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Accessibility Instruments for Planning Practice

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COST- the acronym for European Cooperation in Science and Technology- is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 36 European countries to cooperate in common research projects supported by national funds.

The funds provided by COST - less than 1% of the total value of the projects - support the COST cooperation networks (COST Actions) through which, with EUR 30 million per year, more than 30 000 European scientists are involved in research having a total value which exceeds EUR 2 billion per year. This is the financial worth of the European added value which COST achieves.

A "bottom up approach" (the initiative of launching a COST Action comes from the European scientists themselves), "à la carte participation" (only countries interested in the Action participate), "equality of access" (participation is open also to the scientific communities of countries not belonging to the European Union) and "flexible structure" (easy implementation and light management of the research initiatives) are the main characteristics of COST.

As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of "Networks of Excellence" in many key scientific domains such as: Biomedicine and Molecular Biosciences; Food and Agriculture; Forests, their Products and Services; Materials, Physical and Nanosciences; Chemistry and Molecular Sciences and Technologies; Earth System Science and Environmental Management; Information and Communication Technologies; Transport and Urban Development; Individuals, Societies, Cultures and Health. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

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Preface

Angela Hull and Cecilia Silva

Accessibility is a fundamental attribute of a well-functioning city or urban region. In particular, the concept of accessibility provides a framework for understanding the reciprocal relationships between land use and mobility. Accessibility, however, encapsulates more than a measure of vehicle speed; it is a measure of opportunity or ease of access for people, with different attributes, to the activities they wish to engage in. The concept, thus, incorporates a focus on the proximity of origins to destinations, the concentration or spatiality of activities, the quality of mobility systems available to overcome spatial separation, and the perceptions, interests and preferences of people who live and work there. Such a framework has important potential advantages when transferred to the realm of urban planning. However, despite the large number of accessibility instruments available in the literature, they are not widely used to support urban planning practices.

This report represents a review of accessibility instruments and of the use of accessibility concerns in planning practice. It starts with an overview of the concepts and theory concerning the measurement of accessibility followed by a review accessibility concerns and measurements in current planning practice. The report also provides a compendium of examples of accessibility planning instruments developed in several European Countries: the planning problem addressed by these instruments and how the instruments influence practitioners and decision-makers. It, thus, offers a detailed understanding and comparison of accessibility instruments across Europe and further afield in order to launch a wide debate on their purpose and operational detail and to foreground ways of improving their potential for use in practice.

This report presents the outcomes of the first stage of the COST Action TU1002 “Accessibility Instruments for Planning Practice in Europe” financed by the COST Office (supported by the EU Framework Programme). The aim of the Action is to gain insight into the usability of accessibility instruments in planning practice acting as a catalyst for the effective implementation of accessibility instruments in European planning practice. The Action will promote knowledge on how accessibility instruments can be effectively applied to support urban planners in their daily practice. It brings together researchers, with different approaches to accessibility, and a set of practitioners from selected reference cities. The relevance of accessibility instruments for specific (land use and mobility related) urban planning challenges will be studied through reflection workshops involving local practitioners. Central aim of these workshops is to shed light on the potential of accessibility instruments to support planning practice.

This Action, therefore, has added value for both accessibility instrument developers and users. For developers, this Action will provide information on the planning context and tasks, and the skills and preferences of urban planning practitioners so that these characteristics can be reflected more effectively in existing and new instruments being developed. For potential users, the Action will, through piloting accessibility instruments with practitioners in interactive workshops, demonstrate how accessibility instruments can provide information on the appropriate and equitable level of service provision and provide information on the impact of proposed urban planning decisions on the accessibility of people across their jurisdiction. We expect that the additional knowledge on the potential of accessibility instruments for urban planning practice will have beneficial impacts on urban quality and decision making on urban land use patterns in each of the countries involved in the Action. It is our intention to disseminate the scientific knowledge produced in the course of this Action more widely across Europe and the world.

This report presents the scientific outcomes of the research carried out during 2011-2012 by Work Group 2 (WG2) *"Accessibility Instruments"*. Considerable empirical research has been developed to examine several issues, including:

1. Documentary review of the state of art of the development of accessibility instruments (Chapter 1).
2. Inventory and review of the use of accessibility instruments in planning practice (Chapter 2).
3. Description and critical review of the accessibility instruments proposed by national Work Unite (WU) of the COST Action for the research propose of the Action (Chapter 3).
4. Web-based survey (Appendix A) of the components and planning function of the same accessibility instruments (Chapter 4) providing objective and comparable information on these instruments enabling the development of summary sheets for each accessibility instrument being researched (Appendix B). An online discussion forum to create a Glossary or common language on accessibility terms (Glossary).

Many scholars agree that accessibility is an old idea in planning research that needs fresh thinking to make the jump to planning practice. This report has benefited from the fresh thinking from the disciplines of transport and land use planning, bringing together researchers from different backgrounds and local and national contexts across several countries, developing both complex *and* simple accessibility planning instruments.

The report is divided into the following chapters:

List of Acronyms used

CHAPTER 1: Accessibility Measures and Instruments

Based on the literature review this will consist of:

1. Review of concepts and theory concerning the measurement of accessibility i.e. the conceptual discussion.
2. Presentation of the diversity of measures defined in the theory.

CHAPTER 2: Accessibility in Planning Practice

Focus on two types of accessibility instrument:

1. Single –case practice examples: single planning cases where a case specific methodology of accessibility analysis has been applied;
2. Standardized accessibility analysis methodologies or planning guidelines.

Instruments reviewed on the basis of the:

- context of the accessibility analysis application (e.g. public transport planning, neighbourhood planning, social exclusion, etc);
- impact of accessibility analysis on planning process and outcomes;
- experiences of tool usability by practitioners.

CHAPTER 3: Accessibility Instruments (in this COST Action)

Presents short reports of all accessibility instruments proposed for this Action and an analysis of these accessibility instruments based on the:

1. Background or motivation for development.
2. Conceptual framework and theoretical underpinnings.
3. Operational aspects.
4. Relevance for planning practice.
5. Strengths and Weaknesses.

CHAPTER 4: Discussion on Accessibility Instruments

1. Overview of Accessibility Instrument Survey.
2. Analysis of Results /Overall patterns emerging.

CHAPTER 5 Conclusions

1. State of play on the design of Accessibility-based instruments.
2. Implementation of Accessibility-based instruments in practice – overview.
3. Recent progress in Accessibility-based instruments.
4. Reflection on the usefulness/ usability of Accessibility-based instruments in urban planning.
5. Next steps in COST TU1002.

GLOSSARY

Presenting the main concepts requiring definition for this report.

Appendices

This report is the first of a series of reports to be produced by this COST Action. It will be followed by a second report on workshop evaluations of accessibility instruments presented in this report. Following the work plan of this Action, the accessibility instruments collected for this report will next be evaluated in local workshops across several Europe. The second report will present the workshop methodology and the results of the different workshops. The final report will present the cross analysis of workshop evaluations and the main findings of this research, providing recommendations for the development more useful accessibility instruments.

This publication is supported by COST.

Notes on contributors

The first report of COST Action TU1002 *Accessibility instruments for Planning Practice in Europe*, has been produced by Work Group 2 (WG2) of this COST Action, under the management of Angela Hull and general management of Cecília Silva (Chair) and Luca Bertolini (Vice Chair). The work of this WG and of the whole Action is supervised by the Management Committee (MC) closely coordinated by the Core Group (CG) and by the Rapporteur of the Action, Willi Hüstler. WG2 has also benefited from the support of other groups and individuals form the COST Action during specific tasks. At the time of conclusion of this report WG2 had 32 members from 15 of the 22 participating countries (see detailed list below). Although only some of these have contributed to the writing up of this report all have actively contributed to the discussions which led to this publication.

The work conducted for this report started formally during the first MC meeting in Oporto, organised by Cecília Silva and her local research team. The WG2 meetings held during this MC meeting and subsequent meetings (in Edinburgh, organised by Derek Halden and Angela Hull and in Turin organised by Matteo Tabasso) where of vital importance to the development of this report.

The first meeting in Amsterdam launched the discussion on the Action Glossary. Following a general discussion among all members on the need for commonly agreed concepts, Enrica Papa produced a 1st version of this Glossary, which was published on our website for continuing discussion between meetings (http://www.accessibilityplanning.eu/). The Glossary received several contributions and suggestions from several members on the website forum and during the WG2 meeting in Turin. A concluding web-based discussion period was organised after the Turin meeting, coordinated by Magda Mavridou.

The first MC meeting also launched the development of the Accessibility Instrument Survey, with general suggestions from the entire MC and later worked on by WG2 in a separate session. As manager of WG2, Angela Hull had the main role in the development of this survey from day one, preparing the first proposals to be discussed in the referred meeting and leading the development from there on. The contributions collected during the MC and WG meeting were later compiled and consolidated into the first version of the survey by Angela Hull, Enrica Papa and Anssi Joutsiniemi. This was later revised following contributions from other members (Cecilia Silva, Derek Halden, Marco te Brömmelstroet, Luca Bertolini) The internet survey was prepared by Enrica Papa with the help of Marco the Brömmelstroet (member of WG3). Results collected from the survey were converted by Ana Amante (member of WG3) into a data sheet ready for statistical analysis. Finally, analysis of the results was developed by the authors of Chapter 4. The res ults of this survey were also used to develop summary sheets for each Accessibility Instrument (Appendix B) by Tiago Patatas and Cecília Silva.

