en termes d'amélioration de la mobilité et de l'accessibilité. Ces deux aspects sont abordés dans une évaluation plus quantitative dans les deuxième et troisième tâches, afin de fournir des données permettant aux villes de comprendre et d'améliorer ces aspects de leur système de transport urbain.

Les tâches 4 et 5 examinent ensuite les mesures et politiques pouvant contribuer à améliorer l'accessibilité. La tâche 4 considère l'éventail de mesures disponibles au niveau des villes et des exemples de meilleures pratiques de leur application. La tâche 5 rassemble les enseignements tirés de toutes les autres tâches et envisage des mesures aux niveaux national et européen susceptibles d'aider les villes à améliorer l'accessibilité.

La tâche 5 avait pour objectif de recommander des politiques destinées à améliorer l'accessibilité dans les zones urbaines / les villes européennes. Nous nous sommes dès lors en grande partie appuyés sur les conclusions de toutes les tâches précédentes, en nous centrant en particulier sur la première tâche (pour laquelle nous avions consulté des décideurs, des chercheurs et des associations dans le cadre d'entretiens et d'événements des parties prenantes) et sur la quatrième (pour laquelle nous avions identifié des meilleures pratiques permettant d'augmenter l'accessibilité des zones urbaines).

Nous avons étudié des propositions de politiques à un haut niveau stratégique – c'est pourquoi l'identification des propositions de politiques a été développée selon une approche ascendante plutôt que descendante. Autrement dit, depuis le point de départ des causes et problèmes fondamentaux, nous avons proposé des politiques visant à aborder chaque problème aux niveaux local, national et européen.

Un certain nombre de problèmes ont été identifiés dans la foulée des tâches 1 à 4 et de l'engagement associé des parties prenantes. Il s'agit notamment des problèmes suivants :

- absence de définition commune de l'accessibilité ;
- absence de données de suivi comparables et cohérentes ;
- manque de compréhension des mesures destinées à améliorer l'accessibilité ;
- absence d'interprétation de l'accessibilité comme objectif principal ;
- manque de compréhension des coûts liés aux embouteillages ;
- ressources financières insuffisantes ; et
- prise en considération insuffisante de l'accessibilité dans les autres politiques.

Des mesures et des politiques potentielles d'amélioration de l'accessibilité dans les zones urbaines ont été identifiées et décrites de manière plus détaillée au regard de chacun des problèmes ci-dessus. Les politiques potentielles identifiées aux niveaux européen, national et local sont synthétisées ci-dessous.

Au niveau de l'Union européenne, les recommandations de politiques suivantes ont notamment été émises :

- fournir une compréhension et une définition communes de l'accessibilité et de sa relation avec les embouteillages et les plans de mobilité urbaine durable ;
- élaborer un ensemble d'indicateurs comparables ;
- promouvoir la collecte de données cohérentes et comparables aux fins du calcul des indicateurs ;
- inclure l'amélioration de l'accessibilité comme objectif explicite dans l'évaluation des politiques (au même niveau que les bénéfices actuellement estimés dans les analyses coûts-bénéfices), dans le cadre de la politique en matière de transport urbain mais également en dehors, en soulignant comment l'accessibilité peut être promue par les politiques non liées au transport ;
- soutenir le partage de connaissances et de meilleures pratiques entre villes européennes, en s'appuyant sur les programmes existants de mobilité urbaine ;
- contribuer à fournir aux villes les ressources financières nécessaires pour mettre en œuvre des politiques d'amélioration de l'accessibilité.

Au **niveau national**, les autorités devront faire le lien entre les actions au niveau européen et au niveau local, où les mesures sont mises en œuvre. Par conséquent, les recommandations au niveau national seront les suivantes :

- élaborer des directives nationales, adaptées au contexte national/local ;

- élaborer des procédures et des responsabilités afin d’assurer la collecte des données ;
- intégrer l’analyse des impacts sur l’accessibilité dans les procédures officielles requises pour solliciter un financement public.

Les autorités locales et les organisations municipales sont responsables de la mise en œuvre des mesures d’amélioration de l’accessibilité. Elles tiendront dès lors compte de toutes orientations ou meilleures pratiques mises au point au niveau européen ou national lorsqu’elles réfléchiront aux manières d’évaluer l’accessibilité puis, le cas échéant, de mettre en œuvre les mesures visant à l’améliorer.

Dans une certaine mesure, la tâche 4 a étudié les mesures qui pourraient être mises en œuvre au niveau local et leurs effets potentiels sur l’accessibilité. Il est toutefois recommandé de poursuivre les recherches dans ce domaine, notamment en ce qui concerne les mesures qui ne sont pas spécifiquement liées aux politiques de transport (mesures sociales, aménagement du territoire, soins de santé, etc.). Les recommandations suivantes sont donc émises au niveau local :

- adopter les plans de mobilité urbaine durable et les autres directives mises au point aux niveaux européen et national en matière d’accessibilité ;
- identifier des cibles d’accessibilité claires reposant sur des définitions communes et tenant compte du fait que des conflits peuvent surgir entre différentes versions de l’accessibilité ;
- faire participer les citoyens à la définition des cibles et des instruments politiques ;
- définir des stratégies fondées sur des ensembles complets de mesures plutôt que sur des mesures isolées ;
- envisager de faire le lien entre les objectifs de réduction des embouteillages et les objectifs plus larges d’amélioration de l’accessibilité.

Contents

1 INTRODUCTION

Ricardo Energy & Environment (UK) and Transporti e Territorio (TRT, Italy) were commissioned by the European Commission to undertake a study on urban mobility and assessing and improving the accessibility of urban areas. The study comprised five key tasks covering:

- Task 1 State of the art review – understanding and assessing urban accessibility
- Task 2 Estimation of European urban road congestion costs
- Task 3 Relative efficiency of urban passenger transport modes
- Task 4 Best practice examples – increasing accessibility
- Task 5 Policy recommendations

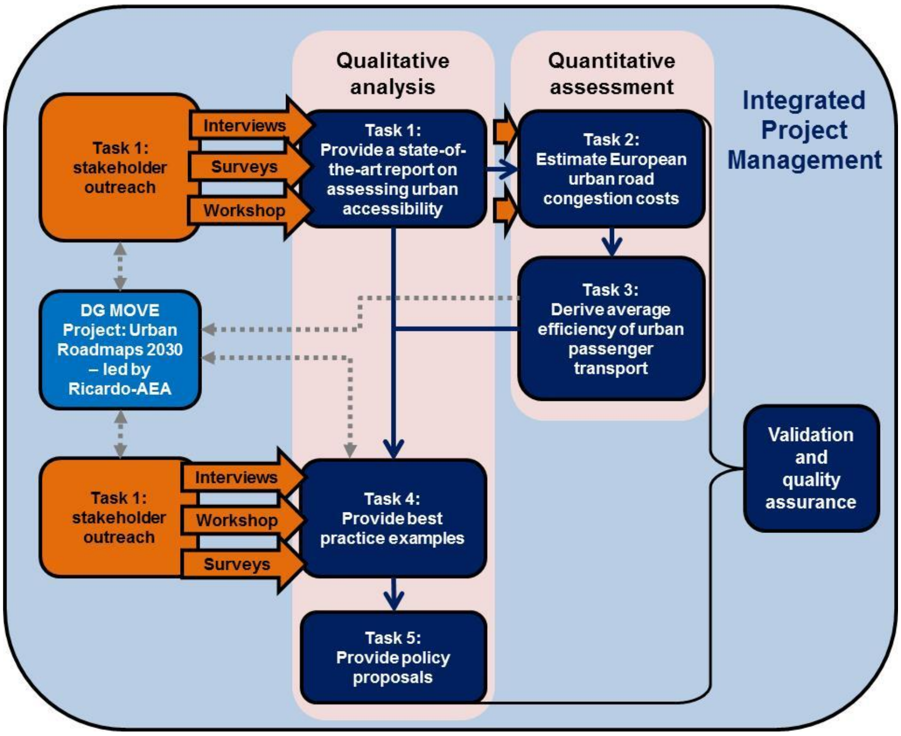
Individual detailed reports have been developed covering tasks 1 to 4. This is the fifth and final deliverable for the study, which provides an overview of tasks 1 to 4 but also includes policy proposals/recommendations for improving accessibility in urban areas (Task 5).

1.1 Study objectives and overview

This study in urban accessibility has been designed in order to maximise the potential for useful outputs that will advance the understanding of urban accessibility in order to improve the functioning of urban areas and make the transport system in Europe's urban areas more efficient.

The study's five key tasks were outlined above. Figure 1-1 provides an overview of how the different tasks fit together.

Figure 1-1: Overview of study tasks and methodology



The state of the art review in Task 1 made clear that accessibility differs from mobility, which just refers to the movement of people and goods, in that it involves consideration of the opportunities enabled by mobility. It also identified four key dimensions of accessibility:

- Transport – covering the various aspects of transport options available for passenger or freight movement, and is essentially the mobility element of accessibility.
- Land-use – the distribution and quality of destinations that passengers and goods need to access;
- Individual – the personal needs in terms of travel options or destinations;
- Temporal – the time constraints in relation to when destinations are open or transport services operate.

The key dimensions that can be influenced by urban policy are the transport and land-use dimensions, which together can be considered the factors that should be integrated within a Sustainable Urban Mobility Plan. Within the transport dimension the level of urban congestion and the efficiency of urban transport modes are key considerations in improving both mobility and accessibility. These two aspects are considered in a more quantitative assessment in Tasks 2 and 3, to provide data to help cities understand and improve these aspects of their urban transport system.

Tasks 4 and 5 go on to look at measures and policies that can help to improve accessibility. Task 4 considers the range of measures available at the city level and examples of best practice in applying them. Task 5 pulls together the lessons from all the other tasks and considers action at the national and European level that can support cities in delivering improvements to accessibility.

1.2 Study Methodology

The detailed methodology for each task can be found in the separate Task Reports (Tasks 1 to 4). An overview is provided here of the stakeholder engagement activities that took place during the project and contributed to the completion of tasks.

1.2.1 Stakeholder engagement

There were a number of stakeholder engagement activities during the study. Throughout the study, a range of stakeholders were involved, including:

- Authors of relevant reports (identified through the review of the literature)
- Key stakeholders in the areas of policy-making
- ITS/ICT solution providers, infrastructure development
- Transport service providers/contractors
- Associations
- City networks; and
- Academics/think tanks.

An overview of the approach taken to stakeholder engagement is provided in Table 1-1 .

Table 1-1: Overview of stakeholder engagement – 2015-16

Dates	Engagement approach	Summary
May to September 2015	Email survey Telephone interviews	▪ Identification of potential urban accessibility indicators. ▪ Suggestions for common accessibility indicators for comparing European Cities, including identification of potential problems/barriers. ▪ Identification of urban accessibility projects that stakeholders have been involved in or are aware of. Primarily contributing to Task 1.
September 2015	Workshop – Brussels	▪ Defining urban accessibility (including participant exercise on accessibility metrics). ▪ Data and modelling (including discussion on existing European data and modelling techniques). ▪ Congestion and accessibility. ▪ Participant exercise on identifying potential measures to improve accessibility. ▪ Providing an overview of Tasks 1 and 2 ▪ Collecting initial information for Tasks 4 and 5.
May to June 2016	Email survey	▪ Actions available to improve accessibility in European cities. ▪ Supporting actions (EU level). Primarily contributing to Tasks 4 and 5
December 2016	Final seminar	▪ Presentation of key results and recommendations – Tasks 1 to 5. ▪ Presentations from relevant guest speakers

1.3 Overview of the report structure

An overview of the outcomes of task Tasks 1 to 4 is set out in the following sections, and for each task there is also a stand-alone, final publishable report. The policy analysis carried out in Task 5 is detailed in the remaining sections and pulls together the outputs from the project and provides clear guidance on how urban accessibility can be improved.

The remainder of this report is structured as follows:

- Section 2: State of the Art Report on assessing urban accessibility (Task 1)
- Section 3: Estimating European road congestion costs (Task 2)
- Section 4: Relative efficiency of urban passenger transport modes (Task 3)
- Section 5: Best practice policy examples – increasing accessibility (Task 4)
- Section 6: Policies and actions to improve accessibility (Task 5)

2 STATE OF THE ART REVIEW ON ASSESSING URBAN ACCESSIBILITY (TASK 1)

The main aim of Task 1 was to prepare a State of the Art Review on accessibility and assessing/improving the accessibility of urban areas. A review of relevant literature was undertaken, which covered:

- Accessibility definitions and scope;
- Metrics in use;
- Modelling techniques and their applications; and
- Policy initiatives affecting accessibility.

The review of the literature was complemented by stakeholder engagement, including telephone interviews and a workshop with key experts and academics in the field of accessibility.

2.1 Defining Accessibility

It is clear from the review of the literature that many definitions of accessibility currently exist, including:

- 'the opportunity which an individual or type of person at a given location possesses to take part in a particular activity or set of activities' (Hansen, 1959)
- 'the average opportunity which the residents of the area possess to take part in a particular activity or set of activities' (Wachs & Kumaga, 1973)
- 'the consumer surplus, or net benefit, that people achieve from using the transport and land use system' (Leonardi, 1978)
- 'the extent to which the land use-transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s)' (Geurs & van Eck, 2001)
- 'the number and diversity of places that can be reached within a given travel time and/or cost' (Bertolini, Le Clercq, & Kapoen, 2005)
- 'the ease in meeting one's needs in locations distributed over space for a subject located in a given area' (Cascetta, Carteni, & Montanino, 2013)
- As property of an individual: "Accessibility is a measure of the ease of an individual to pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time" (Bhat, et al., 2000);
- Property of individuals' surroundings (e.g. the transport-land use system) or particular places: "[Accessibility is] the extent to which the land use-transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s)." (Geurs & van Eck, 2001)

By any of these definitions, it should be clear that accessibility differs from *mobility*, which just refers to the movement of people and goods (Litman, 2011). Accessibility involves consideration of the *opportunities* enabled by mobility.

Urban accessibility can therefore be defined as: "….*the ease of reaching goods, services, activities and destinations in urban areas. It includes factors such as mobility options, travel information, transport network connectivity, land use patterns and cost for both passengers and freight*."

2.2 Dimensions of Accessibility

There are typically four dimensions of accessibility, which can be described as follows:

- The **transport dimension** of accessibility comprises the various available options for transport. This component partly determines the disutility an individual would experience in travelling between an origin and destination (or the disutility an agent would experience when transporting their freight between an origin and destination).
- The **land use dimension** of accessibility consists of the amount, quality and spatial distribution of activity locations (or "opportunities" or "destinations") which individuals might want to travel to (or which agents might want to move their freight to).
- The **individual dimension** of accessibility relates to the (different) needs, capabilities and perceptions of (different) individuals. Individuals vary in terms of their physical capabilities, which can affect their feasible set of options for transport. Their options can also be affected by their economic resources, or the time constraints they face in their lives, or the information that is available and salient to them, and so on. There may be analogous situations in freight transport, for example due to the fact that different types of freight need to be handled differently.
- Accessibility also has a **temporal dimension** for several reasons; activities/opportunities are often only available at particular times (for example shops will often close for part of the day) or else it is mandated that certain activities (like work) take place at certain times. Furthermore, individuals are constrained in when they can travel to certain destinations and perform certain activities due to the other activities they must perform (such as work, care, or meeting other individuals) (Geurs & van Wee, 2004).

2.3 Accessibility Metrics

There are a range of accessibility measures/indicators in use, which can be grouped into the following categories:

- **Infrastructure-based** – quantify accessibility in terms of the performance of the transport system, e.g. average speed on the road network, levels of congestion, or availability of cycle paths etc.
- **Location-based** – define accessibility in terms of how many individuals/freight loads can access a location, or how many locations an individual/freight load can reach.
- **Person-based** – consider accessibility at the level of individuals e.g. details of the set of employment centres specific individuals can practically access, taking into consideration personal constraints of time or physical ability (physical access to public transport vehicles, ability to walk/cycle various distances etc.).
- **Utility-based** – quantify accessibility in terms of utility an individual or individuals derive from being able to access activities/opportunities distributed across space (economic benefit).

A number of recent studies were identified that involved the development and use of accessibility (and mobility) metrics. The Sustainable Mobility Project was conducted by the World Business Council for Sustainable Development (WBCSD, 2015), which involved the development of a set of indicators measuring the potential for sustainable mobility in cities around the world. However, the indicator set was not designed so that the sustainable mobility of cities could be compared, rather than other similar cities could use the indicator set to potentially understand where they could improve their local situation.

Arthur D Little's (2014) '*Future of Urban Mobility'* study included an updated urban mobility index assessing the mobility maturity and performance of 84 cities worldwide. Like the WBCSD study, the main focus is again on mobility rather than accessibility, but includes related criteria that could be useful in assessing accessibility of cities (e.g. public transport frequency, mean travel time to work, etc.). However, there is a strong focus on the transport aspects, and less consideration for the availability of opportunities, and the ndividual.