In parallel to the development and implementation of the Accessibility Instruments Survey, each Work Unit was responsible for producing a short report presenting the Accessibility Instrument they were bringing into this Action. These short reports presented in Chapter 3, followed a common structure developed with the contribution of Cecília Silva, Angela Hull, the editorial team of Chapter 3 and the Core Group. The structure of these reports was then discussed by WG2 during the Edinburgh meeting. Results of this discussion where then used to consolidate the final structure by the editorial team of Chapter 3. This editorial team has followed the production of the short reports closely, providing support to authors and working as reviewers of these reports which were developed in two stages, with an intermediate peer review stage.

The review presented in Chapter 1 and Chapter 2 was developed by two junior researchers. These reviews benefitted from the contributions of several members of the action, who provided literature and even their own publications on the reviewed subjects. In case of 0, some of these contributions went as far as becoming co-authors of the chapter.

The production of this report was coordinated by Angela Hull and Cecília Silva. English proofreading was done by Angela Hull. Final editing of the report and the design of the cover were developed by Tiago Patatas.

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List of Acronyms

ABICA: Activity based indicators of connections and access needs

ACCALC: Database suite for calculation of UK accessibility statistics

AIS: Accessibility Instrument Survey

ASAMeD: Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance

ATI: From Accessibility to the Land Development Potential

CAPITAL: CalculAtor for Public Transport Accessibility in London

CBD: Central Business District

CG: Core Group

DfT: Department for Transport

DLR: Docklands Light Rail

EMM: Erreichbarkeitsatlas der Europäischen Metropolregion München

GDATI: Geographic/Demographic Accessibility of Transport Infrastructure

GIS: Geographic Information System

GraBAM: Gravity-Based Accessibility measures for Integrated Transport-land Use Planning

HIMMELI: Heuristic three-level Instrument combining urban Morphology, Mobility, service Environments and Locational Information

IMaFa: Isochrone maps to facilities. Shopping centres in the Metrosur influence area

InViTo: Interactive Visualization Tool

JAD: Joint-accessibility Design

MaReSi SC: Method for arriving at maximum recommendable size of shopping centres

MC: Management Committee

MoSC: Measures of Street Connectivity: Spatialist_Lines

OS: Ordnance Survey

PST: Place Syntax Tool

PTALS: Public Transport Accessibility Levels

PTAM: Public Transport Accessibility Mapper

RIN: The German Guidelines for Integrated Network Design– binding accessibility standards

SAL: Structural Accessibility Layer

SNAMUTS: Spatial network analysis for multimodal urban transport systems"

SNAPTA: Spatial Network Analysis of Public Transport Accessibility

SONATA: Social Needs And Transport Accessibility

SoSINeTi: Social spatial influences of new transport infrastructure

STAG: Scottish Transport Appraisal Guidance

TMfS: Transport Model for Scotland

TRACE: Retail Cluster Accessibility

TRANSAM: Transport Accessibility Modelling

UrbCA: Cellular automata modeling for accessibility appraisal in spatial plans

WALC: Weighted Access for Local Catchments

WG: Working Group

WU: Work Unit

Chapter 1. ACCESSIBILITY MEASURES AND INSTRUMENTS

Saleem Karou, Angela Hull

There has been a growth of interest in the concept of accessibility in recent decades, with many accessibility studies published in the academic press discussing how to measure accessibility, the implementation of the concept of accessibility in urban planning and transport and the contribution such decision support tools might have. This interest in accessibility, more recently, has broadened such that there is a multitude of approaches used in the consideration of the development of accessibility instruments (or tools) and the contribution they could make to urban planning practice to inform land use and transport decision-making. This report focuses on these new approaches to accessibility modelling and aims to help practitioners choose the most appropriate accessibility instrument based on the urban management problem.

This chapter, however, seeks to provide a benchmark to these later instruments by categorising the 'first wave' of accessibility instruments developed using the descriptions of these instruments in the academic press. This documentary review is limited to the accessibility-based planning instruments in the English language academic press and seeks to explain early conceptualisations of accessibility and how the concept is measured and incorporated in the instrument.

The chapter has the following structure: Section 2.1 presents the categorisation and components of accessibility-based planning instruments that have been widely reported in the literature. Section 2.2 describes the aspects and dimensions of accessibility instruments while Section 2.3 focuses on accessibility modelling in a GIS environment. Section 2.4 takes a more thematic approach to the categorisation of accessibility instruments developed for urban planning practice using some of the most common accessibility instruments developed in Europe. This section explains the themes or approaches to accessibility, the concept(s) incorporated in the instrument and what is measured as well as further relevant technical issues of accessibility modelling including input and output data. Finally, Section 2.5 presents what can be seen as some of the omissions in the 'first wave' of accessibility instruments suggesting that that tool developers should address these omissions if accessibility instruments are to have wider application in urban management.

1.1. Categorisation and Components of Accessibility Instruments

The concept of accessibility is about movement and, in particular, about the ease of getting around from place to place. One can categorise the different derivations of accessibility into two broad families (Hull, 2011), The first, is focussed on mobility or the ability to travel and is derived from classical location theory which hypothesises that there is a direct correlation between changes in the transport system (e.g. transport costs) and journey length (Banister, 2002; Ney, 2001; Geurs and van Wee, 2006). This conception has held the attention of geographers and transport engineers interested in the geography of flows and the movement patterns between origins and destinations noting the average speeds and predicting the direct costs of travel.

From this conceptualisation has grown another derivation of accessibility which focuses more on the 'ease of reaching' a number of daily activities at different destinations. This conceptualisation is, therefore, interested in the ability of social groups to reach destinations where they can carry out a given activity as well as the transport network (Bhat et al, 2000; SEU, 2003). This conceptualisation of how efficiently the spatial distribution of services and facilities is connected/ integrated with the transport infrastructure creates a new challenge for tool developers and urban managers.

The academic literature deals more thoroughly with the first conceptualisation of accessibility than the second. Whilst this Action is more concerned with the second conceptualisation, it is important to understand the antecedents of the current wave of accessibility instruments. This section, therefore, examines earlier published work to identify and compare the use of accessibility components and how these are incorporated in the measurement of accessibility (see Martin and Dalvi, 1976; Geurs and Ritsema van Eck (2001); Jones et al, 2005). According to Martin and Dalvi (1976), there are three equally important components in modelling accessibility. These are people's preferences and choice groups, existing opportunities, and the degree or intensity of the transport service provided to tackle distances. Handy and Niemeier (1997) identified four key components of accessibility measures: the level and type of spatial separation, representation of origins and destinations, size of travel deterrence and size of attractiveness. In the study by Reneland (1998), accessibility indictors can be split into four groups by defining four aspects of accessibility: origins and destinations, time of day, available transport modes and the characteristics of passengers including gender, age, physical condition, and type of job. Geurs and Ritsema van Eck (2001) defined four types of components important in the measurement of accessibility including land use, transport, individual and temporal components. Further, Geurs and Ritsema van Eck show that these components may be affected by accessibility through feedback mechanisms.

Based on the authors above, in general three key elements have been commonly considered in the scientific academic literature to characterise accessibility measures: (1) a determined geographical "origin" location or category of people or freight that is being considered for accessibility, (2) a set of relevant destinations that might be weighted by the size or quality of associated opportunities, and (3) a measure of physical separation between (1) and (2) that is usually expressed in terms of time, distance or generalised cost.

Some accessibility instruments focus on origins or people, some on opportunities, and some on the connection. Accessibility instruments and models have been categorised in different ways (see Spiekermann and Neubauer, 2002; Transport Scotland, 2003; DHC, 2007). Scottish Transport Appraisal Guidance (STAG) used the objective of developing the indicators of local accessibility, by cycling and walking and the coverage of public transport network, as a basis for the categorisation of instruments (Transport Scotland, 2003). In this respect, three major categories have been presented as follows:

- Category 1- Accessibility instruments analysing walk times to public transport services or to local facilities. In these instruments, public transport systems are classified according to types of desired destination, frequency, mode, and time of day while local facilities are classified by an associated function. For example, Glasgow City Council Bus Network Coverage Model, and PTALS Models (e.g. Hammersmith and Fulham), etc.;

- Category 2 - Accessibility instruments analysing travel times using public transport systems and motorised vehicles through the motorway network. In these instruments, public transport networks are described in terms of journey planning techniques and destinations are expressed as opportunities, activities or places (e.g. CBD). For example, SONATA (Steer Davis Gleave), ACCMAP (MVA), APTT (Halcrow), ABRA (Colin Buchanan and Partners);
- Category 3 – Instruments or models that are not specifically developed to measure accessibility that, however, involve the process of accessibility modelling. These incorporate: land use models that describe the spatial interaction in terms of accessibility (e.g. DELTA, MEPLAN, LILT, TRANUS, etc.); demand models that measure accessibility change for input to an economic appraisal; and activity based models that estimate behaviour according to accessibility to opportunities. For example, four stage models used in conjunction with accessibility analysis processors - e.g. ACCALC (Derek Halden Consultancy), CSTM3, TMfS, SITM used in conjunction with the SPT accessibility model;

In the same context, Derek Halden Consultancy (2007) split the accessibility instruments available internationally into three categories based on their functionality. First, catchment instruments that are used by service providers such as public transport operators and retailers. These instruments help providers to plan suitably for residents/customers to enable access to their facilities based on the analysis of the local population and output information on potential customers within the catchment area. The second category of accessibility instruments is that obtained from public transport or road journey planners. These instruments usually focus only on calculation of the time required to reach desired destinations. The third category includes land use and transport models which are more complex compared with the catchment or journey planning instruments. These can incorporate information on different features such as the type of opportunity and traveller behaviour that can be connected with separate accessibility models to produce a better quality accessibility calculation.

This chapter takes the categorisation types used by the Scottish Transport Appraisal Guidance (see above) to illustrate the different approaches taken by tool developers in the first wave of accessibility instrument development. This categorisation connects well with the application of accessibility instruments in urban planning practice which is the main concern of this Action.