A study that focuses specifically on accessibility is 'TRansport ACCessibility at regional/local scale and patterns in Europe' (TRACC) (ESPON, 2015). The main aim of the TRACC study was to update results of previous studies on accessibility at the European scale, reviewing/extending indicators used, extending the spatial resolution of indicators, and exploring the likely impacts of policies at the European/national scale to improve global, European and regional accessibility in the light of a range of emerging challenges (e.g., globalisation, energy scarcity, climate change etc.). In addition to the generic indicators, four further indicators are considered in the TRACC study, including multimodal accessibility, intermodal accessibility, global accessibility and regional accessibility. The TRACC study used a European-wide accessibility model, which requires data from cities to be collated, including data on a range of opportunities (secondary schools, hospitals, surgeries etc.). The study acknowledges that there is no single standard accessibility indicator that can serve all purposes. A set of accessibility indicators was therefore developed, which takes into account three spatial contexts global, European and regional), and is further differentiated between travel and freight (ESPON, 2015).

Other studies consider accessibility to/of public transport (one aspect of 'accessibility' in urban areas). A recently published paper considers 'measuring access to public transport in European cities' (Poelman & Dijkstra, 2015). The study produced a set of comparable indicators to assess the access to and comparison of the offer of public transport that is easily accessible to the urban population, enabling cities to benchmark themselves against similarly-sized cities. The methodology developed enables the comparison of cities in an identical manner, taking into account the extent of the urban centre, distribution of population and exact location of public transport stops, and the frequency of departures. However, it is acknowledged that data availability is a constraint, particularly open access to public transport data in the right format. Also, high resolution data on location of jobs at the workplace is also quite rare.

In order to model accessibility, data will be required from a variety of sources, most often relating to the transport system, land use, and the individual. Availability of data and difficulty in obtaining data varies greatly, and can include the undertaking of surveys, stated-preference surveys, consulting timetables, existing maps, traffic monitoring, censuses, intelligent transport systems, interviews etc. Mathematical and analytical models are often used to operationalise the concept of accessibility. Once calculated accessibility measures (and their distribution over space, time and individuals) are often visualised in modelling suites in order to facilitate understanding by the user. The following subsections look in more detail at the data required for modelling accessibility.

2.3.1 Transport data

Almost all accessibility models and measures will incorporate data on travel times between zones or locations. This data may need to be derived from other data about the transport system, including:

- **Data on the provision of transport infrastructure**, for example the layout of the road network or the spatial distribution of railway stations. Typically digital maps of the road/rail network.
- **Data on the provision of (public) transport services**, e.g. timetable data of bus and train services sufficient to understand the frequency and speed of

services, routes served, possible interchanges, etc. Typically information from timetables.

- **Data on the performance of the transport network**, for example information on average road speeds, delay, and reliability. Either routinely measured data (sensors in and around transport infrastructure), manually collected (surveys on actual journeys), or GNSS trackers to measure travel times and speeds.
- **Data on costs of travel** (in particular fares and fuel) is also often collected, or estimated on the basis of typical costs per unit distance.

2.3.2 Individual data

Attributes of individuals which may have a bearing on accessibility, such as their age, employment status, and whether they have access to a car they can use, are often asked about in travel surveys and other social surveys. Stated preference surveys can also be used to understand underlying preferences and variation across individuals in those preferences. For example, (Bocarejo S. & Oviedo, 2012) used stated preference surveys in Bogota to establish the amount of time and percentage of income individuals were willing to spend on accessing work, then used this to produce measures of accessibility that were sensitive to the different affordability constraints different individuals face.

The **actual travel and activity patterns** of individuals are also measured by travel surveys, or might be derived from smartcard data in intelligent transport systems. Many travel surveys incorporate "travel diaries" for individuals to give details of all the trips they made over a recent period of time. (Time use surveys are another potential source of data on activity patterns.) In principle, information on the actual activity patterns of individuals can be used to construct space-time prism measures of accessibility. The information that travel diaries can provide for constructing space-time prisms is limited, and so scholars have sometimes tried to flesh out diary data with reasonable assumptions in order to establish the temporal and spatial constraints different individuals face. For example, in a study of individuals' accessibility in Ghent, Belgium, (Neutens, Delafontaine, Scott, & De Maeyer, 2012) assume that the work and education activities that individuals report in their travel diaries are "fixed" and so visits to certain other activities would have to fit around the need to be at a specific workplace/college/school at specific times. To capture the complex spatial-temporal constraints individuals face in a more comprehensive way, as is done in (Schwanen & de Jong, 2008), in-depth interviews or other qualitative research methods are needed.

Variability in individuals' interactions with the transport system can be explored through interviews, directly observed in the field, or observed in laboratory settings. University College London's Pedestrian Accessibility Movement Environment Laboratory (PAMELA) is a laboratory that has been used to observe interactions between individuals and transport infrastructure, such as the boarding and alighting of trains. Such laboratory experiments have been used to establish facts about how the ergonomic design of transport infrastructure affects its use by mobility-restrained individuals (University College London, 2015). As an example of qualitative data collection, (Jones, 2012) used focus groups to understand physical and psychological restrictions affecting individuals' ability to use the transport system in Yorkshire, UK.

2.3.3 Land use data

Data on location of individuals and opportunities is often gathered by surveys. Censuses provide high-quality data on the spatial distribution of individuals, although if this data needs to be supplemented and matched with other information about individuals (such as their travel behaviour) census surveys may be insufficient. Other types of survey that may have relevance to land use include employment surveys; for example, the UK Department for Transport constructs distance-based measures of accessibility to jobs partly on the basis of an official labour market survey sent to employers which generates data on the locations of jobs (UK Department for Transport, 2012).

Databases of locations of opportunities also often pre-exist for other purposes. For example, central governments keep information on the locations of schools, hospitals, and other public services. Data on the spatial distribution of certain types of opportunity will often be held by the private sector too, for example, the UK Department for Transport uses a private company's data on the locations of food shops in order to compute its shopping accessibility metrics. That data exists to serve another purpose, i.e. to meet the demand among retailers for intelligence on the locations of their rivals' outlets (UK Department for Transport, 2012).

2.4 Accessibility Indicators for Comparing European Cities

One of the objectives of this study is to contribute to the development of a European Urban Mobility Scoreboard, which could be used to facilitate comparison between areas and over time. The review of the literature has highlighted that an extremely diverse set of indicators are used and/or required to quantify accessibility, each with their own advantages and disadvantages, due to the fact that accessibility is "*a multifaceted concept, not readily packaged into a one-size-fits-all indicator or index*" (Scheurer & Curtis, 2007). Such indicators and their merits were also discussed in detail during our engagement with stakeholders (interviews and workshop). However, it is evident that some indicators would be more useful in developing a scoreboard than others.

In particular, it would be impossible to base city-level accessibility metrics around the use of space-time prisms and other ways of measuring accessibility that are extremely sensitive to individuals' unique circumstances.

The use of infrastructure-based measures of accessibility also have their drawbacks due to the fact that they do not often take into account the spatial distribution (and re-distribution over time) of opportunities/activities. This is fundamental in considering *accessibility* rather than just *mobility*.

After eliminating those possibilities, the remaining possibilities are to use the following types of indicators:

- Location-based measures considering both potential accessibility indicators and/or distance indicators;
- Utility-based indicators.

The literature and engagement with stakeholders have already provided some examples of indicators that fall within these categories. Some examples of the types of indicators that could be used to compare cities are provided in the table below.

Example city comparator accessibility indicators

City comparator example indicators
Number of opportunities e.g. doctors surgeries, jobs, schools etc. within **X** m/km
Number of opportunities e.g. doctors surgeries, jobs, schools etc. within **X** minutes by public transport, private car, walking, cycling etc.
Number or proportion of individuals (population) within **X** distance/time of an opportunity.
Potential accessibility to e.g. healthcare, education, jobs etc.

Within this set of options, there will be a trade-off between accuracy, and ease of implementation and interpretation. Accuracy is obviously necessary if comparisons between cities and over time are to be informative. But ease of interpretation is also important if the scoreboard is going to have an influential effect on policymakers, which may rule out the use of utility-based statistics derived from a "black box" (where inputs and outputs are known but there is no knowledge of internal workings).

An important consideration for any selected accessibility metric is the necessary data – including its format, availability and ease of collection. In order to be able to make comparisons between European cities, data supporting accessibility metrics will need to be readily available to most cities, and can potentially be collected at the European level.

As the scoreboard is envisaged as facilitating comparisons between areas, there will need to be some careful consideration of the substantial area-level differences between individuals in different parts of the EU. For example, individuals in different countries or even different cities may differ not only in terms of their income but also in terms of how much they are willing to spend on travel as a proportion of their income. Hence the measures should compare accessibility (e.g. time or distance to access opportunities) between cities, but should not provide judgement on what is considered to be acceptable, desirable etc.

Given these considerations the most likely candidates for a European level indicator(s) on accessibility are location-based measures in terms of simple travel distances/times to opportunities. This is supported by the use of these type of indicators in comparative accessibility studies such as the ESPON TRACC study (ESPON, 2015) and UK Department for Transport's Accessibility Statistics (UK Department for Transport, 2014).

2.5 Key conclusions

This review has highlighted that Member States including the UK, the Netherlands, and Germany have already taken some steps to let accessibility modelling and analysis inform the decisions governments and municipal authorities take in transport, urban planning, and provision of public services. Inevitably, some areas of the Community lag behind others in terms of the progress made on this front (it is probably the case that larger municipal governments generally lead the way). The CIVITAS initiative – which promotes dissemination between cities of innovative sustainable transport measures – supports projects that link "leading cities" and "learning cities" for this reason. Either CIVITAS or a new initiative could be used to disseminate best practice in the use of accessibility measures as policy-informers.

Use of accessibility measures in a European Urban Mobility Scoreboard would raise the profile of accessibility measurement, but it may prove difficult to distil complex accessibility issues into concise indicators over an area as diverse as Europe.

The EU might also take action to improve levels of urban accessibility with the structural and cohesion funds. Projects to improve accessibility through upgrades to local transport systems have received very significant financial support from the European Regional Development Funds for many years. This review has also highlighted the salience of urban land use to accessibility, and the importance of transport in social exclusion. These are potentially other areas in which the EU might in future offer more financial support. The European Social Fund has historically funded *training* for socially excluded individuals to help them find access to employment – it could in future be used to fund initiatives aimed at improving the *accessibility* of socially excluded groups partly in order to improve their employment prospects.

Finally, it is recommended that there should be increased focus on accessibility rather than mobility. By addressing accessibility, mobility issues will be intrinsically addressed. However, improving urban accessibility is likely to generate more economic and social benefits than mobility alone. It is therefore recommended that the focus sustainable urban mobility initiatives should be widened to address the wider issue of accessibility.

3 ESTIMATING EUROPEAN URBAN ROAD CONGESTION COSTS (TASK 2)

Task 2 addressed the estimation of road congestion costs at the European level. More specifically, the objectives of the task were to:

- Analyse the availability of congestion cost estimates;
- Review the methodological approaches used for generating these estimates;
- Develop estimates of urban congestion costs from the literature that are as comparable as possible; and
- Estimate congestion costs at the national level for EU Member States.

The task was therefore not supposed to measure congestion or to develop a methodology to estimate congestion costs on specific spots but to use existing estimates and methods to produce integrated and consistent estimations at the EU level.

3.1 Definition of congestion costs

The estimation of congestion costs required initially a clear definition of such costs. Sometimes cost of congestion is extended to other effects beyond time losses, e.g. additional energy consumption, additional polluting emissions. While we acknowledge that congestion may cause these additional effects, the scope of this study was to estimate only the cost generated by congestion in terms of longer travel time. Other sources of costs were not considered.

From another perspective, there is an increasing interest in considering the performance of the whole transport system serving door-to-door trips rather than just the level of service of roads (used by private cars). While this is desirable, the scope of this study was limited to estimating the cost of road congestion. It should be also considered that measuring congestion costs for the whole transport system requires detailed data on personal movements and supply conditions that are currently not readily available.

Basically two main definitions of congestion cost based on high travel time were considered. An intuitive stylisation of congestion considers vehicles using a link of a given capacity. As the number of vehicles increases the speed deteriorates and all users will experience a delay with respect to free-flow conditions. The monetary value of this delay is a measure of the economic value of congestion. We called this measure a **"Delay cost"**.

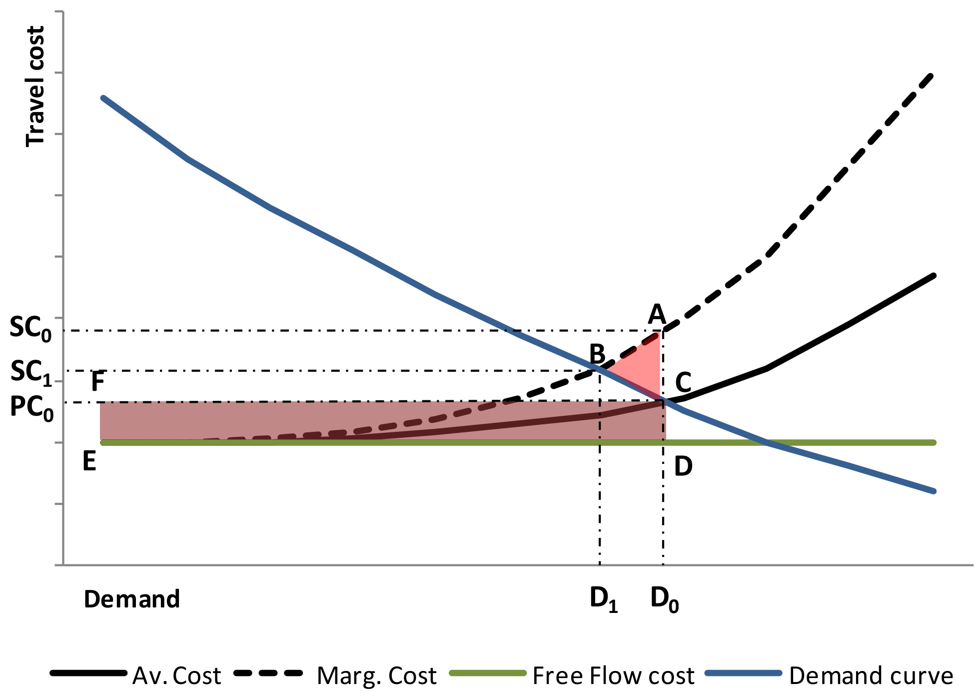
The attractive feature of this measure is that it is based on an objective reference[1], i.e. the free-flow conditions. However, the implicit logic behind delay cost is that congestion cost will be always positive unless everyone can travel in free-flow conditions, which is quite unrealistic especially in urban areas where the capacity required to deliver undisturbed travels could not be provided.

The economic view of congestion, based on the principles of welfare economics, incorporates this aspect. Under the economic approach, it is assumed that the level of demand on links is the result of individual choices based on minimisation of costs. Motorists' choices are based on the perceived average costs. When a new vehicle enters a link, it increases the cost for all the vehicles already using the network. However, the driver of the marginal vehicle neither perceives this additional cost nor pay for its impact on other drivers. Therefore, an external cost arises. According to the welfare economics principle, the cost of congestion is an externality at the extent it exceeds the willingness to pay of road users.

[1] As noted in CREATE (2016), even free flow conditions might be defined in different ways and so are not necessarily an objective term of comparison.

Figure 3-1 below helps to illustrate the concept of external costs of congestion. The level of demand on a given link tends to the equilibrium at the value D_0, where the average cost curve crosses the demand curve. The demand curve shows the willingness to pay of different levels of demand for travelling on the link. However, the social cost SC_0 for the demand level D_0 is larger than the private cost PC_0. Efficient equilibrium is at the level of demand D_1 where the demand curve crosses the marginal cost curve, which includes the extra costs generated by additional vehicles which enter the link. The external costs of congestion are those generated by demand in excess of D_1. The area between the demand curve and the social cost curve (area CBA) is the measure of the external cost of congestion. This measure is often termed as **"Deadweight loss"** and we have used this definition.

Figure 3-1: Different definitions of congestion costs



In principle deadweight loss (i.e. external cost) is more representative of realistic conditions than delay cost (i.e. internal cost) (OECD/ECMT, 2007). However, it should be remembered that using this approach comparisons of costs between different situations is difficult, because the level of congestion that is acceptable varies according to the initial level of demand.

3.2 Definition of a methodology for estimating congestion costs

It was expected that the estimation of congestion costs was based on existing studies. However, a survey of literature revealed that only a very few estimates of urban congestion costs exist. They do not provide any robust ground to generalise the analysis at the European level. Given the purposes of this study an independent estimation was arranged based on available information. Two separate methodologies were used for urban and inter-urban costs.

3.2.1 Urban congestion costs

Urban congestion costs were estimated building on public data published by TomTom[2] and INRIX[3] for a sample of European cities[4]. Namely, indexes reporting the total average percentage increase in travel time with respect to Free Flow conditions as well as other indicators, e.g. the delay with a 30 min commute during peak periods (within a day and/or a year) were used to estimate delay. Then, literature values of value of travel time by country (HEATCO project, 2006) were applied to estimate the delay cost[5]. Furthermore, we have estimated how delay congestion costs would change considering reference conditions other than free-flow (i.e. considering a certain level of capacity occupancy).

For the estimation of deadweight loss a more complex procedure was required. An overview of this procedure is presented in Figure 3-2. This procedure is based on the definition of aggregate demand curves and speed-flow curves to represent the effect of additional vehicles on travel time. In principle this model applies to single links, but we apply the same concept at the level of whole urban areas. We are aware that this generalisation raises methodological issues but at the scale of our study working at link levels would not be feasible.