1.2. Dimensions of Accessibility

Accessibility instruments can be sensitive to a range of various dimensions or aspects which characterise the functionality and capability of the instrument. This section introduces several dimensions of accessibility modelling derived from the documentary review of the academic literature covering the last two decades. These aspects include:

1. Spatial separation (deterrence) factor: The spatial separation factor represents one or more attributes of the links between areas that separate places and people from the opportunities. These can be distance (crow-fly or network distance), travel time, travel cost, reliability, information, convenience, safety or other attribute that acts as a deterrent or constraint to access.
2. Type of accessibility indicator and the measurement of spatial separation: In many studies accessibility indicators have been split into different types based on different criteria. Geurs and Ritsema van Eck's categorisation is one of the most commonly referenced and has therefore been selected for this study. Geurs and Ritsema van Eck (2001) differentiated between infrastructure-based, activity-based and utility-based accessibility measures. Further, the activity-based measures were broken down into distance, contour potential accessibility, inverse balancing factors and space-time measures.
3. Origins: Accessibility can be measured from the point of view of different population groups (e.g. age, gender or social groups) or types of economic actors (e.g. firms or industries) in the area, or people using the area (e.g. tourists or travellers). The origins may be locations (location-based measures) or people such as economic actors (person-based measures).
4. Destinations, type of associated opportunities and measurement of their attractiveness: Accessibility to the location of an area can be measured with regard to activities, opportunities and assets; for example, population, business activities, universities, health services, shopping facilities or tourist attractions. The attractiveness of these opportunities can be measured in different dimensions such as population; number of employees, students, patients or facilities; the total gross floor area of facilities; volume of sales; percentage of gross domestic product; etc.
5. Input data and parameters: These incorporate all the data required to carry out accessibility planning and modelling which, according to Titheridge (2004), can be classified into three groups including data on transport infrastructure and operations, data on people and data on facilities and amenities.
6. Output of accessibility modelling: Modelling outputs vary according to the functionality and objective of the accessibility instrument.
7. Dimension of accessibility values: Most of the indicators that have been used in accessibility instruments present the accessibility of locations as non-dimensional values which are not comparable with each other. This complicates the output interpretation and assessment of infrastructure improvements. Ranking is a useful method that has been widely used by accessibility modellers for comparison of different accessibility measures (Baradaran and Ramjerdi, 2001).
8. Spatial detail and geographical scale: Accessibility analysis may be applied at a continental, transnational, interregional, regional, municipality or neighbourhood scale. The selection of detail and level of the analysis is based on the scale of the issues considered and the detail that needs to be

understood. Every spatial scale requires data of different spatial resolution with regard to area size and network representation; transfer time; and intra-area access and intra-node terminal.

9. Type of transport: Accessibility analysis might consider only personal travel or freight transport, or both.
10. Travel modes and mode choice: Accessibility might be measured for only one transport mode such as walking, bicycle, car, bus, rail, ferry, air, or bespoke services (i.e. patient transport or school transport). An accessibility model also might be run for a multi-modal transport system in which the choice between the modes is being considered based on particular criteria or where travel modes are specified by the model user.
11. Route choice: Accessibility might be measured taking into account the ability to make a choice between routes, for example minimum cost, minimum time, shortest distance, least amount of walking, route via a location or locations, route avoiding a location, include or exclude modes, etc (DHC, 2007).
12. Interchange options: Interchange options might be considered in accessibility analysis, for example minimum number of interchanges, minimum time for interchange, availability of guaranteed connections, through or avoiding a particular interchange.
13. Interchange points by facilities available: Accessibility analysis might consider the availability of facilities and services at interchange points; for example information, shelter, porters/ staff, CCTV, luggage trolleys, etc (DHC, 2007).
14. Scheduling: An accessibility instrument might be able to calculate accessibility taking into account target arrival or departure time or both, arrival or departure during a specified period, depart after, and arrive before (DHC, 2007).
15. Travel costs and fares: Accessibility analysis might consider travel cards and concessions, season tickets option, fares restricted by quota and time of day restrictions (DHC, 2007).
16. Walking time and waiting time (for public transport): Calculating accessibility by public transport should consider the total travel time of the journey including the walk access time to the public transport service, waiting time, in-vehicle time and interchange time. However, some accessibility instruments do not have the capability to consider all these details and calculate only in-vehicle travel time rather than the total time. Also, time of travel by public transport can be measured in different ways. Accessibility instruments might estimate it using service frequencies, actual service schedules for a specified time of day and day of the week, or based on speed limits and journey distance.
17. Real time updates and reliability: This reflects the instrument’s capability to take into account the change in journey time due to roadwork, congestion, delays, etc.

18. Type of vehicle: Accessibility analysis might consider the physical characteristics of vehicles such as luggage carrying capability, low floor bus, etc.
19. Day of the week, seasonal variations: An accessibility instrument might be able to calculate the difference between accessibility during week days and the weekend. Also, seasonal variations might be considered in an accessibility calculation.
20. Time of day: An accessibility instrument might be able to consider the calculation of accessibility in different times of the day, for example peak time or off-peak time.
21. Environmental impact: Accessibility instruments might provide some environmental information, for example, on the amount of emissions resulting from a journey.
22. Health impact: Some health information might be also provided by the accessibility instrument such as an amount of calories burnt off to carry out the journey.
23. Safety and security information: Accessibility instruments might consider safety and security issues during the journey including real and perceived safety, speed limits, presence of road crossing facilities and travel during darkness (e.g. lack of street lighting) (Halden, 2010).
24. Physical features: Accessibility can be measured whilst taking into account the physical features during the journey that, according to Halden (2010), are categorised into three groups including steep hills and topographic constraints, kerbs and physical obstructions, and surfacing and maintenance.
25. Non-spatial barriers: In addition to spatial constraints, the accessibility instrument might consider the non-spatial barriers between areas such as economical, political, cultural, legal or linguistic barriers. Non-spatial linkages between areas (e.g. complementary industrial composition) might be considered as well (Spiekermann and Neubauer, 2002).
26. Quality and environment of journey: Accessibility analysis may consider the quality and environment of travel that can be expressed in five features: opportunities for rest points and for shelter from weather, aesthetics and attractiveness of journey routes, comfort of vehicles and waiting places, support services during journey (e.g. catering), and help and assistance from public transport staff (Halden, 2010).
27. Information and booking: This may be considered in accessibility analysis by taking account of the availability of information needed to plan the journey, time spent for planning and booking the journey, and the availability of information during the journey itself.
28. Equity: Accessibility instruments may be developed to calculate accessibility for particular areas or groups in order to find out inequities in accessibility between poor and rich, urban and rural, central and peripheral, or nodal and interstitial areas.
29. Dynamics: Accessibility instruments may be developed to calculate accessibility for different points in time in order to identify changes in

accessibility due to investmentin transport infrastructure or the impacts of other transport policies (Spiekermann and Neubauer, 2002).

30. Land use analysis: Accessibility instruments may be developed to identify how changes in land use patterns and location choice affect accessibility.
31. Modelling programme: Most of the accessibility instruments have been developed to be run under a Geographic Information System (GIS) environment while some instruments rely more heavily on bespoke programming with a direct or indirect link with a GIS database.

1.3. Accessibility Modelling in a GIS Environment

With the rapid increase in computer power and availability of a wide range of electronic data sets, the dependence on GIS techniques for accessibility analysis has significantly risen in the last decade. GIS is well-known for its capability to analyse, model and visualise geographical data such as transport and socio-economic data. It facilitates the utilisation of quantitative geographical approaches within a digital environment. A GIS map can incorporate many and various layers of information that are accompanied with a linked database and which can demonstrate them in innovative ways (Grid, 3-D, thematic maps, etc.) to ease data interpretation (Wu and Hine, 2003).

In the past, GIS users used to analyse accessibility by using “buffer” and “overlay” tools. The main drawback of these conventional tools was their inability to consider the transport network. Accessibility was being measured based on crow-fly or Euclidean distances rather than using actual distances on the network. Furthermore, all the locations within the computed buffer zones were equally weighted which means the nearest location to the desired destination or service is as equivalent as the furthest one to the same destination (de Jong and van Eck, 1996; Geertman *et al.*, 2004).

In 1991, Geertman and Bosveld used potential measures based upon a real world transport network for the first time in GIS-based accessibility analysis (de Jong and van Eck, 1996). The analysis overcame the drawbacks of “buffer” and “overlay” functions, dividing the study area into many hexagonal tiles that are equal in size. The new GIS-based accessibility analysis usually uses accessibility measures that are especially designed in a way that can be integrated in a separate modelling programme with a direct or indirect link with the GIS database. An integrated GIS tool, ACCESS, was developed by Liu and Zhu, 2004, within the ArcView 3.2 offering flexible and interactive GIS environment that supports accessibility analysis for many planning and decision making applications on a whole urban area or region. Accessibility Analyst is another new ArcView extension which was also created by Liu and Zhu working with the other ArcView extensions such as Network Analyst, Spatial Analyst, Patch Analyst and 3D Analyst in order to run advanced potential models in addition to the usual potential and contour models.

Recently, a software package named Flowmap designed to analyse and display interaction or flow data between two different geographical locations was developed at the Faculty of Geosciences of the Utrecht University in the Netherlands (Utrecht University, 2011). Since most thematic mapping and GIS packages have little functionality for handling this type of information, Flowmap fills this gap in GIS packages by dealing with:

- Storage, visualisation and analysis of spatial flow patterns (e.g. trade flows and commuter journeys);
- Computing travel times, distances, or transport costs using a transport network map;
- Modelling the market areas of current or programmed services.

It presents some unique and practical graphical measures including catchment profile, location profile and proximity profile. All these abilities make Flowmap a very efficient technique that can be integrated in planning support systems especially in terms of facility and service location planning (Geertman *et al.*, 2003). However, since it is developed as an extension for a particular spatial analysis that is difficult to run in GIS packages, data management, network analysis and mapping functions in Flowmap are further behind those provided in GIS packages (Liu and Zhu, 2004).

Another main tool that can be linked to GIS to improve its analysis capability of developing transport models is ACCMAP. It is a trip access and travel time mapping package which provides an accessibility calculation from and to any point using travel costs through highway and public transport networks (Citilabs, a). ACCMAP is able to show the impact of network changes on the transport system by overlaying accessibility mapping on any background map. Also, the tool facilitates the generation of Public Transport Accessibility Level (PTAL) indices for different time periods using public transport services (Wu and Hine, 2003). Lately, a considerable development has been executed in the ACCMAP package by MVA and Citilabs on behalf of the UK Department for Transport (DfT) to build a new tool named Accession. This tool is able to measure accessibility using many more origin and destination combinations and to produce different types of indicators (Citilabs, a

1.4. Accessibility-based Planning Instruments

This section compares the different approaches to accessibility instrument development using the three-fold categorisation of instruments employed by Transport for Scotland in their Scottish Transport Appraisal Guidance (STAG). This categorisation is used to illustrate the different approaches to the access indicators used (see Section 2.1 above). The STAG categorisation is used here because it is consistent with the classifications articulated in the state of the art scientific literature (Handy and Niemeyer (1997), Geurts and vanWee (2006), and Silva (2008)) and at the same time relates easily with the context in which practitioners apply ideas on accessibility. As noted earlier, this English language review is heavily dependent on accessibility instruments developed in the United Kingdom.

1.4.1. Category 1: Accessibility by Public Transport

This first category includes accessibility instruments that examine the accessibility by public transport incorporating analysis of the walk times to public transport services or to local facilities.

Within this category are instruments that measure access to the public transport network at a geographical point without measuring the separation or interaction between places. One example of this approach is PTAL (Public Transport Accessibility Levels) which has been developed by the London Borough of Hammersmith and Fulham. PTAL deals only with the origin or destination of a journey using a set formula to measure the intensity of public transport provision at different points (bus stop or train station) within easy walking distance of each area or site (Jones *et al.*, 2005). This formula takes account of walk time to nearby public transport services, the number of services available, service reliability and average waiting time in order to score each location on a six-point scale (Halden *et al.* 2005). The main datasets required are the public transport network including locations of public transport stops, delineation of routes and schedule frequency in order produce the PTAL indices (Wu and Hine, 2003). The ACCMAP software has been used to facilitate the production of these indices for different time periods of public transport service. The output of the PTAL's analysis, expressed as a set of Accessibility Indices for a range of locations, is classified into six-value ranges and spatially mapped, and then defined in terms of Accessibility Levels.

Another examples of this category, which incorporates more robust measures of the perceived walk access times to bus stops and rail transport, is WALC (Weighted Access for Local Catchments) developed by the Transport Studies Group (TSG) at the University of Westminster. This is a walk access instrument based on a very detailed representation of the local walking network, covering pedestrian only routes, alleyways and short cuts. WALC calculates walk access times for different groups of people taking account of several limitations that accompany the local environment. These limitations include: the local terrain (e.g. steep hills); the lack of provision of a shelter and seating at bus stops; low levels of street lighting; and difficulties in crossing busy roads because of heavy traffic volumes, speeding traffic, barriers (e.g. guard railing) preventing crossing at convenient points and lack of safe crossing points (Jones et al, 2005). WALC aims to demonstrate how the consideration of the hindrances to walking (physical obstacles and individual limitations) will change and shrink the shape of standard catchment areas.

The instrument uses the catchment (contour) measure based on different walk speeds and maximum acceptable walk times to different public transport nodes, and with regard to the concerns of various population groups. Weighted values for lack of bus stop facilities (e.g. shelter and/or seating), steep gradients (=>1:5), low levels of street lighting, and absence of formal pedestrian crossing arrangements are used to produce the catchment areas. Several different types of data are required for calculating each catchment; these include (Jones et al, 2005):

- A road network including a detailed pedestrian network;
- The location of bus stops (and facilities available); crossing points; steep hills; lamp posts as well as lighting levels;
- The weighted perceptions of different groups in regard to each of the limitations associated with walk access; and
- Other relevant data, including data on traffic flow data and pavement characteristics.

After applying the various weighting factors to the pedestrian network and to certain railway stations / bus stops, the outputs of WALC analysis are presented using ArcGIS as maps showing how the catchment sizes differ from each other according to the type of population group. The analysis is able to generate three different types of catchment area for each of the socially disadvantaged groups considered, to/from selected railway stations and bus stops: unadjusted walk catchments (no penalties); daytime penalties catchments; and night time penalties catchments (Jones et al, 2005).

1.4.2. Category 2: Accessibility by motorised vehicles through the transport system

These are instruments that focus on the flow of motorised traffic through the motorway network. Instruments cover one or more motorised modes and describe the transport network in terms of journey planning techniques with destinations expressed as opportunities, activities or places.

One application that focuses only on the bus network accessibility and buses run by the same operator is PTAM (Public Transport Accessibility Mapper) developed by West Yorkshire Passenger Transport Executive. PTAM can generate both origin and destination-based indicators and has an integrated GIS-based accessibility mapping instrument that. The instrument measures the accessibility of a location or set of locations by calculating the total travel time by bus taking account of walking time (based on straight line walking distance from and to bus stops), bus waiting time (estimated from service frequencies) and bus journey time (calculated from bus timetable database) (Halden *et al.* 2005). In order to carry out an accessibility calculation, PTAM requires the following data (Jones *et al.*, 2005):

- Bus services databases including timetables, stops and routes;
- Ordnance Survey mapping illustrating road networks, different physical features and administrative boundaries;
- Census statistics including many population characteristics;
- Employment location characteristics, and;
- Facilities databases including information on the provision of retail, education, health, and leisure services.

The output of PTAM can be presented as isochrones on an Ordnance Survey background or as tables including census statistics, employment statistics and lists of facilities associated with their attributes (Jones *et al.*, 2005).

Another application that focuses on the bus network is SONATA (SOcial Needs And Transport Accessibility) which has been used by rural local authorities in the UK to address travel needs and prioritise their expenditure on rural public transport (DfT, 2000). SONATA is a technique that was developed by Steer Davies Gleave in the late 1980s to estimate travel needs and identify gaps in the transport network across a given area (Helm, 1999). It evaluates the extent to which the existing public transport services are able to meet people’s travel needs based on trip profiles estimated from maximum travel times and duration of purpose, and also test the effect of service changes and define those services that are most significant in meeting these needs (Cumbria County Council, 2002).

SONATA employs a combination of local surveys and social indicators to measure travel needs. It assigns total travel needs to particular journey purposes according to percentages obtained from travel survey data (Titheridge, 2004). The model analyses the use of bus services for work, health, senior education, leisure and shopping purposes. By applying car ownership, population and other socio-economic factors, numbers of unmet journeys can be estimated (Somerset County Council, 1997-2000).

The key output of SONATA is a prediction about the proportion of travel needs produced by each area which are met by the public transport networks. The output can be expressed in terms of need met/unmet. A mapping system has been included to present the results on a geographical base. Since SONATA measures fulfilment of different types of travel need separately, it is possible to map needs met for each journey purpose at different times of day. In addition, SONATA is able to generate a report on the number of travel needs that are met by each separate public transport service (Steer Davies Gleave, 2004).

Some instruments in this category can cover all the key features of journey time by public transport covering walking time, waiting time, in-vehicle time (actual not generalised/ weighted) and interchange time. An example of this type of instrument is CAPITAL (CalculAtor for Public Transport Accessibility in London).CAPITAL measures accessibility based on the minimum of total travel time between two zones using any combination of public transport modes in Greater London (i.e. bus, underground, Docklands Light Railway and national rail) in addition to walk access times (by assuming an average walk speed of 5km/h) to the public transport network (London Transport, 1999). However, accessibility cannot be calculated at different times of the day since data is only collected for the morning peak travel period. Furthermore, different population groups can be only considered in measuring accessibility in CAPITAL by using standard representative values for walk speeds, thresholds, etc. (Jones *et al.*, 2005).

The CAPITAL instrument combines information from Transport for London's Planning and Development Geographical Information System (PDGIS) and its public transport assignment model (RAILPLAN) (Jones *et al.*, 2005). CAPITAL relies on the Ordnance Survey Centre Alignment of Roads (OSCAR) database as a source of the road network in Greater London, containing all the major and minor roads, which has some supplementary information on walk links. RAILPLAN represents links, stops and services together with route characteristics (i.e. frequency) and uses a multi-routing assignment algorithm.

The analysis output is typically provided as shaded maps illustrating isochrones of journey travel times from and to a specific location, or set of locations using GIS mapping software. Further, the output file can be also presented as a spreadsheet where other types of analysis can be carried out (London Transport, 1999).

There are instruments in this category that support multi-modal travel including public transport, car, cycling and walking. Two examples of this approach are TRANSAM (TRANSport Accessibility Modelling) and Accession.

TRANSAM is an approach developed by Brown & Root to measure and quantify road network accessibility by competing travel modes and to analyse access changes in terms of network improvements and new public transport services. It provides the ability to make a comparison of accessibility measures for cycle, walk and public transport networks, or for a combination of these travel modes for the complete journey from origin through to destination (Robbins, 1999).