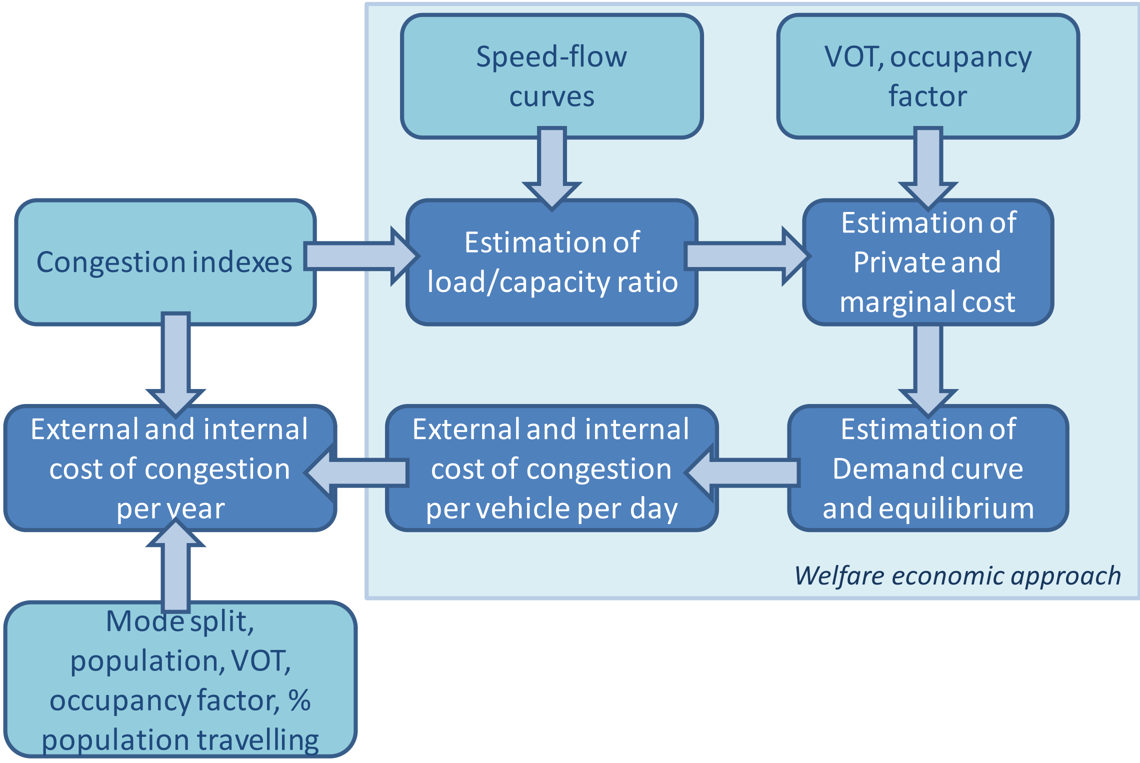
[2] https://www.tomtom.com/it_it/trafficindex/

[3] http://inrix.com/scorecard/

[4] The final sample used for the estimation included 101 cities representing nearly 75 million inhabitants, i.e. some 15% of the whole European population.

[5] The estimation was based on the 2014 edition the data and all calculations were made at 2014 prices. Therefore, also HEATCO Values of Travel time have been deflated to 2014 prices

Figure 3-2: Methodology for the estimation of urban congestion costs



As shown in Figure 3-2, the methodology took into account car mode share and occupancy factors. As mentioned in CREATE (2016), congestion cannot be reasonably compared between different cities if these factors are not considered, because the number of individuals involved in delay of an average car can differ significantly.

Estimated urban congestion costs related to passenger cars for several European cities have been used for a statistical analysis aimed at identifying correlations between the size of congestion cost and some known features of the cities such as size, or mode split of trips. However, the statistical analysis has suggested that congestion is mainly dependent on local conditions, i.e. on elements that cannot be readily recognised using simple indicators like the mode shares or the population size. The only minor correlation found was between deadweight loss per capita and population of the cities by classes: the higher the population size the lower the average congestion cost per capita. As mentioned above, deadweight loss costs depend on initial conditions (see the discussion in the Task 2 report for more details). In larger cities inhabitants are more familiar with congestion and this might be explain a lower willingness to pay for its reduction. In terms of delay cost per capita, simple average[6] was estimated to generalise congestion cost estimations to the whole universe of cities.

Using these results, the costs estimated on the sample of cities have been applied country by country to all cities with at least 50,000 inhabitants. A simplified approach was adopted to generalise urban congestion costs also to cities below the threshold of 50,000 inhabitants. The simplified approach consisted in estimating the number of additional urban areas to consider in each NUTS3 zone according to two elements: the total population in the NUTS3 zone compared to the population in the cities with more than

[6] The average value is 432 Euro/individual. The deviation standard of the distribution – which is broadly symmetrical – is 156 Euro/individual. 60% of the individual values lie in the interval 300 – 550 Euro/individual

50,000 inhabitants located in the same zone and, the typology of NUTS3 according of the classification urban / mixed / rural.

At urban level, congestion costs were estimated for passenger cars only as available information does not allow to provide a reliable estimation of congestion costs for other type of traffic (e.g. freight vehicles or public transport users).

3.2.2 Inter-urban congestion

At inter-urban level, congestion costs were estimated for both passenger cars and trucks (the methodology applied allowed to quantify costs for road freight traffic as well). The estimation covered delays occurring on the main European network, i.e. the TEN-T Comprehensive network (motorways, primary roads) as well as other roads of regional and sub-regional interest. Again, the estimations referred only to time losses and do not include other costs.

The available information consisted of the localisation of congested spots on the European road network and of the amount of delay on each spot. Building on this information, the methodology applied for the estimation of costs included two main steps. In the first step the amount of passenger and freight vehicles-km in congested spots was quantified. In the second step, unitary costs (Euro/vehicle-km) provided by CE Delft and others (2011) as well as passenger and freight country-based Values of travel Time for long distance trip (HEATCO project, 2006) were used for the estimation of deadweight loss and, respectively, delay costs.

The quantification of traffic experiencing congestion on inter-urban roads was carried out using two main sources. One source was a map of the congested spots on the European inter-urban road network provided by JRC-IPTS. This map identified spots where road traffic is delayed in the most congested peak hour because of traffic and, for each spot, provided the amount of delay (in terms of additional time per km). The map was helpful in identifying where congestion occurs and the range of its severity. The quantification of the amount of demand involved in congestion was estimated by means of parameters used in the TRUST model[7].

Using the range of delay reported on the map of the congested spots and the speed-flow function associated to the links in the model it was possible to estimate the level of road occupancy in peak time. Then using daily traffic profiles the load in each hour was estimated for both passenger cars and trucks.

3.3 Results of the estimation of congestion costs

3.3.1 Urban congestion

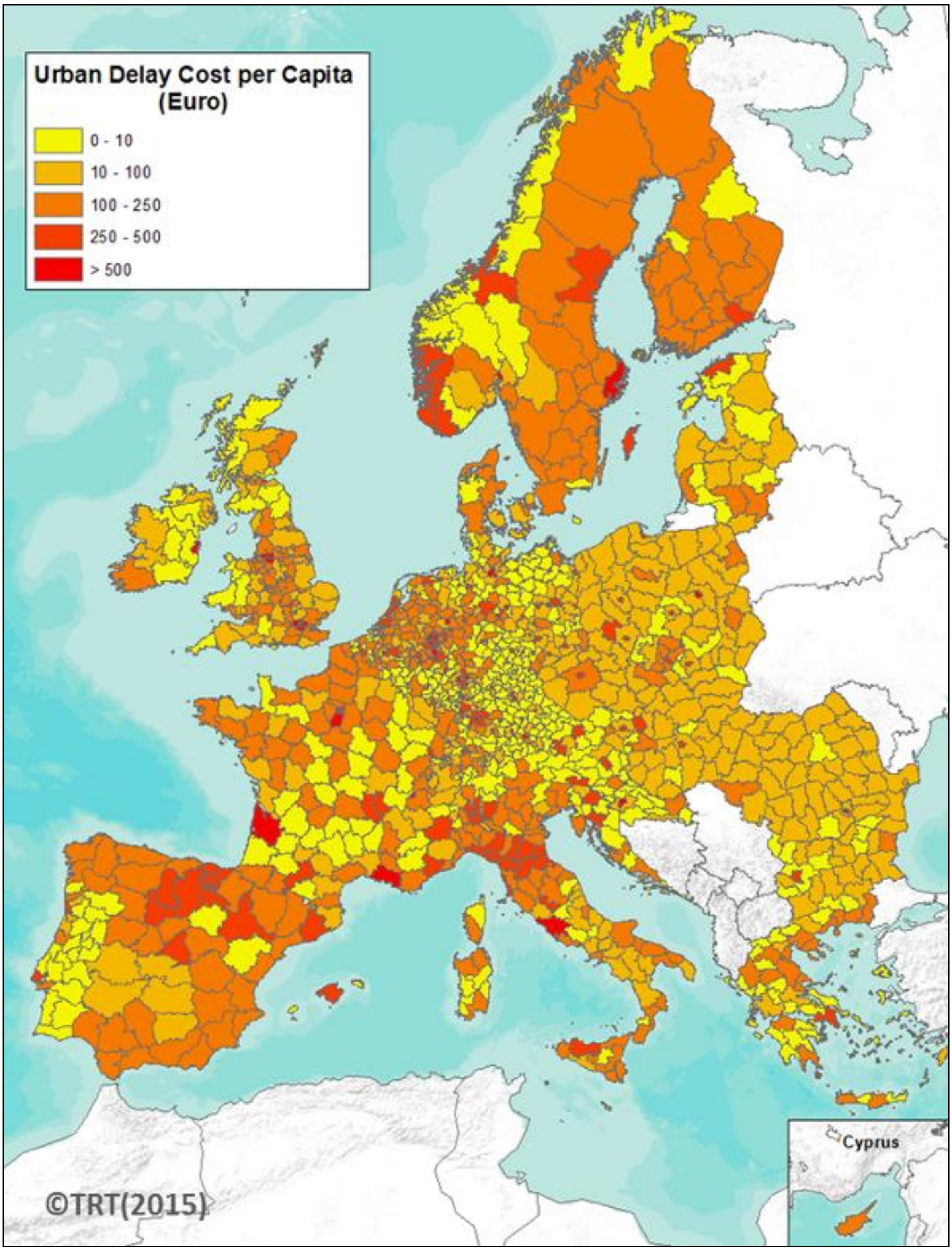
Using the methodology described we estimated that urban congestion costs related to passenger cars account for more than 110 billion Euros/year in terms of delay cost and about 10.9 billion Euros/year in terms of deadweight loss at European level (EU28). These two figures are equivalent to about 0.8% and, respectively, 0.1% of GDP. These estimates are sensitive to different assumptions regarding some parameters and some input data used for the estimations. Namely, if demand is assumed to be more elastic and if steeper speed-flow curves are used, deadweight loss (external cost) could be significantly higher, up to twice the reference estimate. At the same time, if average delays proposed by INRIX are used instead of TomTom data, delay congestion costs would be lower.

[7] TRUST is a transport network model covering the whole Europe developed by TRT

In absolute terms, bigger countries explain the largest part of this cost, while in terms of cost per unit of GDP Eastern European countries are above the EU average (see

Table 3-1). Given the methodology applied, an estimation is available for each NUTS3 zone. The cost per capita is different zone by zone (see **Figure 3-3**) depending on the level of congestion, but also on the population of the area and its distribution between urban and rural areas.

Figure 3-3: Yearly urban delay cost per capita by NUTS3 region in 2014



Source: TRT estimation

Table 3-1: Yearly urban congestion cost by country

Country	Yearly urban delay cost (million Euro/year)	Urban delay cost: share of GDP (%)	Yearly urban deadweight loss (million Euro/year)	Urban deadweight loss: share of GDP (%)
Austria	1,179	0.39%	125	0.04%
Belgium	2,208	0.60%	220	0.06%
Bulgaria	697	1.81%	71	0.18%
Croatia	766	1.73%	79	0.18%
Cyprus	143	0.80%	15	0.08%
Czech Republic	1,387	0.89%	149	0.10%
Denmark	865	0.37%	91	0.04%
Estonia	181	1.12%	19	0.12%
Finland	932	0.49%	104	0.05%
France	14,210	0.71%	1,447	0.07%
Germany	18,400	0.71%	2,045	0.08%
Greece	2,547	1.22%	253	0.12%
Hungary	1,098	1.11%	81	0.08%
Ireland	1,281	0.79%	107	0.07%
Italy	14,921	0.95%	1,444	0.09%
Latvia	291	1.44%	30	0.15%
Lithuania	340	1.10%	35	0.11%
Luxembourg	109	0.25%	10	0.02%
Malta	33	0.50%	3	0.05%
Netherlands	3,391	0.57%	362	0.06%
Norway	1,375	0.51%	136	0.05%

Poland	4,457	1.20%	455	0.12%
Portugal	1,703	1.00%	171	0.10%
Romania	1,837	1.40%	157	0.12%
Slovakia	404	0.59%	39	0.06%
Slovenia	220	0.61%	23	0.06%
Spain	10,049	0.96%	1,092	0.10%
Sweden	2,610	0.68%	274	0.07%
Switzerland	1,108	0.23%	107	0.02%
United Kingdom	23,862	0.71%	2,071	0.06%
EU28	110,120	0.77%	10,972	0.08%

Source: TRT estimation

3.3.2 Inter-urban congestion

As far as delay cost is concerned, our estimation was that inter-urban congestion costs related to passenger cars account for about 31, billion euro/year, i.e. about 0.2% of GDP at European level (EU28). If cost per unit of GDP is considered the top values were found in Poland (0.52% of GDP), Belgium (0.48%) and Bulgaria (0.45%) whereas for a large country like Germany the estimated cost was 0.10% of GDP. There are not large differences between Eastern and Western European countries. In the former group cost ranges from 0.07% of Croatia to 0.52% of Poland, while in the latter group the range is from 0.08% of Sweden to 0.48% of Belgium.

Table 3-2: Estimated road passenger inter-urban congestion cost in EU by country (million Euros/year)

Country	Inter-urban delay congestion cost	Delay costs % share of GDP	Inter-urban deadweight loss	Deadweight loss % share of GDP
Austria	350	0.12%	56	0.02%
Belgium	1,777	0.48%	284	0.08%
Bulgaria	174	0.45%	28	0.07%
Croatia	32	0.07%	5	0.01%
Cyprus	n.a.		n.a.	
Czech Republic	284	0.18%	45	0.03%
Denmark	462	0.20%	74	0.03%

Estonia	15	0.09%	2	0.01%
Finland	154	0.08%	25	0.01%
France	7,084	0.35%	1,133	0.06%
Germany	2,504	0.10%	401	0.02%
Greece	270	0.13%	43	0.02%
Hungary	156	0.16%	25	0.03%
Ireland	367	0.23%	59	0.04%
Italy	4,379	0.28%	701	0.04%
Latvia	27	0.13%	4	0.02%
Lithuania	61	0.20%	10	0.03%
Luxembourg	81	0.19%	13	0.03%
Malta	n.a.		n.a.	
Netherlands	1,545	0.26%	247	0.04%
Norway	98	0.04%	16	0.01%
Poland	1,945	0.52%	311	0.08%
Portugal	633	0.37%	101	0.06%
Romania	350	0.27%	56	0.04%
Slovakia	158	0.23%	25	0.04%
Slovenia	42	0.12%	7	0.02%
Spain	2,450	0.23%	392	0.04%
Sweden	315	0.08%	50	0.01%
Switzerland	597	0.13%	95	0.02%
United Kingdom	4,239	0.13%	678	0.02%
EU28	30,957	0.22%	4,953	0.03%

Source: TRT estimation

With reference to freight road transport, inter-urban delay cost were estimated as much as 2.4 billion euro/year at European level (EU28), i.e. less than 0.02% of GDP, while deadweight loss was about 385 million euro.

3.3.3 Total passenger congestion costs

At the European level (EU28), the total estimated delay congestion cost for passenger accounts to nearly 140 billion euro/year while estimated deadweight loss amounts to some 15,7 billion euro/year. The value of delay cost corresponds to about 1% of EU GDP. This is a not negligible cost for European drivers even though one should always keep in mind that it is an estimation of the monetary equivalent of additional travel time rather than a financial cost actually borne by individuals.

Table 3-3: Yearly total delay congestion cost per country (passengers)

Country	Yearly total congestion cost (million Euro/year)	Share of GDP (%)	Yearly inter-urban delay cost (million Euro/year)	Yearly urban delay cost (million Euro/year)
Austria	1,529	0.51%	350	1,179
Belgium	3,985	1.08%	1777	2,208
Bulgaria	871	2.26%	174	697
Croatia	798	1.80%	32	766
Cyprus	143	0.80%	n.a.	143
Czech Republic	1,671	1.07%	284	1,387
Denmark	1,327	0.57%	462	865
Estonia	196	1.21%	15	181
Finland	1,086	0.58%	154	932
France	21,294	1.06%	7084	14,210
Germany	20,904	0.80%	2504	18,400
Greece	2,817	1.35%	270	2,547
Hungary	1,254	1.27%	156	1,098
Ireland	1,648	1.01%	367	1,281
Italy	19,300	1.22%	4379	14,921
Latvia	318	1.58%	27	291
Lithuania	401	1.30%	61	340

Luxembourg	190	0.44%	81	109
Malta	33	0.50%	n.a.	33
Netherlands	4,936	0.83%	1545	3,391
Norway	1,473	0.55%	98	1,375
Poland	6,402	1.73%	1945	4,457
Portugal	2,336	1.37%	633	1,703
Romania	2,187	1.66%	350	1,837
Slovakia	562	0.81%	158	404
Slovenia	262	0.72%	42	220
Spain	12,499	1.20%	2450	10,049
Sweden	2,925	0.76%	315	2,610
Switzerland	1,705	0.36%	597	1,108
United Kingdom	28,101	0.83%	4239	23,862
EU28	139,974,	0.98%	29,854,	110,120,

** only urban cost for Cyprus and Malta*

Source: TRT estimation

The order of magnitude of our estimates compares well with other studies providing figures for European wide cost of road congestion such as CE Delft et al. (2011) and the JRC study (Christidis and Ibáñez, 2012).

Table 3-4: Yearly total deadweight loss (external congestion cost) per country (passengers)

Country	Yearly total deadweight loss (million Euro/year)	Share of GDP (%)	Yearly inter-urban deadweight loss (million Euro/year)	Yearly urban deadweight loss (million Euro/year)
Austria	181	0.06%	56	125
Belgium	504	0.14%	284	220
Bulgaria	99	0.26%	28	71
Croatia	84	0.19%	5	79

Cyprus	15	0.08%	n.a.	15
Czech Republic	194	0.12%	45	149
Denmark	165	0.07%	74	91
Estonia	21	0.13%	2	19
Finland	129	0.07%	25	104
France	2,580	0.13%	1133	1,447
Germany	2,446	0.09%	401	2,045
Greece	296	0.14%	43	253
Hungary	106	0.11%	25	81
Ireland	166	0.10%	59	107
Italy	2,145	0.14%	701	1,444
Latvia	34	0.17%	4	30
Lithuania	45	0.15%	10	35
Luxembourg	23	0.05%	13	10
Malta	3	0.05%	n.a.	3
Netherlands	609	0.10%	247	362
Norway	152	0.06%	16	136
Poland	766	0.21%	311	455
Portugal	272	0.16%	101	171
Romania	213	0.16%	56	157
Slovakia	64	0.09%	25	39
Slovenia	30	0.08%	7	23
Spain	1,484	0.14%	392	1,092
Sweden	324	0.08%	50	274
Switzerland	202	0.04%	95	107

United Kingdom	2,749	0.08%	678	2,071
EU28	15,747	0.11%	4,775	10,972

** only urban cost for Cyprus and Malta*

Source: TRT estimation

Of course, the absolute value of congestion cost is higher in larger Western countries (e.g. United Kingdom, France, Germany and Italy). However, when analysed as percentage of GDP, Eastern countries are more often above the EU average, with Bulgaria at the top of the ranking (more than 2% of GDP) and also Poland and Romania above 1.5%of GDP. On the other end of the ranking there are countries like Austria and Luxembourg where passengers delay cost is estimated to half percentage point of GDP or even less. This does not necessarily mean that in these countries congestion is very limited: at least in part the result depends on the high GDP level.

3.4 Key conclusions

Making reference to impact of congestion on time losses (therefore not considering other costs such as additional fuel consumption or additional environmental externalities) we identified two different definitions of congestion cost based on alternative interpretations of impacts that traffic generates: delay cost and deadweight loss.

Delay cost and deadweight loss provide two alternative measures of congestion costs. Using one or another of the two estimations is a matter of perspective. If one wants to answer the questions "what is the cost of road congestion?" we think that the most useful reference is to the delay costs. However, if one wants to compare the costs of policy interventions aimed at alleviating congestion (e.g. infrastructure investments) with the potential benefit achievable, deadweight loss is a more meaningful measure because it takes into account of willingness to pay of individuals.

Using a range of available information and tools, in Task 2 we developed a methodology to provide a quantification of congestion costs under both definitions. Results are related to congestion experienced by passenger cars at both urban and inter-urban level, while for the freight case only the inter-urban dimension has been considered due to lack of data.

We have demonstrated via the use of sensitivity analysis[8] that different assumptions on key parameters can lead to significantly different values at least for urban congestion cost measured in terms of deadweight loss. However, even considering these sources of uncertainty, the order of magnitude of the estimates is basically confirmed. Measured in terms of delay cost, the monetary value of congestion in EU is slightly more than 140 billion Euro per year, equivalent to some 1% of the GDP in the same area. Deadweight loss amounts to some 10% - 15% of this figure. In the theoretical analysis we underlined that this is a monetary equivalent of time wasted rather than an actual expenditure.

Congestion affects all European countries with some differences. In absolute terms congestion costs are higher in larger countries in Western Europe, but if compared to GDP most Eastern Europe countries suffer for higher costs. A large proportion of these costs depend on urban congestion, which explains on average some 80% of total costs (but more in many Eastern Europe countries). Inter-urban costs are more relevant especially

[8] Assessing the outcomes of congestion cost calculations and their sensitivity to the input parameters.

in rich countries in the middle of Europe where probably the inhabitants of cities can use more efficient urban transport systems.

Our analysis has not unveiled any significant correlation between the estimated urban congestion cost (delay cost and deadweight loss) and simple variables representing the features of the cities (e.g. population size, car mode share, public transport mode share)[9]. Congestion costs at urban level seems strictly related to local conditions of each specific city.

The methodology used for the estimation makes use of real traffic data in various forms. As the availability of this data is expected to grow in the future, the methodology could be replicated and refined (e.g. with larger sets of delay data) to update the estimates and monitor the trend of congestion costs over time.

[9] The lack of apparent correlation between congestion cost and observed market share of car and public transport does not imply that measuring modal shares is useless or that the objective of shifting demand to sustainable modes is meaningless. In a given urban area it is quite likely that shifting demand from car to other modes can reduce congestion. Our analysis just revealed that other local conditions matter so that comparing mode shares between two cities is insufficient to deduct where congestion costs are higher.

4 Relative efficiency of urban passenger transport modes (Task 3)

4.1 Introduction

The Task 3 report assessed the relative performance of different urban transport modes under a range of operating conditions. The data is intended to aid cities in understanding the performance of different modes in their local situation, with the aim of supporting improved functioning of urban areas and better urban accessibility.

In the context of this study the performance of urban transport modes was assessed in relation to:

- *Capacity* – defined in terms of passengers per vehicle and passengers per hour in relation to the capacity of the infrastructure
- *Energy use* – defined in terms of MJ per passenger km
- *CO2 emissions* – defined in terms of CO2 per passenger km
- *Cost* – defined in terms of Euros per passenger km.

The above metrics were assessed for a range of private modes (car and motorcycle) and public transport modes (bus and rail). The transport modes were further divided into sub-modes (for example, bus was divided into midi bus, large bus and bus rapid transit (BRT)) to account for the range of vehicles in operation across Europe and to add value to the final results. For the road categories, a range of fuel technologies were also considered; these covered petrol, diesel, compressed natural gas (CNG), liquid petroleum gas (LPG), petrol-electric hybrid and battery electric. The full list of transport modes and fuels that were assessed is shown in Table 4-1. In addition, some commentary is provided on active modes such as walking and cycling to put these in context with the motorised modes which are the focus of the assessment.

Table 4-1: Urban transport modes and fuels assessed in the study

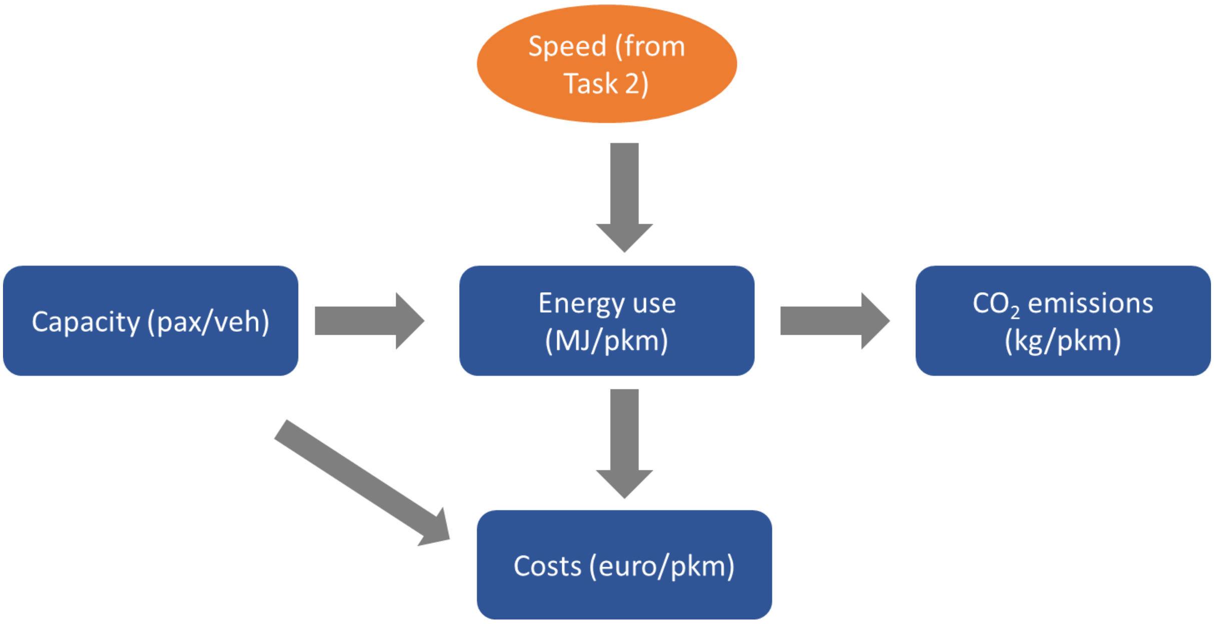
Main mode	Sub modes	Fuels
Passenger Car		Petrol Diesel Gas (CNG and LPG) Hybrid Electric (petrol only) Battery Electric
Motorcycle	Moped Motorcycle	Petrol
Bus	Midi Large Bus rapid transit	Diesel Gas (CNG) Hybrid electric (diesel) Battery electric
Rail	Tram/light rail	Electric

	Metro Heavy rail	Diesel (heavy rail only)

In addition, each of the metrics was assessed for different 'real world' conditions. Two types of urban area were considered (metropolitan areas and medium cities), and results were calculated for peak (or congested) traffic and off-peak (or uncongested) traffic conditions in each area. These differing operating conditions will affect a range of factors that influence the operating performance of different transport modes such as service frequency, occupancy load factors and vehicle speeds.

There is a clear relationship between the performance metrics assessed in this task, as illustrated in Figure 4-1 below. In addition, there is a link with the congestion assessment carried out in Task 2 of this study, which provided input into the average traffic speeds in peak and off-peak times for the two different city types. Further information concerning the data sources, literature and methodologies used in order to derive the performance metrics can be found in the Task 3 report.

Figure 4-1: Relationship between the performance metrics



An overview of the results for each of the metrics (capacity, energy use, CO_2 emissions and cost) is presented in the next sections, followed by the main conclusions from this task.

For more detailed information and data, please refer to the Task 3 report. In particular, the detailed data provided in the annexes of the report is intended to be an information resource that can be used by cities to assess the performance of transport modes relevant to their local conditions.

4.2 Capacity

The capacity of transport modes can have different meanings and be affected by a variety of factors. For private transport, capacity is usually considered in terms of road capacity (although vehicles also have a capacity), while for road public transport, vehicle size and frequency of service are much more relevant than the physical capacity of infrastructure.

This difference was considered in the data analysis and therefore average figures were estimated for both the **'theoretical' capacity** and the **'actual' capacity** of each transport mode. The theoretical capacity is mainly based on the physical characteristics of infrastructure, while the values for actual capacity are representative of the performance of the transport modes in EU urban contexts.

Although a common definition of capacity is identified as the number of passengers which are transported in a unit of time by the different modes of transport, different factors can influence this measure, as shown in Table 4-2.

Table 4-2: Elements affecting capacity of different urban transport modes

Transport mode	Theoretical capacity				Actual capacity		
	Vehicle capacity (pass./ vehicle)	Road infr. capacity (vehicles/ hour)	Passenger Car Unit (PCU) factor (PCUs/ vehicle)	Theoretical Frequency of service (vehicles/ hour)	Occupancy rate (%)	Demand profile impact	Frequency of service (vehicles/ hour)
Private car	✓	✓			✓	✓	
Motorbike	✓	✓	✓		✓	✓	
Bus/ Trolleybus	✓			✓	✓		✓
Tram/ Metro/ LTR/ Heavy Rail	✓			✓	✓		✓

The estimation of theoretical and actual capacity was based on a review of both literature and real-world conditions, although the latter are not the same in all cities and countries (e.g. occupancy rates or frequency of services). Nevertheless, some of the relevant elements required to estimate capacity are not site-dependent, e.g. the capacity of a representative urban road, of an average bus, or of a typical metro system is relatively similar across the European Union's urban areas.

In terms of **theoretical capacity**, metro services provide the highest capacity in metropolitan areas as well as in medium cities (followed by heavy rail, which also plays a significant role). Cars and motorcycles provide higher values of theoretical capacity in comparison to buses. This may appear to be surprising, however these values are explained when considering that a full utilisation of vehicle capacity is assumed (i.e. five passengers for cars and two passengers for motorcycle) and that even the theoretical bus capacity is constrained by the frequency of service.

Among public transport modes, BRT and large bus services provide better performance than midi buses in terms of theoretical capacity. Tram/light rail services are comparable to BRT in medium cities, while in metropolitan areas it is assumed that larger tram/light rail vehicles are used and therefore the theoretical capacity is higher than for the other modes.

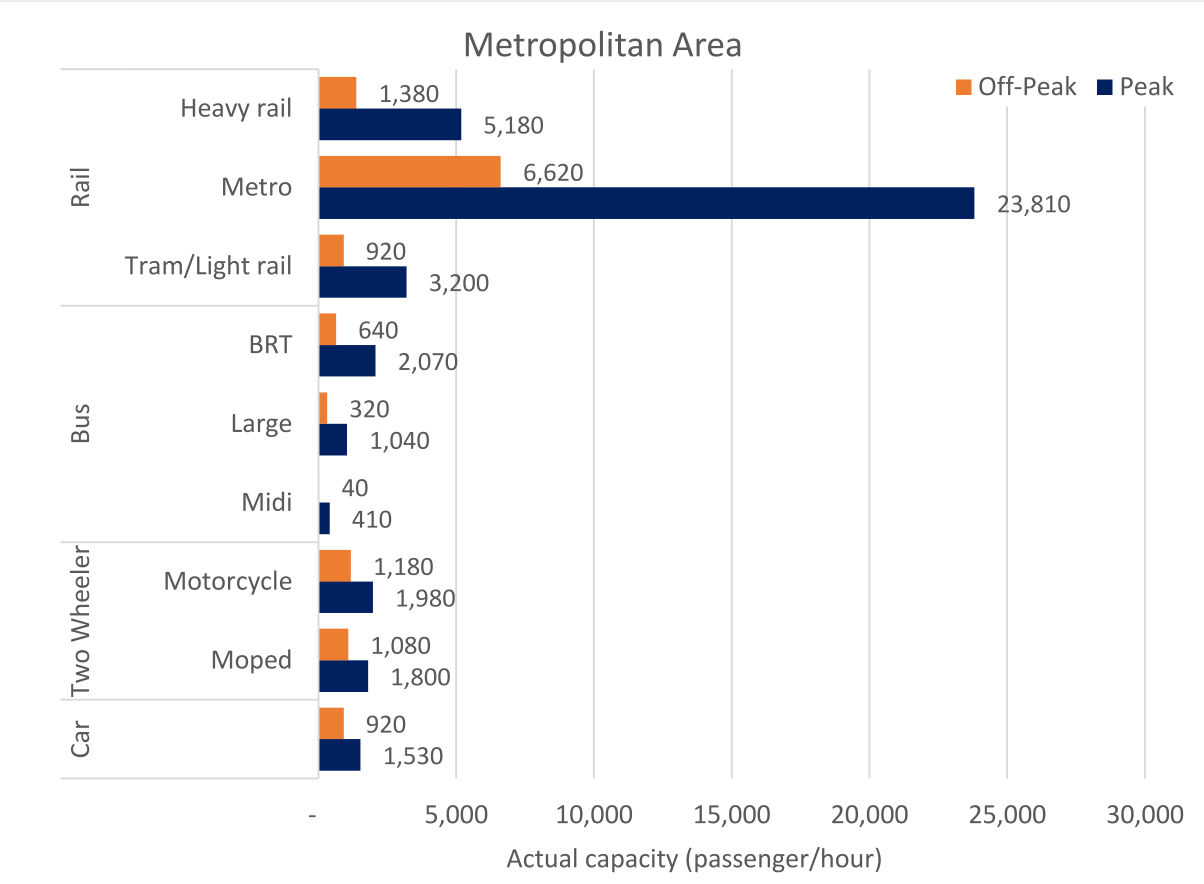
If average capacity under "**common, real-world conditions**" is considered rather than the theoretical capacity, the results show a different picture. In particular, the time of day considered makes a significant difference. During peak periods public transport modes generally provide higher capacity than private modes, while during off-peak periods the opposite is expected.