The TRANSAM model is based on a customised GIS which can create travel time contours based on the lowest generalised cost route for a range of travel modes (rail, bus, car, cycle and car) from all network nodes to the destination node. The calculation takes into account the walk time at the start and end of the public transport journey, the wait time at the bus stops and railway stations, and the on board travel time (Titheridge, 2004).

Data sets have to be set up in GIS for TRANSAM. These include the car network with the associated speed-flow relationships and observed volumetric information for each link; the public transport network (i.e. bus and rail) with the service time tables; cycle and walk networks; network nodes reflecting bus stops and railway stations; points of interest or "focal" points on the network such as transport interchanges, centres of employment and key hospitals; and other relevant statistical data (Robbins, 1999). By running TRANSAM, travel time contours will be created and then GIS can demonstrate visually the extent of travel attainable for acceptable combinations of travel modes. In this context, the output from TRANSAM is able to highlight the areas where levels of network accessibility for different travel modes are relatively low and high.

Accession is a travel access and travel time mapping package that was developed by MVA and Citilabs on behalf of the UK Department of Transport (Jones et al, 2005). It is built from a fully functional GIS with many features to help Local Authorities and their partners in: setting up strategic and action plans; the evolution and development of proposed actions; the prioritisation of resources; and the monitoring of accessibility strategies and action plans (DfT, 2004). Accession supports multi-modal travel and flexible routed and demand responsive transport modes (DfT, 2004).

The instrument measures accessibility to and from any point based on travel time, cost, distance or generalised cost through road and public transport networks (Titheridge, 2004). It is able to consider many origin and destination combinations in calculating accessibility and to generate different types of indicators (Halden *et al.* 2005). Accession offers a number of calculation methods: Threshold Hansen/ Gravity measure, Hansen/ Gravity Measure, Relative Hansen/ Gravity measure, Simple Utility or logsum measure or simple time-constrained accessibility (Citilabs, b). Access to local public transport is represented as a combination of walk time to a boarding point and the average wait time for a service. This can be calculated based on either the actual walk time or a straight-line walk time, while in-vehicle travel time is usually calculated based on scheduled arrival or departure times. The accessibility calculation can be carried out for specific catchment values of origins/ destinations, for selected modes, for particular routes/ services, and for particular days of the week and times of day (Titheridge, 2004). Moreover, other criteria can be considered in the analysis, for example road speed, maximum speed, frequency, start and end times, and delays for wheelchairs (Citilabs, b).

In order to measure accessibility, Accession requires a collection of data sets with regard to: public transport data (rail and bus) including boarding points and full timetables; the road network with the associated speed limits; walk and cycle links; and demographic and other data that can be disaggregated from census geography and other polygon systems onto origin points (Citilabs, b). The outputs of Accession can be presented as tables and various contours reflecting accessibility. Also, the results can be exported for mapping or analysis in other packages.

1.4.3. Category 3: Other models that incorporate accessibility

In this category are models and instruments that have not been developed specifically to measure accessibility that, however, incorporate some dimensions of accessibility modelling. Included in this category as examples are two land use and transport interaction models and a technique from urban space design.

GenMod

GenMod is a static multimodal transport model that was developed by the Transportation Planning Department of Amsterdam (DIVV) and the University of Amsterdam (Brömmelstroet and Bertolini, 2008). It is basically a traditional four-step model based on household surveys and mobility counts. As a by-product, GenMod can be used for measuring accessibility as it calculates travel times between 933 zones within the Amsterdam region using extensive public and car transport networks.

GenMod has been used to show the land use - transport system consequences of land use/ transport alternatives, by calculating network consequences (e.g. level of service), network opportunities (e.g. for more efficient use) and the dynamics of indicators that show the change from a baseline scenario; for example potential accessibility (e.g. the number of people or jobs accessible from each zone within acceptable travel time) and sustainability (e.g. the number of people or jobs reachable within a crow flight distance) (Brömmelstroet and Bertolini, 2008).

In order to run the model, land use data including the number of people or jobs held by zone, and road and public transport networks are required. The outputs of GenMod runs are presented as clear overviews of all the indicators used and spatial maps produced by GIS that help to define which land use - transport system choices have a negative effect on the chosen indicators and which a positive one. These can be used to build a list of appropriate land use transport choices and strategies.

TMfS (Transport Model for Scotland)

TMfS is a strategic, multi-modal demand and assignment model which was developed by MVA Consultancy, with its land-use capability developed by David Simmonds Consultancy (Transport Scotland, b).

The key objective of TMfS is to enable the Scottish Government and Local Authorities across Scotland to examine the impact of and/or interaction between major inter-urban road and public transport schemes and major transport policy options in forecast years (MVA, 2006) TMfS measures the implications of these schemes for accessibility and travel demand and, consequently, helps Local Authorities in prioritising and scheduling their transport interventions (Transport Scotland, a). Other objectives are to undertake economic, traffic and land-use assessments of proposed transport schemes and policies, and also to produce robust traffic forecasts on all Trunk Roads within the model area (Transport Scotland, b; MVA, 2006).

An accessibility analysis package is included as an add-on to the basic TMfS model. The analysis uses the output costs obtained from running the basic model along with several parameters specified by the user, and produces a number of accessibility measures. These measures can be for either destinations or origins and can be weighted by demographic and socio-economic data related to each geographical zone such as the number in employment or the number of households (Transport Scotland, b). The model takes into account the main responses of passengers to schemes or policies such as destination choice, mode choice, route choice, trip frequency and peak spreading. A wide range of data is required to run TMfS which is built using a system of zones and a transport network. The main data include (Transport Scotland, b):

- Census and travel to work data including travel diaries, roadside and public transport passenger interview data, and rail ticket data;
- Planning data forecasts that are set up by Local Authorities and focus on future development land allocations for each TMfS zone;
- National/regional economic and geo-demographic assumptions;
- Public transport service data including routes, boarding points, fares and frequencies;
- Road network details including number of lanes, link lengths, junction lay-outs, typography, signal timings and speed limits, and;
- Count data including traffic counts, public transport user counts, turning counts at junctions and car park surveys.

This is a strategic regional model that generates a variety of outputs that can be used to evaluate policy initiatives or public transport and road infrastructure schemes as well as to predict changes in both transport and land use patterns over the model area. The key outputs available from TMfS are: operational analysis; accessibility analysis (that can be performed by linking the operational analysis of the transport model with graphical and tabular analysis of land use changes); congestion mapping; accident analysis; environmental analysis; economic and financial assessment; sub-area analysis; and demographic and land-use predictions (Transport Scotland, b; MVA, 2006).

Space Syntax

Space Syntax is a technique developed by Bill Hillier, Julienne Hanson and colleagues at the Bartlett, University College London that provides a spatial analysis of aspects and structure of space and helps to describe social activities and human behaviour from a spatial configuration perspective (Jiang et al, 2000). Space Syntax has been used to estimate the connectivity and, consequently, accessibility of architectural or urban spaces (i.e. buildings, open spaces, streets and cities) (Hillier, 1996). It is also able to define movement patterns and the degree of difficulty in mobility. Moreover, the instrument can be used for other applications including land-use distribution, criminal activity, estate prices and other spatial related characteristics.

The main principle of Space Syntax is to model a spatial structure as a set of axial lines and calculate spatial indices of a space in order to estimate the relation between various parts of indoor or urban spaces (Jun et al, 2007). Axial lines are lines of unhindered movement used in measuring accessibility, and they are defined as the least number of longest straight lines. This is illustrated with a connectivity graph where axial lines are represented as nodes and line intersections as links, which reverses the terminology used in the traditional method (Abubakar and Aina, 2006).

Three key measures using different configuration parameters can be applied in the calculation: "connectivity" which computes the degree that each space (node) is directly linked to other spaces (nodes) in the connectivity graph, "control" which computes the potential of any space to provide part of a route linking between any two spaces within a defined distance (modelling movement *through* spaces), and "integration" which computes relative depth from any space to all other spaces (modelling movement *to* spaces), and (Abubakar and Aina, 2006; Vaughan and Geddes, 2009).

In addition, three different types of distance calculation can be considered in accessibility analysis by using Space Syntax. These are metric (shortest paths), topological (fewest turns' paths) and geometric (least angle change paths). For example, when topological distance is applied, the most accessible sites are not those closest to all other sites in terms of metric distance, but rather those in terms of number of changes of direction through the journey (Hillier, Turner *et al.* 2007). The topological method, called depth-based accessibility, is commonly more significant since it assesses the complexity of routes within the defined area (Rose and Stonor, 2009). Depth of one node from another can be directly estimated by calculating the number of turns (or steps) between two nodes, while the depth of a node (or a street) in a particular step distance is measured by the number of nodes that are separated from that node by the given number of steps (Jun et al, 2007). However, the Space Syntax-based measure has a key weakness in calculating the actual journey length since it does not considertraditional travel costs such as travel time or distance (Jun et al, 2007).

In order to measure accessibility in Space Syntax, the transport network (i.e. public transport services, roads, cycle and/or walk routes) as well as the associated lengths of the network links are required to be built. The spatial indices derived from Space Syntax analysis reflect the extent to which a space (or node) is integrated and connected with other spaces (or nodes) in the studied area (Jun et al, 2007). The resulting maps can be presented in several scales of colours showing the different range of accessibility values (Vaughan and Geddes, 2009).

1.5. Recommendations for Accessibility Instruments Improvements

The review above has focused on accessibility instruments that are well described in the literature identifying some of the gaps in the coverage of accessibility. The following list summarizes a number of issues contributing to enhance the soundness of accessibility instruments.

However, it is not necessary that each accessibility instrument should consider all the recommendations listed below since the various objectives of accessibility analysis in planning practice require different considerations.

- Consider, in addition to public transport and car, other modes including walking and cycling;
- Consider all public transport networks (i.e. bus, rail, underground, ferry, air, etc) in the modelled area rather than the bus network only;
- Consider interchange options between public transport services of different operators and modes (e.g. bus, rail and underground);
- Consider interchange options based on the minimum time accepted for interchange, best route (fastest route, cheapest route or shortest distance), priority for interchange between public transport services of the same mode or operator, and/or minimum number of interchanges required to complete the journey;
- Considered the influence of specific times of day for specific days of the week (i.e. during weekday or the weekend) associated with access requirements to particular types of facility;
- Consider the declining attractiveness of potential destinations with increasing travel time (or distance) from an origin location, by using a distance decay measure (e.g. Hansen measure),
- Consider different walk access speeds according to area and type of population group;
- Consider different walk access thresholds (time or distance) to boarding point (bus stops and stations) according to area and type of population group;
- Consider real time updates due to traffic congestion, roadwork or delay;
- Consider physical features including physical obstructions, steep hills and topographic constraints, and maintenance and surfacing;
- Consider the type of vehicle to gain a better assessment of accessibility for a specific journey purpose or for some population groups. For example, a bus with luggage carrying capability for people travelling to an airport, and a bus with assigned space for a wheelchair/ pushchair for disabled people or those travelling with young children in pushchairs;
- Consider the quality and environment of the journey including opportunities for shelter from weather and for rest points; comfort of waiting areas and vehicles; attractiveness and aesthetics of walking routes; support services

when travelling (e.g. catering); and assistance and helpfulness of public transport staff;

- Consider the safety and security factor during the journey including real and perceived safety whether outside or in the vehicle, speed limits, obstructions during hours of darkness (e.g. lack of street lighting), and availability of road crossing facilities;
- Give an indication of the environmental impact of the route choice, for example emissions resulting from the journey;
- Be able to identify changes in demand and in land-use patterns that might result from an improvement – or deterioration – in accessibility in an area.

1.6. Conclusion

The importance of using accessibility instruments in planning practice has recently been rising in many countries. This chapter has reviewed the way in which accessibility instruments have been categorised in the literature focusing on the conceptualisation of accessibility and the dimensions modelled in the instruments.

To illustrate the approaches used by tool developers a three-fold categorisation was used which matched well with the state of the art categorisations by leading tool developers and related to how accessibility is being articulated by practitioners. Examples of each category were demonstrated to illustrate the general issues and themes. The chapter concluded with recommendations on how to improve accessibility instruments to make them more usable for urban management practitioners.

Chapter 2. ACCESSIBILITY IN PLANNING PRACTICE

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2.1 Introduction

There have been plenty of applications of accessibility analysis techniques since HANSEN introduced the issue of accessibility to the spatial planning sphere in 1959. Several methodological approaches with a great number of variations have been developed and tested in various case studies. Most of these case studies focus on issues concerning the mathematical accuracy of different accessibility indicators to address real world planning problems.

Consequently, the ability of modelers today to measure different aspects of accessibility with sophisticated, highly specific indicators is very advanced. The constant increase of computer-based calculation and data storage capacities allow highly disaggregated analyses to be carried out on normal office computers. Chapter 1 of this report has provided a detailed overview on the state-of-the-art of accessibility modeling, addressing the common indicator types as well as a number of accessibility planning software tools.

A question less often addressed by planning research is the usefulness of the available tools. In other words: are the available concepts of measuring accessibility and their implementation in the form of planning tools helpful for planners and decision-makers in making good plans and decisions? Do planning and communication processes benefit from these tools? Can they understand and interpret different kinds of accessibility indicators with regard to these planning contexts? Are the available software tools helpful in the sense that they enable planners to make use of accessibility analysis techniques in their everyday work?

This chapter of the report intends to deliver an overview of the knowledge that is available on these questions concerning the usefulness and applicability of accessibility planning methods and tools. To reach this goal, this chapter will sum up the relevant scientific literature and present a variety of relevant case studies. It must be pointed out though, that this chapter cannot provide a final and comprehensive overview of case studies since knowledge about these studies – especially regarding usefulness issues – is often scarcely documented, anecdotal and subjective. Therefore, this study rather tries to extract a number of hypothetical conclusions that may be drawn from those case studies that are known to the authors and have thus been taken into consideration for this report. These hypotheses may be used later on in the process of this COST action and beyond as a starting point for further research into the addressed issues.

2.2 Planning context

Planning practice is a quite diverse activity, and offers a variety of planning contexts where accessibility instruments can be useful in different ways. The planning contexts define what is required from the accessibility instrument in order to be useful. Here we will present a broad framework of planning contexts, within which the usefulness and usability of different accessibility instruments can be discussed. The chapter is heavily based on the works conducted in a previous COST action (Fischer *et al.*, 2010).

These planning processes are usually highly complex and often marked by controversy. Complexity is enhanced by issues of multi-layer governance, with transport decisions normally affecting different administrative levels (e.g. national, regional, local), systematic tiers (i.e. policy, plan, program, project) as well as sectors (e.g. transport, land use, energy).

2.2.1 Strategic – tactical – operational dimensions

Planning can normally be classified along strategic - tactical - operational dimensions. A number of decision making systems are organized along these dimensions. Land use and planning acts are often organized in this way (national guidelines, municipal land use plans, zoning plans), and the same could be said about sector plans (National transport plan, regional transport planning, local transport plans). Whether the planning process is strategic, tactical or operational will matter to determine which kind of accessibility instrument might be useful in a specific situation.

Decisions made at the *strategic level* are long-term decisions about what to do in order to achieve something. This could be generic decisions about how to e.g. reduce GHG emissions from transport, or more specific decisions about how to solve traffic and environment problems, like congestion on major roads or health problems caused by transport at the municipal level. Municipal overall plans would be classified as strategic plans, since they often strive at being strategic as well as comprehensive. The national transport plan would also be a strategic plan.

The tactical level is of a more medium term nature and considers how to achieve what is decided on at the strategic level, including decisions on alternatives.

Operational planning, finally, is more short term and concerns the actual implementation in ways that maximize the positive outcomes and minimize and mitigate negative effects and impacts. Zoning plans may often be considered as operational plans.

2.2.2 Various tasks in planning processes

The understanding of planning has changed over the past decades. Through the shifting discussions, however, some tasks seem to define planning and to be unavoidable in a practice defined as planning (Friedmann, 1987). Based on among others Friedmann (*ibid*) and Banfield (1959; 1973), the tasks involved in planning and decision-making may be listed as in Figure 2.1. These tasks are carried out in overall land use and transport planning as well as in zoning plan processes (at least they are supposed to be).

Planning and decision-making processes will normally not follow a direct course of action from task number one to task number nine. Rather, they are iterative processes, more to be understood as continuous discussions regarding where we are going, what needs to be changed, where we want to go, how to get there and whether a proposed project contributes to take us there or not.

1. Situation analysis and problem definition
2. Formulation of goals and objectives
3. Identification and design of alternatives
4. Identification, prediction and assessments of impacts and consequences for each alternative (impact assessment)
5. Comparison of alternatives with respect to consequences in relation to desired objectives and other values
6. Recommendations (planning proposals)
7. Decision about action, based on knowledge produced through the preceding steps and other knowledge
8. Implementation of the decision through appropriate institutions
9. Feedback and post-auditing

Figure 2.1: The classic description of tasks involved in planning and decision-making (based on among others BANFIELD (1959; 1973) and FRIEDMANN (1987))

Accessibility instruments can be applied in different ways and play different roles in several tasks of planning. For instance, when analysing the situation and defining the problems, accessibility instruments can be applied in a descriptive way illuminating the lack of accessibility to important services in certain areas. When assessing the effects and consequences of different alternatives, accessibility instruments can be used as analytical tools, helping to predict whether implementing a certain action would contribute to achieving defined objectives, as well as disclosing unwanted consequences. In feedback and post-auditing, accessibility instruments can be applied when comparing a previous situation, planned situations and the existing situation after implementing the action in question.

The different tasks in a planning process hence call for different kinds of accessibility instruments.

A framework for defining planning context when discussing the usefulness of accessibility instruments

Usefulness of accessibility instruments should be discussed in relation to the planning context.

Table 2.1 illustrates a framework for defining the planning contexts.

Table 2.1 The objective and expert knowledge in question may be prioritised or not and applied or not in each of the tasks involved in planning and decision-making processes, in different ways and for different reasons

Questions/issues Tasks	Strategic	Tactical	Operational
Problem definition			
Formulation of objectives			
Identification of alternatives			
Impact assessments			
Comparison of alternatives			
Recommendation - plan			
Decision made			
Implementation			
Feedback			

2.3 The baseline – literature review

To develop a baseline of understanding and knowledge on usefulness aspects with regard to accessibility analysis methods and tools Geurs and Van Eck's work "Accessibility Measures: review and applications" (2001) is the relevant text. In their report, the authors introduce and test as well as evaluate different techniques of measuring accessibility.

While the focus of Geurs/Van Eck's work lies rather on methodological aspects of different types of accessibility indicators, they also cover the aspect of usefulness on a general level. Categories they use for this evaluation are:

- Interpretability;
- data need and;
- usability.

Their main finding is that "the most simple activity-based measures are the most easy to interpret, (...) the potential accessibility measure is somewhat less easily interpreted" whereas "more theoretically and methodologically sound accessibility measures (...) are even more difficult to interpret" (ibid, p.135). It is not surprising that this ranking turns out to be vice versa for the issue of data need: apparently ease of interpretation is a direct consequence of a small variety of information being subject to a very limited and simple series of data processing steps. (For more detailed discussions of advantages and disadvantages of different indicator types, see e.g. Handy and Niemeier, 1997; Geurs and Van Eck, 2001; Bertolini *et al.*, 2005.)