In metropolitan areas (Figure 4-2), metro services provide the greatest capacity during both peak and off-peak periods. During peak periods, heavy rail and tram/light rail provide higher capacity values compared to bus. The capacity of cars and moped/motorcycle is below that of heavier public transport modes but higher than bus capacity.

During off-peak periods, private road modes provide better or at least similar performance in comparison to most public transport services. For cars, mopeds and motorcycles values are estimated in a range of 900 to 1,100 passengers per hour - the same as tram/light rail. Only heavy rail (and metro) has a higher capacity of about 1,400 passengers per hour.

The actual capacity of bus public transport services in real-world conditions is strongly affected by low frequencies and low occupancy factors. For BRT and large bus service values are estimated as 600 and 300 passenger per hour respectively, while for midi buses it is less than 50 passenger per hour. Of course these actual conditions are average values and might not reflect specific circumstances in every city.

Figure 4-2: Actual capacity (passenger/hour) in a metropolitan area



Source: TRT estimation

In medium cities the estimated actual capacity is lower than in metropolitan areas for public transport modes (because of lower frequencies) while for private modes the capacity is the same or even slightly higher (for motorcycles) because of lower congestion. The comparison by mode shows very similar conclusions to those observed for metropolitan areas.

The capacity of active modes is not necessarily directly comparable with the vehicle modes set out above. The capacity of walking as an urban transport mode is very dependent on the pedestrian area and its use, and so no direct comparison is given here. For cycling a simple assumption can be made that the capacity for cycling on a typical road is similar to a moped as they are both single person two-wheeled vehicles.

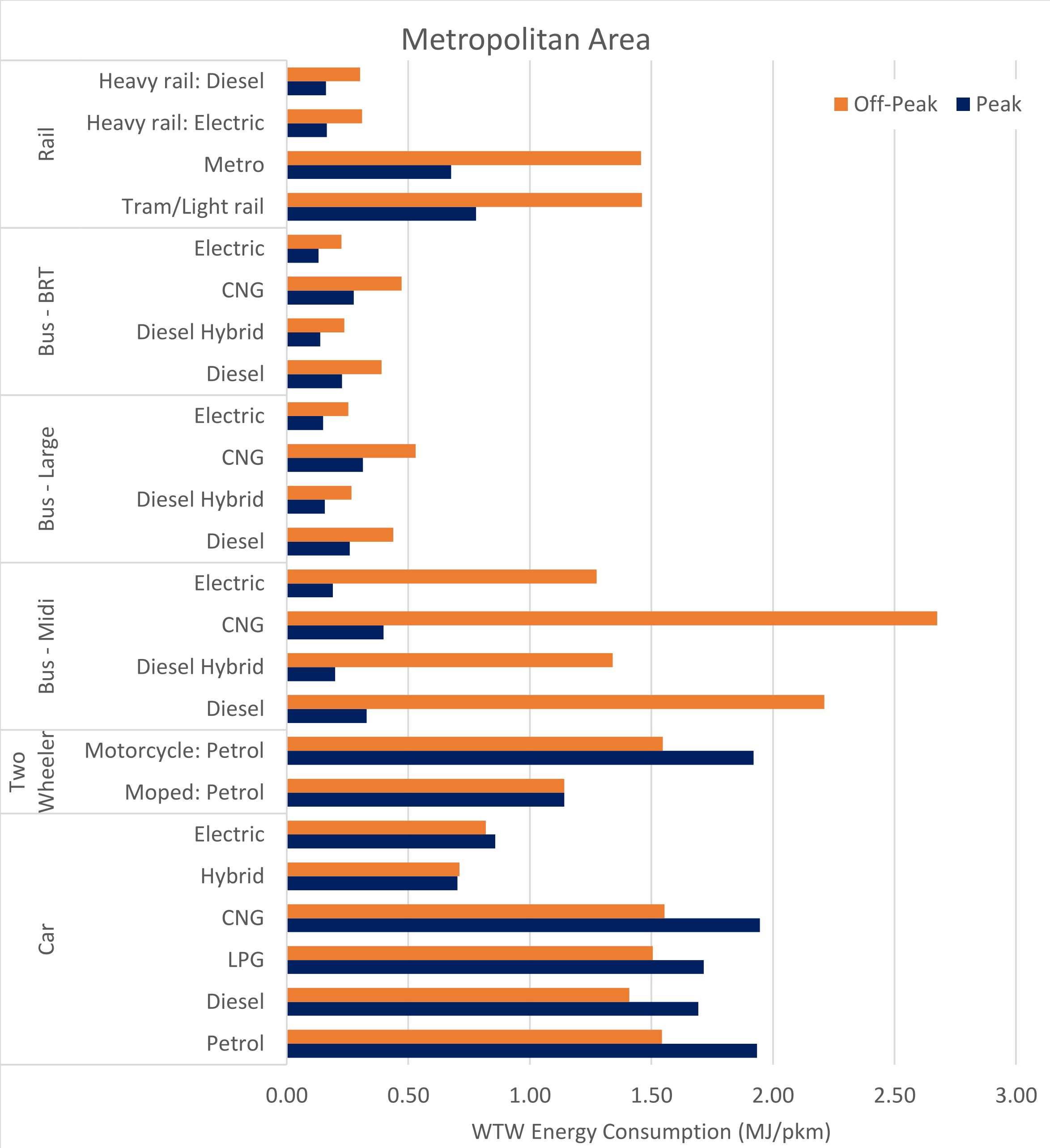
4.3 Energy use and CO_2 emissions

Energy consumption and CO_2 emissions are two closely related metrics that can be used to assess the **environmental performance** of urban transport options. The metrics calculated in this task are representative of the average environmental performance of transport systems across the EU. By presenting the results in terms of megajoules per passenger kilometre (MJ/pkm), the figures can be used to develop comparisons between different modes of transport, which may be useful to a broad range of audiences.

Data concerning the **average energy consumption** for each transport mode (in terms of MJ per vehicle km) was first collected. Using the vehicle capacity and occupancy factors derived in Subtask 3.1 of this project, average energy consumption figures were then calculated in terms of MJ/pkm depending on the type of urban area (metropolitan area or medium city) and the time of the journey (peak or off-peak).

The results for metropolitan areas (Figure 4-3) show that the energy consumption of private transport modes (passenger cars, mopeds and motorbikes) is mainly dependent on the fuel type and the speed travelled (i.e. whether travel occurs at peak or off-peak time). Vehicle occupancy factors for private transport modes are considered to be the same at both peak and off-peak times and therefore do not have an impact on the results. For passenger cars the average energy consumption of petrol, diesel, LPG and CNG fuelled passenger cars is relatively similar, while for hybrids and electric vehicles energy use is substantially lower (on average, less than half the energy use).

Figure 4-3: Average WTW energy consumption (MJ/pkm) in a metropolitan area



Source: Ricardo Energy & Environment calculations

Similarly to private transport modes, the results for public transport (buses and trains) are also dependent on the vehicle fuel type. However, compared to private transport modes, the energy consumption per passenger kilometre is more heavily dependent on the time of travel (whether the journey occurs at peak or off-peak time). This is mainly due to significant differences in occupancy factors at peak and off-peak times (for private transport modes, occupancy is estimated to be constant regardless of journey time). The average speed travelled also has a very minor effect for buses due to the slight difference in speed at peak and at off-peak time. As noted in the methodology, the calculation of energy usage for trains did not consider the speed travelled, therefore energy consumption per pkm is only dependent on fuel type and occupancy factor.

At peak times, energy consumption for public transport modes is generally significantly lower than at off-peak time and the most efficient modes are seen to be large and BRT buses (0.13 – 0.31 MJ/pkm, depending on fuel type) and heavy rail (0.16 MJ/pkm for both diesel and electric). On the other hand, the least efficient modes are tram/light rail and metro systems, with energy usage of 0.72 and 0.61 MJ/pkm respectively. Compared to private transport modes, public transport modes are generally significantly more efficient (except if compared to hybrid and electric cars, which have an average energy consumption of 0.70 and 0.86 MJ/pkm).

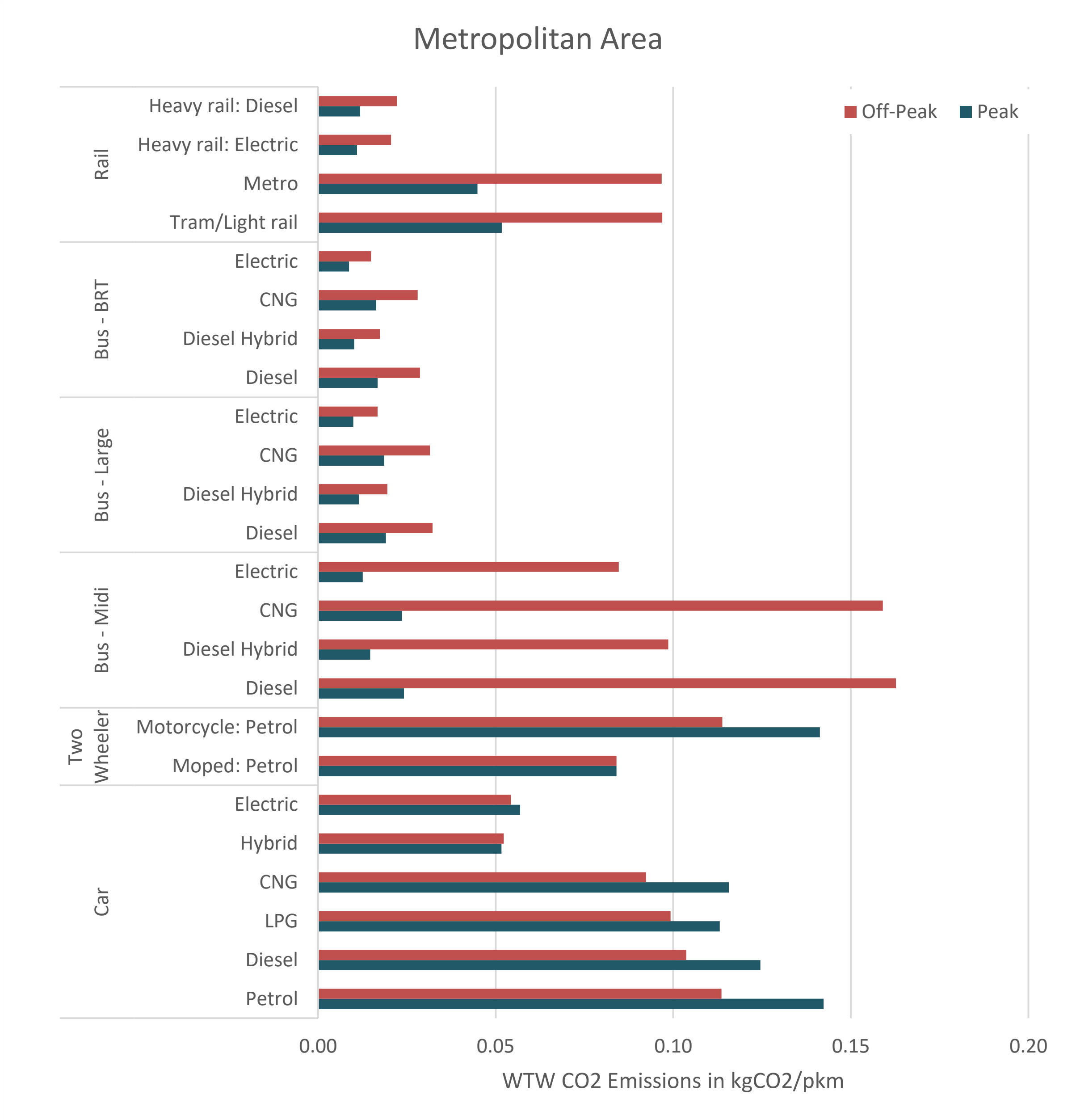
At off-peak times, the most efficient sub-modes for public transport were calculated to be large and BRT buses. These had energy usage values of 0.23-0.53 MJ/pkm, depending on the fuel type. In particular, diesel hybrid and electric buses are the most efficient. Heavy rail was also seen to be one of the more efficient modes during off-peak times. Diesel and electric trains were calculated to have an average energy usage of 0.30-0.31 MJ/pkm. On the other hand the least efficient off-peak mode are diesel and CNG midi buses due to their much lower occupancy factor with average energy use of between 2.21 to 2.89 MJ/pkm.

Overall, the trends seen in medium cities are similar to those observed in metropolitan areas, with only slight differences in average fuel consumption calculated due to the higher average speed of travel in urban areas. This higher average speed represents a less congested urban environment with more free flowing traffic and fewer stopping and starting manoeuvres, which have a detrimental impact on fuel economy.

The **CO_2 emissions** per pkm are derived from the energy use results using CO_2 emissions factors related to both direct emissions (from combustion of the fuel) and indirect emissions from production of the fuel. This provides CO_2 emissions results on a well to wheel (WTW) basis. The overall trends seen for the average WTW CO_2 emissions are actually very similar to that shown for energy consumption as seen in Figure 4-4. Any differences in the CO_2 intensity of the various fuels is largely masked by bigger differences caused by vehicle type and occupancy levels.

In relation to active modes, walking and cycling are generally assumed to have zero energy use and CO_2 emissions, however, this is not strictly true as individuals who walk and cycle compared to a motorised transport user have been found to have higher dietary intakes. This can be translated into an energy value and a related CO_2 value for this additional food production. The results are significantly lower than for motorised modes as might be expected with walking being estimated to consume an additional 0.11 MJ/km and emit 0.035kg CO_2/km, cycling estimated to consume 0.05 MJ/km and emit 0.016kg CO_2 /km.

Figure 4-4: Average WTW CO_2 emissions (kg/pkm) in a metropolitan area



Source: Ricardo Energy & Environment calculations

4.4 Cost

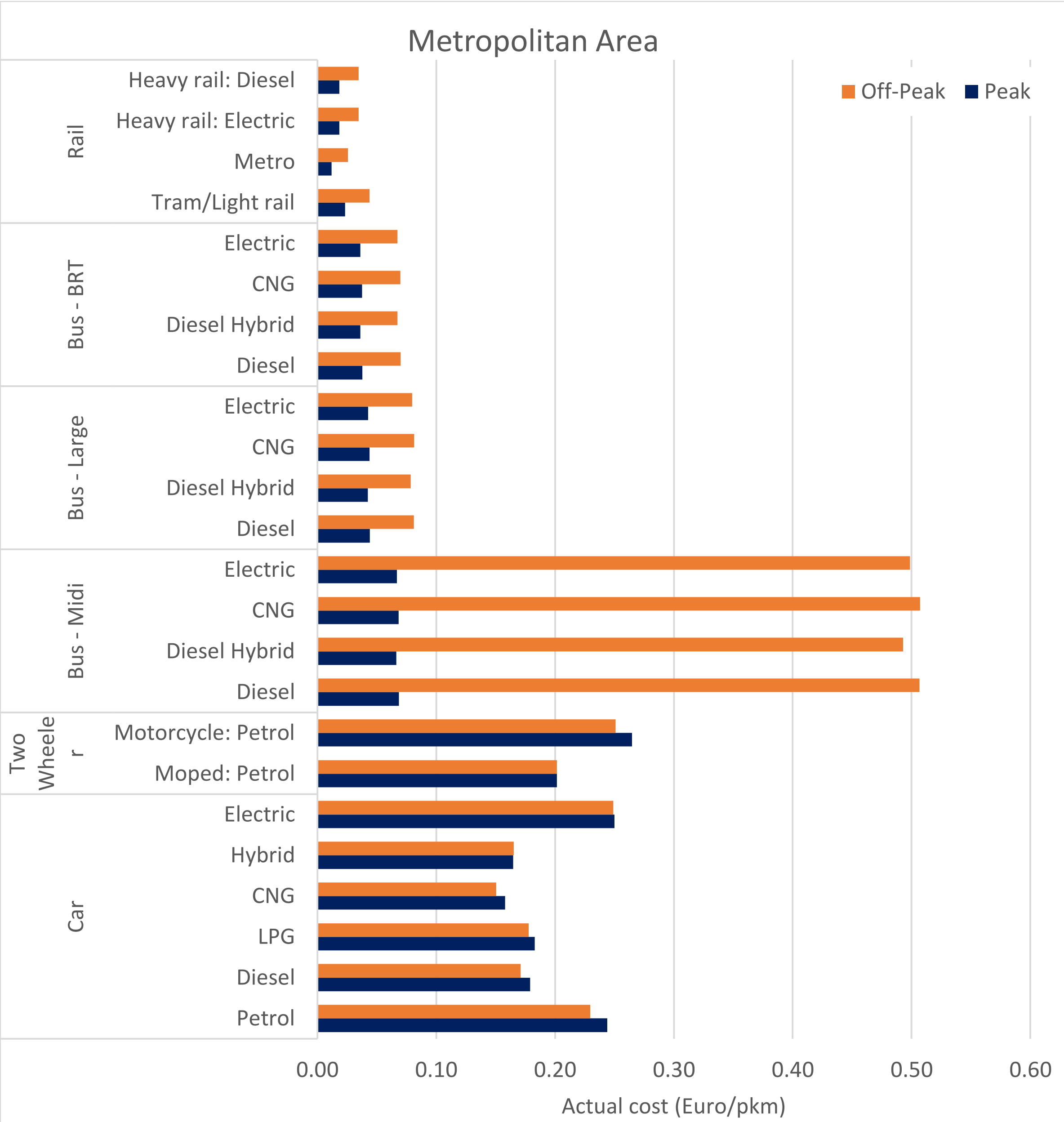
The cost of transport can be considered from two main perspectives. One is the perspective of users (which only includes the costs that are incurred by individuals) and the other is the overall operating cost, which includes factors such as the cost to run public transport services. To undertake a fair comparison with private transport a societal point of view has been adopted and the full operating costs, excluding infrastructure such as roads, of both private and public transport have been estimated. Externality costs have not been considered as the quantification of some of external effects such as CO_2 emissions has been addressed in Section 4.3.

The estimation of urban transport costs is based on a review of both literature and real-word conditions, although often the latter are not the same in all cities and countries (e.g. operating costs of cars or public transport production costs). Therefore, the literature survey considered two different types of sources:

- Technical literature concerning the costs of transport modes
- Information on real world elements related to cost components of urban transport modes.

This allowed the theoretical costs and representative actual (real-world) costs to be estimated for transport systems across the EU.

Figure 4-5: Actual cost (Euro/pkm) in a metropolitan area



Source: TRT estimation

The results of the estimation of **theoretical costs** for metropolitan areas show that the highest average cost per passenger-km is for two-wheelers (0.15-0.20 Euro/pkm). Rail modes show lower values (0.02 Euro/pkm) together with BRT and large buses (0.03 and 0.04 Euro/pkm respectively). The average costs for midi buses and cars show similar values, in a range between 0.06 to 0.08 Euro/pkm. Of course, some differences are observed between cars by fuel type. The most expensive are petrol and electric (the first due to the energy cost, the latter basically due to non-energy cost, e.g. amortisation cost), while hybrid and CNG are the cheapest (about 0.055 Euro/pkm). Similar results are observed for peak and off-peak periods for both metropolitan areas and medium cities.

The **actual costs** in metropolitan areas show a somewhat different picture, especially depending on the time of the day (**Error! Reference source not found.**). During peak p eriods, the average cost of rail modes is the lowest (0.02 Euro/pkm) together with BRT and large buses (both about 0.04 Euro/pkm). Midi buses are slightly more expensive, with 0.07 Euro/pkm, while private road modes (car and two-wheelers) show the highest average cost per passenger-km (0.15 to 0.26 Euro/pkm). Some car fuel types provide better performance but these modes are always more expensive than public transport modes.

During off-peak periods, the average cost of public transport modes increases consistently due to low occupancy rates. This is particularly the case for midi bus services, which become the most expensive mode (0.5 Euro/pkm). The average actual cost of the other public transport modes (rail and bus) is approximately double the peak cost during off-peak hours. As a result, the difference between private modes and public transport services is reduced. Nevertheless, bus and rail are still less expensive than private transport modes.

Similar trends are seen in medium cities, although public transport modes are slightly more expensive. This is mainly due to lower occupancy rates.

For active travel modes the costs are virtually negligible. If we assume no additional costs for the increased food intake, then the costs for walking can be considered zero and those for cycling just the capital cost of the bicycle which is estimated at 0.018 Euro/km over an average lifetime.

4.5 Key conclusions

The performance of different transport modes is dependent on a range of factors including the capacity of the infrastructure and vehicles, occupancy levels and traffic conditions. In addition, the different modes may perform differently depending on which metrics are being considered. Therefore, comparing modes across the four different metrics and different city conditions presents a complex picture.

However, looking across all the results a number of key trends emerge:

- During peak periods the capacity, cost and environmental performance per passenger of public transport is generally better than that of private modes (cars and motorcycles). However, during off peak periods the picture is much more complex.
- Costs are generally lower for public transport than private transport in all conditions, with the exception of midi-buses in off-peak times.
- Overall capacity, including infrastructure, is greatest for rail modes. For road modes, capacities are much more similar for both private and public transport (bus-based) and during off-peak periods the capacity of private modes is often greater given the lower occupancy levels of public transport.

- Energy and CO2 emissions per passenger are generally lower for public transport modes than private modes at peak periods, although metro and light rail systems seem relatively energy intensive. Bus-based modes were calculated to be the most efficient. However, during off peak periods private modes can have lower energy use and emissions per passenger.
- Electric and hybrid cars can have an environmental performance similar to public transport modes, but are more costly than conventional petrol and diesel vehicles. Similarly, hybrid and electric buses have better environmental performance than their diesel or CNG counterparts.

In terms of active modes the energy use, CO_2 emissions and costs are all substantially less than for the motorised modes. The capacity of these modes is not necessarily directly comparable with that of motorised modes, but in essence the capacity of cycling will be similar to mopeds and the capacity of walking will depend on the pedestrian infrastructure. Active modes, especially walking, are also part of an effective multi-modal public transport system.

Overall there is a role for all transport modes in an efficient urban transport system. Public transport should be the primary mode at peak times, with rail modes providing high capacity for key routes. To maximise the environmental performance of public transport systems electric and hybrid systems are favoured. Private modes have a role particularly in off-peak periods when there is insufficient passenger loading to give high occupancy factors on public transport. Again electric and hybrid technologies will improve the environmental performance of private modes, especially during peak periods as they are less affected by slow traffic conditions.

For more detailed information on the data sources, methodologies and final results, please refer to the Task 3 report. In particular, the data provided in the annexes are intended to be an information resource that can be used by cities to assess the performance of transport modes relevant to their local conditions.

5 BEST PRACTICE POLICY EXAMPLES – INCREASING ACCESSIBILITY (TASK 4)

5.1 Introduction

The objective of Task 4 was to identify best practices measures for increasing the accessibility of urban areas for passengers and freight, focused primarily on city level action. The work included two main objectives:

- Identification and classification of the most relevant measures
- Analysis and reporting of best practice measures

5.2 Identification and classification of measures

There are numerous policy measures that have the potential to enhance and increase the accessibility of urban areas. In line with the definition of accessibility in relation to the four dimensions mentioned in Section 2 (the transport component, the land use component, the individual component and the temporal/cost component). Any measure that makes it easier for people or freight to reach opportunities (whether they are referred to as goods, services or destinations) increases the accessibility of an urban area.

The first step in the analysis was to identify a list of factors that have impact on the four dimensions of accessibility. Six main domains covering 14 categories of factors influencing accessibility of urban areas were identified:

- Transport demand (need for transport) – current patterns of transport demand by space and time;
- Transport supply (Road supply, Private transport supply, Public transport supply, Active modes, Shared mobility services, Integration between transport solutions, urban freight logistics infrastructure) – characteristics of the transport system;
- Individual perception of the transport system (transport cost, user information, safety and security (perceived as well as actual));
- Demographic structure (population);
- Territorial policy context (Land use and local economy);
- Geographical and urban context (Territory).

Each of the 14 categories were further subdivided into a list of 67 individual factors affecting accessibility (see Table 5-1).

Table 5-1: List of factors of relevance in determining the level of accessibility of an urban area

Domain	Category	Factors affecting accessibility
Need for transport	**Transport demand**	Need for travel
		Spatial pattern of trips
		Spatial pattern of freight deliveries
		Time pattern of trips
		Time pattern of freight deliveries

		Amount of passengers demand
		Amount of freight demand
Transport supply	**Road supply**	Road availability
		Road quality
		Access restrictions (Time Of Day -TOD, weight, vehicle size or type)
		Parking availability
		Parking payments ease and availability of multiple options
	Private transport supply	Car ownership rate
		Bike availability
		Availability of rechargeable points for electric vehicles (or other alternative fuel infrastructure) - personal cars
		Availability of rechargeable points for electric vehicles (or other alternative fuel infrastructure) - duty vehicles
	Public transport supply	Availability of public transport services (traditional collective passengers transport but also demand-responsive services)
		Accessibility to public transport services (vehicles and stops/terminals)
		Ease of payment of public transport services
		Frequency of public transport services
		Reliability
		Quality of public transport vehicles
		Quality of public transport stops
		Crowding on public transport vehicles
	Active modes	Safety for pedestrian
		Ease of access to pedestrian infrastructure (dropped curbs, way finding, etc.)
		Safety for cyclists
		Security of bikes (protection against thefts, e.g. secure cycle parking)
	Shared mobility services	Bike sharing systems availability (traditional bikes, but also pedelecs, cargo bikes, small bikes)
		Car sharing systems availability (round trip or station based)
	Integration between	Ease of transferring between modes
		Quality of stations / Terminals

	transport solutions	Integrated ticketing
	Urban freight logistics infrastructure	Presence of UCCs (Urban Consolidation Centres)
		Locker boxes or pick up points availability
		Availability of loading/unloading bays
Individual perception of the road transport system	**Transport cost**	Private vehicle cost (fuel, vehicle ownership, insurance, etc.)
		Public transport fares
		Parking fares
		Road charges
	User information	Accessibility to public transport timetables (lines, frequency) and legibility/clarity
		Accessibility to real time traffic information
		Accessibility to real time parking information
		Reliability of information
	Safety & Security (perceived as well as actual)	Security on-board public transport modes
		Security at stations/bus stops
		Security at parking areas
		Security on bike and foot paths
Demographic structure	**Population**	Children, young people, elderly people, reduced mobility people, gender differences
		Propensity to walk
		Propensity to cycle
		Sensitiveness to climate conditions
		Income level
		Digitalization
		Environmental awareness
		Cultural attitude to e-commerce
		Cultural attitude to home-working
Territorial policy context	**Land use and local economy**	Population density
		Availability of relevant opportunities/destinations (jobs, services, etc.)

		Distribution of relevant functions on the territory
		Opening hours of relevant functions
		TOD (Transit Oriented Development)
		City sprawling
Geographic and urban context	**Territory**	Topography
		Climate
		Urban form (historical vs modern)
		Presence of natural or artificial barriers (rivers, lakes, canals, parks, infrastructures, monumental sites, etc.)

Policy measures were analysed to assess their influence on these 67 factors. The list of measures was derived largely from the Urban Transport Road Map 2030 project[10]. For each policy measure, the following key elements were addressed:

1. The factor category and the factor on which there is an impact;
2. Description of the potential impact on accessibility;
3. Description of available evidences (if available from literature)[11]; and
4. Assessment of the overall effectiveness of the measures in improving accessibility (based on evidence and expert judgement).

For each policy measure, the overall effectiveness in terms of accessibility has been evaluated in relation to:

- **Private Modes**: the use of individual cars, vans and motorbikes.
- **Public Transport**: the use of collective passenger transport but also car sharing and van sharing;
- **Active Modes**: walking, the use of individual bikes, and bike sharing options.

Table 5-2 summarizes all the results for all of the policy measures considered. It should be noted that the overall effectiveness is an average of the individual scores for the 67 accessibility factors against each of the measures assessed.

[10] http://urban-transport-roadmaps.eu/

[11] The analysis on these three elements is reported in Appendix 4.

Table 5-2: Measures effects on accessibility and cost considerations

DOMAIN	MEASURES	OVERALL EFFECTIVENESS ON ACCESSIBILITY (+++ to ---, 0 = no impact, n/a = not applicable)			Cost consideration (€ to €€€)
		Public Transport	Private modes	Active modes	
Transport demand management	Area wide and personalised travel planning	++	0	++	€€
	Sustainable travel information and promotion	+	0	+	€
	Shared modes (bike sharing)	++	0	++	€€
	Shared modes (car sharing)	++	+	0	€€
	Delivery and servicing plans	0	+	+	€
Transport Infrastructure	Bus network and facilities	+++	+	++	€€€
	Walking and cycling networks and facilities	+	-	+++	€€
	Park and ride	+++	++	+	€€
	Park and ride	+++	++	+	€€
	Trolley, tram, metro networks and facilities	+++	-/0	++	€€€

	Urban delivery centres and logistics facilities	+	+	+	€€
Transport pricing	Congestion and pollution charging	++	---/--	+++	€€
	Parking regulation and pricing	+/++	--	+/++	€
	Public transport integrated ticketing and tariff schemes	++	-	+	€
Traffic management and control	Legal and regulatory framework of urban freight transport	0	-	+	€
	Prioritising public transport	++	-	0	€€
	Access restrictions and road and parking space reallocation	+++	---	+++	€€
	Traffic calming measures	+	-	+++	€€
Land use planning	Land use planning density and transport infrastructure	++	+	+++	€

5.3 Analysis and reporting of best practice case studies

Considering practical cases, it was difficult to identify cities that have implemented actions with the sole objective of improving accessibility. More commonly, cities implement strategies (packages of measures and actions) to improve urban mobility, addressing a wide range of different issues affecting transport modes (private, public and active). It was also the case that those case studies that were available/selected also presented success stories, rather than enabling the opportunity to identify further improvements or follow-up actions in order to improve their success or accessibility. This was also largely due to the limited availability of strategies that listed accessibility as one of its key objectives.

Therefore, the case studies selected and presented as best practices in achieving good levels of accessibility were cities where strategies implemented were able to improve also accessibility. The best practice case studies were selected primarily from the knowledge developed within the CIVITAS[12] Initiative. They were:

- Porto, Portugal;
- Toulouse, France;
- Dublin, Ireland;
- Gothenburg, Sweden; and
- Donostia/San Sebastian, Spain.

The city of **Porto** was selected as a 'best practice' example as the mobility issues faced by Porto are similar to those encountered by many other European cities, while the solutions developed during the project were effective and are highly transferable to other areas. In particular, the increased availability of real-time public transport information and the development of a late night transport on demand bus service increased the attractiveness of public transport and contributed to improved accessibility.

Toulouse has focused on improving its transport network for many years and has been recognized for its achievements in sustainable urban mobility by the European Commission. This case study demonstrates the benefits of implementing a comprehensive package of measures and building on this strategy over a sustained period of time. The measures implemented in Toulouse cover all transport modes and have improved various aspects of accessibility.

The case study of **Dublin** covers the "dublinbikes" scheme, which is one of the most successful shared bicycle schemes in the world to date. Shared bicycle schemes are applicable to many European cities and can increase accessibility in a number of ways. For example, in Dublin, the scheme and has helped to connect users with public transport (due to the siting of rental stations outside key interchanges) and areas of the city that were previously less accessible without a car.

Gothenburg is a forerunner city in exploring and implementing solutions to improve urban mobility and accessibility. The city is the winner of the Access City Award 2014, the annual competition organized by the European Commission to award European cities that have shown exceptional good work with addressing accessibility issues.

[12] http://www.civitas.eu

Finally, the city of **Donostia/San Sebastián** is a good example of the implementation of a successful strategy towards the achievement of a better level of accessibility thanks to a comprehensive strategy, involving all the transport modes.

For each best practice case study a factsheet was been drafted including the following information:

- **Where:** Place where the best practice has been implemented
- **What**: A description of the measure/s
- **Why**: Primary objective of the policy interventions
- **Policy content**: Short narrative description of the policy intervention
- **Policy intervention**: Known quantitative elements
- **Impacts on accessibility**: Quantitative impacts if available
- **Factors of success**: Elements that can be considered drivers for the success of the initiative
- **Transferability:** Consideration of whether the policy is transferable to other contexts
- **References:** List of references and sources

5.4 Key conclusions

The objective of improving accessibility needs to be specified because accessibility by private transport is not the same as accessibility by public transport or by active modes. In most of the cases, improving one type of accessibility implies that another type is worsened.

Accessibility via public transport tends to be increased by adding new or improved existing facilities and infrastructure (additional lines, expanded services, improved vehicles and stops).

The improvement of accessibility for private modes (i.e. passenger car) mainly assists those areas with low level of public transport accessibility, so that it can be easier for population to reach public transport lines and to use the private mode as a link to transport, or to ensure access where public transport services are poor. Sustainable transport measures may limit access for passenger cars in urban areas, which may also hinder accessibility for certain user groups that rely on this mode. However, whilst 'accessibility' to key services and opportunities needs to be maintained and/or improved for all users, there needs to be a balance. Whilst acknowledging private vehicles may be the most appropriate method of access for certain user groups, sustainable transport or alternative measures (i.e. not relating to transport) should be sought wherever possible. In relation to the accessibility for active modes, it is worth to notice that, in addition to dedicated facilities (pedestrian areas, walking and cycling lanes/facilities), all measures removing or reducing traffic improve accessibility by active modes.

The best practice case studies covered within Task 4 addressed a wide range of issues and can provide local authorities with a starting point for their strategies.

All of the best practice case studies indicate that a broad package of measures helps to achieve the desired improvements. This is because synergies among measures usually exist and amplify each individual effect. To achieve the target of improved accessibility, all transport components (passengers and freight) have to be addressed. If goods transport and delivery is organised efficiently, then passengers' mobility also has more chance of being sustainable and well organised.

The best practice case studies have also shown that the process of implementation is important. Firstly, political commitment, support and cooperation is fundamental. The cooperation between stakeholders and the involvement of citizens at all stages of the project are also key factors in overcoming some of the barriers to implementation.

Important lesson from the case studies is that no universal solutions exist: tailoring the measures to the local environment is key to success.

6 POLICIES AND ACTIONS TO IMPROVE ACCESSIBILITY (TASK 5)

The aim of Task 5 is to identify and recommend policies and actions that can support city authorities to improve accessibility in urban areas/European cities. We have therefore largely drawn upon the findings of all of the previous tasks (summaries of which were presented in Sections 2 to 5), with a particular focus on Task 1 (where we consulted policy makers, researchers, and associations in the form of interviews ad stakeholder events) and Task 4 (where we identified best practice measures for increasing the accessibility of urban areas).