The term "usability" is used by Geurs and Van Eck in the sense of a measure's ability and validity in capturing and adequately representing certain aspects of the real world.

They point out that some measures (e.g. utility-based measures) are most usable in the context of economic appraisals due to their methodological proximity to economic welfare theory, whereas others (e.g. activity-based measures) are most usable with regard to social evaluations and the analysis of equity issues.

Finally, Geurs and Van Eck conclude that “there seems to be trade-off between the ‘common-sense’ interpretability and methodological soundness of the measure” (ibid, p. 138).

In a more recent work, Geurs and Van Wee (2004) discussed four criteria to evaluate usability: (1) theoretical basis, (2) operationalisation, (3) interpretability and communicability, and (4) usability in social and economic evaluations.

Thus, from the theoretical basis side, these authors argue that an accessibility measure should firstly be sensitive to changes in the transport system, secondly, an accessibility measure should be sensitive to changes in the land-use system and, thirdly, a measure should be sensitive to temporal constraints of opportunities. Finally, a measure should take individual needs, abilities and opportunities into account. These criteria are not considered absolute; applying the full set of criteria would imply a level of complexity and detail that can probably never be achieved in practice. Thus in practical applications, different situations and study purposes demand different approaches. However, it is important to realize the implications of ignoring one or more of these criteria.

Operationalisation is the ease with which the measure can be used in practice, for example, in ascertaining availability of data, models and techniques, and time and budget. It is interesting that the authors highlight that this criterion will usually be in conflict with one or more of the theoretical criteria described above.

In regard to Interpretability and communicability, researchers, planners and policy makers should be able to understand and interpret the measure, otherwise it is not likely to be used in evaluation studies of land use and/or transport developments or policies, and will thus have no impact on the policy making process.

Geurs and Van Wee (2004) uphold that infrastructure-based accessibility measures are easy to interpret and communicate but they lack the land-use component, and temporal and individual elements. More complex location- and utility-based accessibility measures can be considered effective measures of accessibility, which can also be used as input for social and economic evaluations. That is they overcome the most important shortcomings of infrastructure-based measures, but they exclude individuals’ spatial–temporal constraints typically included in person- based accessibility measures. Furthermore, these person-based measures are, in Geurs and Van Wee opinion (2004) potentially very useful for social evaluations, and may also be tied to the utility-based approach, which gives the practitioners the possibility of using them in economic evaluations. On the other hand, person-based measures have some disadvantages related to data availability and complexity, hindering their application.

Moreover, if we look at activity-based transport models, they don´t link daily activity patterns with long-term spatial behavior of household and firms, which does not facilitate their use in land use and transportation investments decision making.

Despite the relevance of methodological soundness, Ross brings into the debate that the purpose of an accessibility indicator is not only to adequately measure but also to "*communicate a trend of events, and to simplify our understanding of these*." (Ross, 2010, p. 3)

These aspects of simplification and communication refer to a more process-oriented understanding of accessibility indicators. According to this indicators should not be expected to contain an objective truth that we can extract with the adequate mathematical method, but rather to be a means towards establishing a common language for planners from different domains (e.g. land use and transport) as described by te Brömmelstroet (2008) and Straatemeier and Bertolini (2008).

Consequently, Ross expects the following principles to be met by a useful accessibility indicator: "it should be simple to use and understand; it should identify the means of improving accessibility; and it must be based on credible data with a convincing and rational method of calculation". (Ross, 2000, p. 3)

This statement finally includes a further very interesting aspect of an indicator's usefulness: its ability to indicate starting points for accessibility-improvement measures.

In conclusion, it can be stated that the usefulness of accessibility indicators is determined by the following aspects: an indicator should be

- methodologically adequate;
- understandable / interpretable;
- solution-oriented and;
- supportive of interdisciplinary communication.

These aspects bear the potential of being in conflict with each other to a certain extent. Consequently, a useful indicator would be one that achieves an ideal trade-off between these aspects with regard to a specific planning problem and within the technological boundaries of data need and computing speeds.

This very issue of a trade-off between methodological and process-oriented criteria is also confirmed by Straatemeier and Bertolini (2008) as a key finding from a series of accessibility planning workshops with practitioners from the Netherlands: they conclude that "*that making accessibility useful means finding the right balance between* relevant perceptions of accessibility without sacrificing appropriate standards of rigor" (ibid, p. 10) and that useful indicators need to be developed in close cooperation with the practitioners.

Less focused on accessibility but more generally looking into Planning Support Systems in the field of Land-Use and Transport Planning is the research conducted by te Brömmelstroet (2010). A survey among 450 Dutch planning practitioners brought up some interesting findings: the Planning Support Systems typically used by the surveyed practitioners

- "do not sufficiently support the generation of new strategies" but;
- adequately support the evaluation of strategies";

- are “not providing enough insight in crucial Land-Use and Transport relationships”;
- are “used to justify existing positions”. (te Brömmelstroet, 2010, p. 32).
- The survey identified the following issues as the most severe obstacles towards a more successful use of Planning Support Systems. They are perceived to be “not transparent”, “not user friendly”, “not interactive” and to have a “low communication value” (te Brömmelstroet, 2010, p. 33).

2.4 Accessibility as part of planning guidelines and laws

2.4.1 Accessibility Planning in the UK

One of the most well-established examples for a systematic integration of accessibility indicators and analysis into legal planning procedures is the UK’s Accessibility Planning scheme. Since 2006, English counties are required by the UK Department of Transport (DfT) to incorporate Accessibility Planning into their Local Transport Plans.

The origins of developing Accessibility Planning in the UK lie in the discussion on social exclusion. Therefore “the primary purpose of accessibility planning is to promote social inclusion by improving the ability of disadvantaged groups and areas to access the job opportunities and essential public services that they need. It should be based on an improved assessment of accessibility problems and the joined-up planning and delivery of transport and other services.” (DfT 2004, p.19)

With “Accessibility Planning Guidance”, the DfT has documented the approach that local actors are supposed to pursue, providing information and assistance on the process as a whole, the use of accessibility indicators and the integration of different stakeholders into the planning procedure.

The guidance recommends that Accessibility Planning should be organized as a continuous process consisting of 5 stages:

- Strategic Accessibility Assessments;
- Local Accessibility Assessments;
- Option Appraisal;
- Accessibility Plan Preparation;
- Performance Monitoring and Evaluation.

The DfT calculates a variety of core accessibility indicators that are available on a small geographic scale for the whole country. It recommends the additional calculation of local accessibility indicators to be used for assessment and monitoring purposes.

The following figure illustrates how accessibility indicators are supposed to be used in the accessibility planning process.

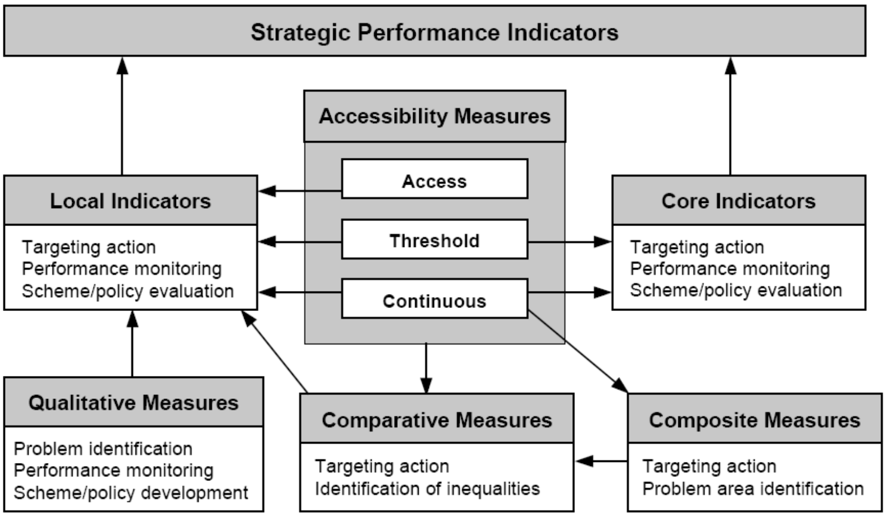

Figure 2.2 Usage of accessibility indicators in the UK Accessibility Planning scheme (Source: DfT 2004)

Due to Accessibility Planning being a large-scale project initiated by the central government and applicable to all of England, it is one of the very few accessibility-based planning approaches that is being evaluated systematically, not only from a technical perspective but also from a user perspective.

Bishop presented some first conclusions on Accessibility Planning at the European Transport Conference 2007. Key findings were:

- Accessibility analyses are “generally too transport-focused and (...) lacking a depth of understanding”;
- “Partnerships (are) limited to ‘easy to reach’ stakeholders such as other council departments; neighbouring local authorities; and those with existing contact.” (Bishop, 2007, p.10).

The University of Leeds has evaluated Accessibility Planning and carried out a survey among local planners within a PhD project. The following are some key results from this survey:

- Accessibility Planning as an independent planning approach is conceived to be useful by a majority of respondents, despite only half of respondents thinking that the contents behind the approach were particularly new (Envall, 2007);
- Despite some doubts on the reliability of the nationally calculated walking and cycling indicators, “*planners identified the use of accessibility indicators as a key strength of the new planning concept.*” (ibid, p. 210) Unfortunately, the survey does not allow deeper insights into why the indicators are perceived so positively;

- Data availability is not a serious obstacle towards detailed accessibility assessments;
- The hypothesis “that there is a significant problem in specifying useful accessibility indicators and that this is a barrier to effective Accessibility Planning“(ibid, p. 216) was confirmed.