We consider policies and actions at a higher strategic level – therefore the identification of policy proposals has been developed from a bottom-up approach, rather than top-down. That is, starting from root causes and problems, we have proposed policies that aim to address each issue at the local, national and European level. Task 4 demonstrated the actions that cities take directly in order to improve accessibility in urban areas. Task 5 aims to identify those policies and actions that can be taken at the European and national level (and sometimes local level) in order to facilitate and support these city-level actions.

6.1 Identification of problems/issues

A number of problems/issues have been identified as a result of Tasks 1 to 4 and associated stakeholder engagement. These include a lack of:

- Common definition of accessibility;
- Comparable and consistent monitoring data;
- Understanding of measures to improve accessibility;
- Interpreting accessibility as a main goal;
- Understanding of congestion costs;
- Financial resources; and
- Consideration of accessibility in other policy areas.

Each of these problems/issues are discussed in more detail in the following sections.

6.1.1 Lack of common definition of accessibility

The Task 1 report (State of the Art Review) revealed that there are a wide range of definitions of accessibility currently in use. This study has used the following definition for urban accessibility "…*the ease of reaching goods, services, activities and destinations in urban areas. It includes factors such as mobility options, travel information, transport network connectivity, land use patterns and cost for both passengers and freight*".

Many other studies used elements of this definition when discussing wider accessibility, including "the ease of reaching". However, it is important to note that there are also other more commonly understood definitions of accessibility that are regularly used referring to the physical access to transport modes. There is a need to therefore make a clear distinction between the two. When referring to wider accessibility (as this study does), a definition should include the four key dimensions of accessibility (individual, transport, land use and temporal), rather than the physical access to transport modes, which tends to be more common. A common definition of wider accessibility is therefore required to ensure that practitioners and policy makers are fully considering wider accessibility in urban areas at the EU Level, rather than just public transport-focused accessibility.

It became clear from the review of recent research that a distinction also needs to be made between 'mobility' and 'accessibility'. 'Mobility' refers to the movement of people and goods, and the ability to move freely and easily. In many cases mobility and accessibility tend to be used interchangeably, but this is incorrect.

Many studies concerning mobility inherently address accessibility issues, but this tends not to be their main focus (this was reinforced when selecting case study cities – the majority did not have specific accessibility objectives, but implemented measures that increased accessibility). Wider accessibility issues and their intricacies are therefore not fully addressed as mobility is the focus, which often has alternative objectives. Through having a greater understanding of wider accessibility and a clearer definition, confusion between the remit of mobility and accessibility measures is likely to be reduced.

Finally, what constitutes 'accessibility' itself can be very subjective. Demand segments (e.g. pedestrians, motorists, public transport users) can have very different assessments of accessibility, or what should be considered 'accessible' based on their own experiences. These disparages should be acknowledged and understood in the assessment of accessibility at the city level.

6.1.2 Lack of comparable and consistent monitoring data

The Task 1 report (State of the Art Review) identified a wide range of methods for assessing/measuring accessibility and discussed the data that is required in order to do so. Accessibility metrics/indicators tend to fall into four categories, including infrastructure-based, location-based, person/individual-based and utility-based indicators. However, there is currently a lack of comparable and consistent monitoring data available to assist in the measurement of these indicators. To some extent this can be explained by the complex nature of accessibility and differences between urban areas.

Infrastructure-based indicators quantify accessibility in terms of the performance of the transport system, e.g. average speed on the road network, or levels of congestion. The data required for infrastructure-based measures is often immediately available. This may include data on the provision of transport infrastructure (e.g. layout of the road network, spatial distribution of railways etc.), provision of (public) transport services (e.g. timetable data for bus/train services including frequency, routes, interchanges etc.), and performance of the transport network (e.g. average road speeds, delay, reliability).

Location-based indicators define accessibility in terms of how many individuals/freight loads can access a location, or how many locations an individual/freight load can reach. Data related to location/land use is likely to include the location of individuals and opportunities, which is likely to be based on census data/surveys or existing databases of opportunity locations. This data is also likely to be readily available, and is often being collected/used for other purposes. Distance-based indicators can sometimes be computed without additional data collection if there are existing datasets describing activity locations, the transport network, and locations of households, which is often the case.

Person/individual-based indicators consider accessibility at the level of individuals e.g. details of the set of employment centres specific individuals can practically access, taking into consideration personal constraints of time or physical ability. Individual data required may include attributes of the individuals, actual travel and activity patterns, and variability in individual's interactions with the transport system. Data related to individuals is inherently more difficult to obtain, and it is most likely to be collected through a range of travel and/or social surveys and interviews. This data is much more challenging and time consuming to collect as it is not readily available or being collected for other purposes. Person-based measures, by contrast, demand extensive amounts of data about individual circumstances which is not typically gathered by travel surveys.

Utility-based indicators quantify accessibility in terms of utility an individual or individuals derive from being able to access activities/opportunities distributed across space (economic benefit). Indicators can also differ in terms of how easily they can be interpreted or explained to the general public, practitioners and policymakers. Gravity models and utility-based models create summary indicators of complex sets of facts, and are less transparent than indicators like the number of schools within a reasonable distance by car, or the average speed on roads. With utility-based models, although the process for deriving the final indicator may be complex, there is a distinct advantage to being able to convert the accessibility benefits into monetary amounts, as these benefits can be compared like-for-like with associated costs when considering the costs and benefits of a policy intervention.

The Task 1 report considered the types of indicators that could be used to compare accessibility in different European cities, potentially as part of a European Mobility Scoreboard. As such a scoreboard would facilitate comparisons between areas, there would also need to be some careful consideration of the substantial area-level differences between individuals in different parts of the EU. For example, individuals in different countries or even different cities may differ not only in terms of their income but also in terms of how much they are willing to spend on travel as a proportion of their income. The aforementioned issue of individuals adapting to congestion is another example of the potential importance of area-level differences in individuals. The measures should compare accessibility (e.g. time or distance) between cities, but should not provide judgement on what is considered to be acceptable, desirable etc.

Such indicators and their merits were also discussed in detail during our engagement with stakeholders (interviews and workshop). However, it is evident that some indicators would be more useful in developing a scoreboard than others. In particular, it would be nearly impossible to base city-level accessibility metrics around person-based measures such as the use of space-time prisms and other ways of measuring accessibility that are extremely sensitive to individuals' idiosyncratic circumstances. The use of infrastructure-based measures of accessibility also have their drawbacks due to the fact that they do not often take into account the spatial distribution (and re-distribution over time) of opportunities which is fundamental to operationalising *accessibility* rather than just *mobility*.

After eliminating those possibilities, the remaining options are to use the following types of indicators:

- Location-based measures considering both potential accessibility indicators and/or distance indicators;
- Utility-based indicators.

The Task 1 report concluded that there is likely to be a trade-off between accuracy and ease of implementation and interpretation. Accuracy is obviously necessary if comparisons between cities and over time are to be informative. But ease of interpretation is also important if the scoreboard is going to have an influential effect on policymakers, which may rule out the use of utility-based statistics derived from a "black box".

Clearly an important consideration for any selected accessibility metric is the necessary data – including its format, availability and ease of collection. In order to be able to make comparisons between European cities, data supporting accessibility metrics will need to be readily available to most cities, and can potentially be collected at the European level.

Given these considerations the most likely candidates for a European level indicator(s) on accessibility are location-based measures in terms of simple travel distances/times to opportunities. This is supported by the use of these type of indicators in comparative accessibility studies such as the ESPON TRACC study (ESPON, 2015) and UK Department for Transport's Accessibility Statistics (UK Department for Transport, 2014).

It will therefore be necessary to work towards ensuring that a comparable or consistent approach within the EU is achieved in terms of assessing accessibility, including the metrics used and/or the data collected in order to calculate it.

6.1.3 Lack of understanding of measures to improve accessibility

The accessibility framework matrix developed in Task 4 aimed to provide an overview of the measures available to improve accessibility. This included an overview of how each measure was linked to the dimensions of accessibility and potential impacts on different users (public, private, active etc.). The best practice case study report (also Task 4) also aimed to identify cities that had implemented 'accessibility' measures with a view to improving accessibility. The measures considered were dominantly transport policy measures, and not necessarily or explicitly accessibility-related. Objectives were more likely to be aimed at increasing sustainability or other environmental/economic goals, although accessibility was often improved as a result of implementation (see Section 6.1.4 for more details). Very little information on evidence of measure's impacts on accessibility was available. It should also be acknowledged that measures not directly linked to transport policy are available and can have a positive impact on improving accessibility. However, there was very little research or evidence in this area.

6.1.4 Lack of interpreting accessibility as the main goal of policies

As demonstrated by the case studies described in the Task 4 report (Best Practice Examples in Improving Urban Accessibility), many urban transport and urban planning related measures can have a positive impact on improving accessibility. However, accessibility is rarely the main policy goal and instead, measures are usually aimed at improving the sustainability (or efficiency) of transport services. In other cases, mode shift may be the main policy objective, which again, could have added benefits in terms of accessibility in the majority of cases.

The lack of interpreting accessibility as the main goal of policies can also be related to other issues highlighted in this task. For example, without a common definition of accessibility, it is difficult to ensure that the relevant aspects of policy measures are applied coherently across different European cities. In addition, comparable and consistent data for measuring accessibility are not yet well developed, which limits the usefulness of stating accessibility as one of the main policy goals. These types of indicators are often useful tools for measuring the success of a policy intervention and determining its transferability to other cities. There are also instances of measures that are implemented aimed at increasing 'sustainable transport' which can actually have negative impacts on accessibility for certain groups, such as limiting private car use in urban areas, which may limit accessibility to services for some who rely on this mode.

In the case studies described in the Task 4 report, very few policies specifically mention accessibility as one of the main policy objectives. However, the measures were shown to significantly improve accessibility. Furthermore, when accessibility is mentioned in this context, it usually refers to improved access for dedicated target groups (such as disabled people, or those without easy access to public transport services), rather than capturing the other elements of accessibility. These other aspects of accessibility are described in the "Analytical Matrix" in the Task 4 report for this study. This problem is also linked to the lack of consideration of accessibility in other policy areas (such as social, education, health and land use) – if these were built into an accepted definition of accessibility, policies could be applied more consistently.

Considering the above issues, there are still numerous examples of measures where accessibility benefits have been delivered, even though improved accessibility was not the main goal of the policy. For example, as discussed in the Toulouse case study, the implementation of new parking policies and the improvement of the public transport system were highly influential in improving access to the city centre for a range of users. However, these policies were primarily aimed at improving congestion and encouraging an increased mode share for public transport modes. With clearer definition of the accessibility goals in such policies, there is potential for greater success with relatively little additional investment required.

6.1.5 Lack of understanding of congestion costs and of the linkage between congestion and accessibility

The costs of congestion in urban areas across Europe were reviewed and estimated as part of the Task 2 report (Estimation of European urban road congestion costs). The report also identified a number of issues concerning the current understanding in this area and in particular noted the different methodologies used to calculate costs. Better understanding of this topic has the potential to contribute to improved urban accessibility. However, as described later in this section, work is still required to understand the relationship between congestion and accessibility. The key issues identified in this area include:

- How to define congestion
- Approaches to calculate congestion costs
- Data availability
- Congestion cost as a monetary equivalent, rather than expenditure
- The links between congestion and urban accessibility.

Firstly, a number of different definitions for congestion have been suggested. Many of these definitions treat congestion as an objective event, while others also introduce subjective elements. Maintaining a consistent definition is important when considering the cost of congestion and will allow for more accurate comparisons between different geographical areas. For the purpose of this study, congestion is defined as 'a condition where vehicles travelling on road links are delayed'.

As for congestion, there are also different definitions/methodologies that can be used to describe and calculate congestion costs. Two main perspectives can be adopted, which are based on alternative interpretations of the impacts that traffic generates. These are **delay costs**, which provide a comparison to free-flow conditions and **deadweight loss**, which utilises a welfare economics approach (in which it is assumed that the level of demand is the result of individual choices based on the minimisation of costs).

This can be beneficial as different approaches may be more suitable for different applications and will bring additional insight when implementing measures to improve urban accessibility, or mitigate congestion. For example, delay costs are considered to be more suitable when considering the magnitude of the problem and when comparing between different areas, while deadweight loss is more applicable when assessing the impact of measures to improve congestion and/or accessibility. However, consistencies within each approach will also be needed in the future, if congestion indicators are to play a more important role in the assessment of the performance of urban transport networks.

The Task 2 report also commented that existing literature on the estimates of urban congestion costs is not abundant, while data sources providing information on congestion levels in cities are not always comparable due to methodological differences. This means that robust analysis at the European level can be a difficult procedure, however this should improve in the future with increased availability of mobile data sources.

The importance of good, detailed data and a variety of comparable sources becomes more apparent when assessing the outcomes of the congestion cost calculations and their sensitivity to the input parameters. Here, it was mentioned that different assumptions on key parameters can lead to significantly different values, especially for urban congestion cost measured in terms of deadweight loss. Statistical analysis was also used to identify correlation between the magnitude of congestion cost and other features of a city (for example, size, or modal share) however the results suggested that congestion is very dependent on local conditions. This means that the relationship between congestion costs and city characteristics cannot be fully captured by using simple indicators such as modal share or population. In fact, the only correlation that was found was between external congestion cost per capita and the population of the cities: the higher the population size, the lower the average congestion cost per capita. Again, with greater data availability in the future, analyses of this nature may provide additional insight.

Another point to consider is how the costs of congestion are best interpreted. In terms of delay cost, the Task 2 report estimates a monetary value of just over 140 billion Euros per year (equivalent to approximately 1% of GDP), while deadweight loss amounts to 10%-15% of this figure. These figures show the **monetary equivalent of time wasted,** rather than actual expenditure. This is important for how the information on costs is utilised. Although this is not a small cost for European drivers, it is important to remember that this is an estimation of the monetary equivalent of additional travel time, rather than a financial cost incurred by individuals. Furthermore, as stated in the Task 2 report, in most cases interpreting this estimation as an economic benefit that would be distributed to individuals if congestion was removed would be incorrect.

Finally, the linkages between congestion and accessibility are currently not well understood. Although congestion generally limits accessibility, there is evidence to suggest that the effects vary across individuals, locations and time, especially when accessibility is viewed as a dynamic concept.

For example, a study performed in Madrid concluded that in general, accessibility is poorest during peak times due to congestion (Moya-Gómez, Salas-Olmedo, García-Palomares, & Gutiérrez, 2016). However, the effects of congestion are partially offset by the distribution of the population density, which tends to be concentrated in the city centre during these times. Another study, which analysed accessibility and congestion in the United States, suggested that congestion does not have a uniform effect on accessibility but instead varies depending on the local environment (Mondschein, Taylor, & Brumbaugh, 2011). The authors found that in some areas congestion was associated with poorer accessibility, while other areas were 'congested adapted' and exhibited high levels of accessibility and activity participation, despite high levels of congestion.

It should also be considered that improved accessibility can also generate congestion, as the demand for services increases. Further research on these topics would be beneficial to understand the complex relationships between congestion and accessibility in different cities across the EU.

6.1.6 Lack of consideration of accessibility in other policy areas, e.g. social, education, health, land use policy

Findings from Task 1 (State of the Art review) and Task 4 (Best Practice examples for Improving Urban Accessibility) revealed that improving urban accessibility is often regarded as a transport policy issue. Whilst transport (all modes) plays a large part in the 'ease of reaching' element of accessibility, and many issues relating to poor accessibility can be solved with transport solutions, it is clear that there are a number of other policy areas that should be included in the urban accessibility debate and therefore considered when attempting to improve urban accessibility. This will include the other aspects of wider accessibility, including the service or destination, and the individual trying to reach it.

Other policy areas that can be affected by lack of accessibility or that can play a part in the accessibility solution include healthcare, social, land use, and education to name but a few. Selected barriers to accessibility are summarised in

Table 6-1, which also indicates the relevant accessibility dimension and potential related relevant policy areas.

Table 6-1: Accessibility barriers and relevant policy areas

Accessibility Barrier	Barrier description / examples	Accessibility Dimension	Relevant policy areas
Spatial barriers – land use	Location of opportunities Location of individuals	Land use Transport	Land use Social Education Healthcare
Temporal barriers	Opening hours of services/opportunities Public transport service times Availability of the individual/other time constraints	Temporal Transport Social	Transport Social Healthcare Education Employment
Fiscal/economic barriers	Cost of transport/travel	Individual Transport	Transport Social
Perceptual barriers	Crime and fear of crime	Individual Transport	Transport Social
Physical barriers	Transport not equipped for elderly, disabled, young children. Severance caused by transport	Transport Individual	Transport Land use Social
Information barriers	Transport information availability and format	Transport	Transport
Mode specific barriers	In addition to cost and physical barriers, e.g. level and type of service	Transport Temporal	Transport
Structural barriers	Mechanisms which discriminate in favour of those who are already mobile, e.g. company car tax breaks, 'free' workplace parking etc.	Transport Individual	Transport Employment Social

As the table above demonstrates, the remit for urban accessibility is far wider than solely transport policy. Through consideration of accessibility in other policy area, or through a joint approach, greater benefits may be achieved in terms of improving accessibility.

6.1.7 Lack of financial resources

As was evident by the work undertaken in Task 4, there are a wide range of measures available to improve accessibility, and a large proportion of them are relatively low cost to implement. However, investment and management costs are required to in order to implement them. Unfortunately many local and regional authorities in Europe have struggled to identify appropriate public funds as a result of continuous downsizing of available budgets and the impacts of the economic crisis over the last eight years. This situation has led to a lack of public resources for the implementation of such measures.

There are currently a number of funding opportunities in Europe which may support and benefit accessibility-related improvements, although currently not explicitly so. European Structural and Investment Funds (ESIFs) are directed to key EU priority areas responding to the needs of the economy by supporting job creation and getting the European economy moving in a sustainable way. They include the Regional Development Fund (ERDF)[13], Cohesion Fund[14] and European Social Fund (ESF)[15] (amongst others).

The ERDF is responsible for managing EU funding dedicated to regional development. The ERDF supports projects and activities that reduce the economic disparity within Member States of the EU, financially aiding projects that:

- Stimulate economic development and increase employment in the poorest regions of the EU;
- Help preserve the nature and environment in order to improve quality of life as well as make the regions more attractive to tourists and investors;
- Improve transport and basic infrastructure;
- Increase the quality of education; and
- Other projects promoting regional development and reducing the gap between wealthiest and poorest regions in the EU.

The Cohesion Fund is available for selected Member States[16] for trans-European transport networks, and environment – supporting projects related to energy or transport, such as those benefiting developing rail transport, supporting intermodality, strengthening public transport etc.

The ESF aims to support jobs, help people get better jobs and ensure that there are fairer job opportunities for all EU citizens. Key themes include the following:

- Promoting employment and supporting labour mobility;
- Promoting social inclusion and combatting poverty;
- Investing in education, skills and lifelong learning; and
- Enhancing institutional capacity and an efficient public administration.

Although the funding streams identified above could potentially fund improvements to accessibility in urban areas, and undoubtedly do indirectly, there seems to be a lack of financial resources specifically allocated to improving accessibility. Whilst it may typically be seen as a transport issue, it is evident that accessibility is also relevant in a number of other policy areas (see also Section 6.1.6), but without a specific lead in the other policy

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[13] http://ec.europa.eu/regional_policy/en/funding/erdf/

[14] http://ec.europa.eu/regional_policy/en/funding/cohesion-fund/

[15] http://ec.europa.eu/regional_policy/en/funding/social-fund/

[16] Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

areas to take it forward. Therefore, whilst funding mechanisms and financial assistance are available to address a wide range of transport or other policy area issues those specifically targeting accessibility are required.

6.2 Recommended policies/actions to improve accessibility

Actions and potential policies to improve accessibility in urban areas have been identified and described in more detail in the following sections to address each of the issues/problems identified above. They have been identified at the EU, national and local level.

6.2.1 Recommended policies/actions at the EU level

Recommended policies/actions at the EU level include the following:

- Provide a common understanding and definition of accessibility and its relationships with congestion and Sustainable Urban Mobility Planning (SUMPS) (linked to issues in 6.1.1 and 6.1.5),
- Develop a set of comparable indicators (linked to issue in 6.1.2),
- Promote consistent and comparable data collection to compute indicators (linked to issue in 6.1.2),
- Include accessibility improvements as an explicit goal in policy assessment (at the same level of benefits currently estimated in CBA analyses), within urban transport policy but also outside transport policy highlighting how accessibility can be promoted by non-transport policy (linked to issue in 6.1.4 and 6.1.6)
- Support knowledge sharing and best practice between EU cities building on existing urban mobility programmes (linked to issue 6.1.3)
- Contribute to provide cities with the financial resources to implement policies to improve accessibility (linked to issue in 6.1.7)

A **common understanding and definition of accessibility and its relationship with congestion** needs to be reached at the EU level, in order to support Member States and subsequently cities. It is recommended that the work undertaken in this study (primarily Task 1 and Task 2) is built upon when working towards defining accessibility. An agreement on a common definition of accessibility to be used in Europe would be a useful basis for then further developing and agreeing on suitable accessibility metrics for measuring and comparing accessibility in European cities, and subsequently identifying appropriate measures to improve accessibility, including the provision of guidance across the EU. Through identifying a set of standard metrics for measuring accessibility some degree of consistency can be achieved (see also 'lack of comparable and consistent monitoring data, issue 6.1.2).

A set of **comparable indicators** for accessibility should be encouraged or developed at the EU level. The Commission should build upon the research undertaken in Task 1 of this study, but also contribute towards future revisions of the work that has been undertaken by the World Business Council on Sustainable Development (WBCSD) or the UN's Sustainable Development Goals (SDGs) (amongst others) when developing a set of accessibility indicators. EU level data sets, such as those including public transport data, geographic data etc. also need to be reviewed when selecting suitable and available data for indicator development. Through identifying a set of indicators for assessing accessibility, **comparable and consistent monitoring data** can be identified and more readily collected at the national and local/city level.

In April 2016, the European Commission endorsed a set of Sustainable Mobility Indicators that have been issued by the World Business Council for Sustainable Development

(WBCSD)[17] [18]. The indicators aim to provide cities with reliable diagnosis tools to assess their sustainable mobility performance and deliver integrated sustainable urban mobility plans (SUMPs). Of course, this also includes addressing the issue of accessibility. A sustainable Mobility Planning tool was subsequently developed and was released at the end of September 2016. The tool has been designed to increase the availability and user-friendliness of the sustainable mobility indicators and the mobility solutions and toolbox of SMP2.0. Cities are encouraged to use the sustainability mobility indicators to measure and improve their individual mobility footprint.

The European Commission has also recently (November 2016) committed to implementing the 2030 Agenda for Sustainable Development and UN's Sustainable Development Goals (SDGs)[19] within the EU. The SDGs include 17 goals and associated targets which run to 2030. The goals cover topics including sustainable cities and communities, good health and wellbeing, quality education, and reduced inequalities, all of which will have relevance to the accessibility agenda. The Commission intends to mainstream the goals in the European policy framework and current Commission priorities.

Other metrics that have also been developed and used, such as the UK Department for transport's accessibility indicators, may also be used as a starting point for developing indicators at the national level and used by cities. This may address issues directly related to accessibility rather than a mobility focus. The advantages and disadvantages of various accessibility metrics were discussed in detail in the Task 1 report, including those issues relating to data collection. These issues will need to be taken into consideration when recommending metrics and associated data for collection by cities/member states, also considering the differences between them.

Accessibility improvements should be included as a specific goal in **wider policy** assessment. As a first step, further research needs to be undertaken into how accessibility could be considered in policy areas wider than solely transport, building upon the research commenced in this study. This should include how accessibility can be promoted by non-transport policy and should involve a wide range of policy areas, including land use, health, social, education etc. This should subsequently lead to the development of guidance of how to consider the improvement of accessibility as a goal in the assessment of other policy areas.

Greater **knowledge sharing,** including the identification of relevant case studies and best practice, should be encouraged and undertaken at the EU level. This could help cities to successfully develop measures that have already been implemented in other places across Europe. Learning from other cities' experiences can lead to a smoother implementation process and help to avoid some of the issues experienced when a measure is first trialled. Knowledge sharing can also help cities to solve specific accessibility problems by gaining experience from cities that have developed solutions to similar issues. Ideally, this type of best practice information (or a database at projects) would be best developed at an EU level. This would allow for a wide range of local environments to be covered and increase the chances of cities finding best practice examples applicable to their needs. To support this process, accessibility could be built into schemes such as the CIVITAS initiative. Indeed, improved accessibility could even support some of the goals of the CIVITAS network. For example, improved urban planning and the development of multimodal

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[17] WBCSD (2016) http://www.wbcsd.org/the-european-commission-endorses-wbcsd-set-of-indicators-to-help-cities-advance.aspx

[18] WBCSD Practical Guide: http://www.wbcsd.org/Projects/Sustainable-Mobility-Project-2.0/Resources/SMP2.0-Final-Report-Integrated-Sustainable-Mobility-in-Cities-a-practical-guide

[19] https://sustainabledevelopment.un.org/?menu=1300

transport hubs have the potential to produce both a more efficient transport network and to connect society to more opportunities, thus contributing to improved accessibility. Knowledge sharing platforms currently exist, including the ELTIS portal[20], which facilitates the exchange of information, knowledge and experiences in the field of sustainable urban mobility, and includes a wealth of information and guidelines on SUMPs.

Alternatively, a European level platform for accessibility could be developed, or integrated with the existing Mobility platform. This would again support the exchange of ideas between cities and help to create synergies between projects. Accessibility could also be built into SUMPS, which would help to increase awareness about the topic. This action is explored in greater detail below (when local authority actions are discussed), however support at the EU level would be beneficial to support this process.

Finally, it is recommended that the **financial mechanisms** are provided at the EU Level to enable cities to implement policies and measures at the local level to address and improve accessibility. This may include updating the scope of existing funding streams to explicitly incorporate improved accessibility as an objective, e.g. considering the improvement of accessibility in cities in relation to allocation of **funding** (including ERDF, ESF, etc.) and selection of relevant projects. Urban accessibility issues are inherent in a number of project types currently listed as eligible for the funding streams listed above, but accessibility's relevance should be made clearer, including highlighting the benefits that the improvement of accessibility will have on other key objectives. This also applies to other relevant EU funding schemes. Funding should continue to be provided for sustainable transport schemes, which largely have positive impacts for improving accessibility (see Task 4 matrix on measures to improve accessibility).

The SUMP concept is already being promoted as part of the consideration for EU level investment funding together with support and capacity building for cities in relations to SUMPS through initiatives such as JASPERS. Linking the accessibility concept into this kind of capacity building for accessing EU funding would help ensure that transport projects are considering and tackling wider accessibility issues not just mobility issues.

6.2.2 Policy recommendations at the national level

At the national level, authorities will have the role of linking EU level actions to the local level, where measures are implemented. Recommendations at the national level will therefore be as follows:

- Develop national guidelines, tailored for appropriate national/local context (linked to issues identified in 6.1.1, 6.1.2, 6.1.3);
- Develop procedures and responsibilities to ensure data collection (linked to issue in 6.1.2);
- Incorporate analysis of impacts on accessibility among formal procedures required to apply for public funding (linked to issue in 6.1.7).

National guidelines should be developed linked to those developed at the EU level, tailored to meet national/local context. This will include guidance on the definition and measurement of accessibility (once developed), but also those related to achievement of comparable and consistent data collection and incorporating 'accessibility' in a wider range of policy areas, rather than just transport.

Procedures and responsibilities to ensure appropriate **data collection** need to be developed and established at the national level to support the assessment of accessibility

[20] http://www.eltis.org/mobility-plans

by cities at the local level, and to ensure consistency across Europe where possible. This will include the support required for cities to collect and use such required data.

With regards to **funding of projects/measures** at the local level, national authorities will need to consider how to incorporate the analysis of impacts of accessibility among the formal procedures required to apply for public financing of projects at the local level by cities/authorities. Again this may require advice on partnerships with policy areas/departments other than transport.

6.2.3 Policy recommendations at the local level

Local authorities and city organisations are responsible for implementing measures to improve accessibility. They will therefore take on-board any guidance or best practice developed at the EU or national level when considering how to assess accessibility and subsequently implement measures to improve it where necessary.

To some extent Task 4 considered the measures that could be implemented at the local level and their potential effects on accessibility. However, it is recommended that further research is undertaken in this area, particularly related to those measures not specifically linked to transport policy (i.e. social, land use, healthcare etc.). Recommendations at the local level therefore include:

- Adopt SUMPs and other policy guidelines developed at EU and national level concerning accessibility (linked to issue in 6.1.1, 6.1.2, 6.1.3);
- Identify clear accessibility targets based on common definitions and considering that conflicts may emerge between alternative versions of accessibility (linked to issue in 6.1.1, 6.1.2);
- Involve citizens in the definition of targets and policy instruments (linked to issue in 6.1.2);
- Define strategies based on integrated packages of measures rather than single measures (linked to issue in 6.1.3, 6.1.6).
- Consider linking congestion reduction objectives with wider accessibility improvement goals (linked to issue 6.1.7)

SUMPs and other policy guidelines developed at EU and national level concerning accessibility can be adopted at the local level. SUMPs (Sustainable Urban Mobility Plans) are based on integrated planning and are an important tool for encouraging the uptake of innovative measures to improve urban transport. A key aspect of SUMPs is the measurement of current performance, combined with target setting for the future, which is used to measure the impact of policies. Taking this into consideration, explicitly stating accessibility as the main goal of a policy and combining it with measureable, accessibility related targets is realistic within a SUMP. If the policy goal could be linked to a set of accessibility indicators this would provide even better clarity and help to further strengthen/support the measures. Indicators are often useful for this purpose as they help to illustrate the effects of policies over time and can be used to compare different local environments.

Using the information available to them developed at the EU level and subsequently national level, local authorities should aim to **identify clear accessibility targets that have been based on common definitions of accessibility**. The conflicts that arise between various measures when implemented should be carefully considered, particularly with regards to the potential negative impacts they may have for accessibility for certain population groups. Where possible, **citizens should be involved** in the definition of the targets and the policy instruments/measures that are to be implemented.

As was identified from the Task 4 research, strategies should be defined based on an **integrated package of measures**, rather than focussing on an individual measure in order to improve accessibility. This includes identifying and implementing measures that may not necessarily be directly linked to transport policy, but from wider policy areas such as land use, social, health or education.

Local authorities could also **consider linking congestion reduction objectives with wider accessibility improvement goals**. An ideal platform for this would be during the development of future Sustainable Urban Mobility Plans. Further studies to investigate the links between accessibility and congestion at a local level (in a range of cities/local environments) should also be encouraged and would be highly valuable.

6.3 Summary and conclusions

An overview of policy recommendations is provided in Table 6-2 below.

Table 6-2: Summary table: Identification and review of policy measures

Level of Action	Recommendation / Policy Proposal	Problem area/issue addressed							Potential costs
		Lack of a common definition of accessibility	Lack of comparable / consistent data	Lack of understanding of accessibility measures	Lack of interpreting accessibility as main goal of policies	Lack of understanding – congestion costs and links to accessibility	Lack of consideration accessibility in wider policy	Lack of financial resources	
EU	Provide a common understanding and definition of accessibility and its relationships with congestion	✓		✓		✓			€
	Develop or recommend a set of comparable indicators		✓						€€
	Promote consistent and comparable data collection to compute indicators		✓						€€
	Include accessibility improvements as an explicit goal in policy assessment (at the same level of benefits currently estimated in CBA analyses), within urban transport policy but also outside transport policy highlighting how accessibility can be promoted by non-transport policy				✓		✓		€

	Support knowledge sharing and best practice between EU cities building on existing urban mobility programmes			✓					€€
	Contribute to provide cities with the financial resources to implement policies to improve accessibility							✓	€€€
National	Develop national guidelines, tailored for appropriate national/local context	✓	✓	✓					€
	Develop procedures and responsibilities to ensure data collection		✓						€€
	Incorporate analysis of impacts on accessibility among formal procedures required to apply for public funding							✓	€€
Local	Adopt SUMPs and other policy guidelines developed at EU and national level concerning accessibility	✓	✓	✓					€
	Identify clear accessibility targets based on common definitions and considering that conflicts may emerge between alternative versions of accessibility	✓	✓						€
	Involve citizens in the definition of targets and policy instruments	✓							€€
	Define strategies based on integrated packages of measures rather than single measures				✓		✓		€€

	Consider linking congestion reduction objectives with wider accessibility improvement goals							✓	€

GLOSSARY OF KEY TERMS

Accessibility	The ease of reaching goods, services, activities and destinations in urban areas. It includes factors such as mobility options, travel information, transport network connectivity, land use patterns and cost for both passengers and freight
Mobility	Movement of people and goods
Indicator	Statistics used to measure current conditions or to forecast trends
State of the art	Most recent ideas and/or methods
Congestion	Condition where vehicles travelling on road links are delayed.
Opportunities (in the context of accessibility)	Key services, activities or destinations which individuals would like to get to/access
Contour measures	Using contours to define an area including all of the places that a person could move to within a given amount of time or cost
Utility measures	Quantification of accessibility in terms of utility an individual could derive from being able to access activities or opportunities (e.g. monetary value or other selected units)
Space-time prism	All points that can be reached by an individual given a maximum possible speed from a starting point in space-time and an end point in space-time, taking into consideration their own personal constraints
Potential accessibility	Catchment areas defined by measuring travel impediment on a continuous scale
Social exclusion	What can happen when individuals or areas suffer from a combination of linked problems such as unemployment, poor skills, low incomes, poor housing, high crime environments, bad heath and family breakdown

ABBREVIATIONS

Acronym	Meaning
BRT	Bus Rapid Transit
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
DG MOVE	Directorate general for Mobility and Transport
EC	European Commission
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union
EU-28	28 EU Member States
GDP	Gross Domestic Product
JRC	Joint Research Council
ICT	Information Communication Technology
ITS	Intelligent Transport Systems
KM	Kilometre
LNG	Liquefied Natural Gas
MJ	Megajoules
MS	Member States
NUTS	Nomenclature of Territorial Units for Statistics
PCU	Passenger Car Unit
PKM	Passenger Kilometre
SDG	Sustainable Development Goals
SUMPs	Sustainable Urban Mobility Plans
TRACC	TR

vim	Vehicle Kilometres
UN	United Nations
WBCSD	World Business Council for Sustainable Development
WTW	Well to wheels

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