These two reviews of the UK accessibility scheme apparently do not allow a definitive assessment of its usefulness. Nonetheless, it is interesting to observe, that criticism is targeted less toward issues like interpretability or data needs but rather to what Geurs and Van Eck (2001) referred to as usability. In other words, there are serious doubts concerning whether the used indicators adequately reflect the complexity of the planning problems to be solved, that they ‘lack depth of understanding’ and that there is a ‘significant problem’ in specifying useful accessibility indicators.

In the light of this finding, it is interesting to quote Halden (2011), who describes a “*widespread abuse*” of accessibility measures. This abuse includes that

- “National measures are adopted by local authorities (...) without questioning whether the assumptions are relevant”;
- “Planning decisions have been made (...) without sufficient thought about what indicator might be relevant or useful”;
- “indicators have been used tactically, to make the case for a development look artificially strong or weak” (Halden 2011, p.15).

Halden refers these problems to the enormous amount (468 different types) of national indicators and sees a need for “*a clearer typology of measures which may help to overcome past difficulties*.” (ibid, p. 18) Yet, it should be noted that the types of accessibility measures used to calculate the UK National Accessibility Indicators mainly belong to the family of threshold measures (e.g. opportunity available within travel time threshold, number of people or opportunities within certain catchment areas) supported by some continuous measures and a so-called frequency score (representing the varying transport service qualities throughout a day) (cp. Halden, 2011). These measures are usually considered to have a low to moderate level of complexity and thus a rather high level of interpretability. Nonetheless many planners do not work with these indicators in an appropriate manner. There is an obvious barrier between theory and practice of accessibility indicators. Using these indicators – in this case very simple and “interpretable” ones – does not guarantee good planning.

Further input to this discussion might be given by a project on “Process and Impact Evaluation of Accessibility Planning” that is being carried out by Loughborough University and is still going on. Results are expected within 2012 but were not available for this report.

2.4.2 Accessibility Standards in German Planning Law

An important backbone of Spatial Planning in Germany is the “System of Central Places” which requires regional planning authorities to assign different levels of centrality to certain cities. For the different centrality levels there are a variety of standards regarding the services that should be available in the city (e.g. education, health facilities). This System of Central Places is supposed to ensure a basic level of service provision for the population and to concentrate spatial developments. The transport-related legislation in Germany defines certain standards of accessibility that should be met with regard to the accessibility of these central places and thus to the services provided by them. These standards are defined in terms of travel time. A binding network planning guideline provides some fundamental standards with regard to the System of Central Places is the "Richtline für Integrierte Netzgestaltung" (RIN) which is discussed in more detail in section 3 of this report.

For Local Public Transport Plans in Germany, the usage of accessibility standards belongs to the state-of-the-art. The following types of indicators are mostly used (cp. Schäfer-Sparenberg *et al.*, 2006; Schwarze, 2005):

- Indicators that define travel time standards with regard to the above-mentioned central places (rural areas) or to central areas of cities (urban areas);
- Indicators describing the areal coverage of the public transport system (percentage of population within a certain distance threshold of a public transport stop).

Methodologically, these accessibility measures belong to the type of "contour measures" which are generally assumed to have a high degree of interpretability. Data and software requirements depend on the degree of precision of the calculations but are also limited. Schwarze criticizes that these stated accessibility indicators, although used to evaluate the existing public transport supply, are only rarely used to evaluate planning scenarios, thus reducing the understandability and transparency of the planning process and its conclusions. Hence, the problem in this case is not a lack of usefulness of the indicators but rather an inconsistent usage of the indicators within the planning process.

Whilst the general objectives and standards of public transport and service provision as well as the appropriateness of the System of Central Places for present-day planning issues are frequently debated in Germany, the literature review conducted here did not result in specific findings on the usefulness of accessibility indicators in planning processes.

2.4.3 Accessibility Standards in Sweden

In Sweden there is a growing interest for accessibility analysis in a wide range of urban planning issues brought forward by the use of GIS in Swedish municipalities and an extensive access to geographic data. Beside the use of transport models for analyzing car transport systems municipalities and regions have analyzed access with public transport and have started to use these analyses as a background for guidelines. For example the municipality of Gothenburg has proposed guidelines for car parking standards based on the access to public transport.

There are some Swedish cities that use accessibility guidelines for park planning, such as the required distance to a park or playground from residential entrances. The guidelines define different distances for different kinds of parks and their staying values. They are based on Swedish research where a strong correlation between pedestrian distance and people habits of using the parks have been observed. One example is the Stockholm park program. (cp. Sociotophandboken by the Municipality of Stockholm).

2.5 Single-case practice examples of accessibility tools and instruments

Innumerable case studies on accessibility measures and analyses have been performed in the last years and decades using a wide variety of methodologies and addressing all kinds of planning questions. Several tools that have been developed and are being used more or less systematically are presented in Chapter 1 of this report.

This section intends to elaborate on how useful accessibility measures and instruments are perceived by those working with them and how planning processes have benefited from the usage of these tools. While section 2.4 described some experiences with accessibility planning guidelines, this section (2.5) goes through a couple of case studies where accessibility tools and measures have been used within real-world planning processes. Generally, it can be said that there is hardly any evidence on this topic, be it quantitative or qualitative, scientific or anecdotal.

The following examples have been found to be interesting contributions to the debate on “Accessibility Instruments in Planning Practice” and give some insights on how these instruments have been integrated into processes and/or on the experiences made by the planners with these instruments.

2.5.1 100 station plan

An interesting case in Italy, in Naples, has been described in Papa (2011). The process of integrated planning between transport and the urban system started in 1994 with the formulation of the Strategies for Urban Planning. The process continued with the Urban Transport Plan (PCT), approved in 1997, the Primary Road Network Plan, approved in 2001 and the Urban Master Plan, approved in July 2003 and adopted in June 2004. Two fundamental methodological innovations were introduced in the transportation planning process. The first was to bring mobility, transport and urban system under a single planning process. The second was to draw up a systemic plan rather than a list of separate, uncoordinated interventions (Camerlingo, 2000).

This plan, approved by the Town Council on July 2003, is an innovative planning instrument. Defining “metro stations as an occasion for urban renewal”, it governs the transformation processes planning both interventions on the public transportation system and on the urban land-use system. The plan is directed to reduce the Neapolitan metropolitan area with its increasing car dependency, expanding the influence area of each station and increasing the accessibility from the public transportation system to major urban activities.

The analyzed application is an extreme case of integration between transportation and land-use planning. The approach used to define the planning methodology is a holistic approach, according to which the mobility system and the land-use system are integrated as far as the activity locations in the territory and the opportunity of displacements offered is concerned.

The strategies and the effects of the plan are evaluated and measured with the support of an integrated transport model and by a 100 Stations GIS, which integrates transportation infrastructure data, socio-economic data, pedestrian paths times and costs, location of major urban activities and specifications of the major projects of urban transformations in the new stations' influence areas.

The relevance of this work to planning consists in providing a methodology for the definition of an land-use and transportation plan as well as a decision support tool for governing the urban transformation processes.

The strategies to attain these goals consist of the development of an integrated and balanced transport system, the integration among the transport supply interventions and the travel demand measures, the available financial resources and the system's economic efficiency. These strategies have been translated into some operational measures. For the public transport system in particular, the plan defines the network integration of the existing lines, the extension of the influence area of the existing lines, through the realization of new stations, the development of new rail axes, the definition for the bus system as the feeder function to the rail transport network (Comune Di Napoli, 1997). The Urban Transport Plan (PCT) faces for the first time in systematic way the problem of the accessibility to the rail lines. The interventions of the Urban Transport Plan are imposed by travel and accessibility demands and vice versa, new urban locations are been influenced by the accessibility offered by the rail lines. In fact, this strong connection was underlined, defining the Urban Transport Plan as an integral part of the Urban Master Plan (PRG). The interrelations between the urban planning choices and the Urban Transport Plan are first of all those to locate trip attractiveness activities in accessible areas. The stations assume the role of central element around which the urban renewal and regeneration of the urban system is reorganized (Cascetta, 2001).

The 100 Stations Plan is inserted into this process of integrated transport land-use planning and represents the last footstep of the planning process. Starting from the programmatic indications of the Urban Transport Plan (PCT), it is oriented to increase the accessibility to the rail transport system stations and to implement processes of urban renewal in the new stations' influence areas. The 100 Stations Plan proposes to increase and to regenerate the territory served by the rail transport system, with interventions oriented to improve the accessibility from and to the 100 stations, to improve the architectural quality of the station buildings and the urban quality of the areas where the stations are located. The stations are defined as "occasions of urban renewal" and, constituting the point of contact between the urban system and the transport system, they represent some strategic nodes for the integrated planning of the transport and the urban activities system (Comune Di Napoli, 2001).

The tools and the analytical models for the impact verification of the different scenarios and for the management of the transformations are a mathematical simulation model and the 100 Stations GIS.

The decision support tools have been used in the study phase of the present state, in the interventions definition phase and in the scenarios simulation phase.

The Geographical Informative System (GIS) has the purpose to acquire, to integrate, to elaborate and to represent the geo-referenced data concerning the integrated transport-land use system. The Stations GIS includes maps, geo-referenced transport supply data (viability, rail stations, cars and bus stops), activities system data (census parcels data, location of activities), influence stations areas data (census parcels belonging to the station's influence areas), transport supply and demand interaction data (ingoing and outgoing persons from the stations and the percentage of the access modes to the stations from 7.00 to 9.30 a.m.).

The interrelations between the urban planning choices and the Urban Transport Plan are first of all those to locate trip attractiveness activities in accessible areas. The stations assume the role of central element around which reorganizes the urban renewal and regeneration of the urban system (Cascetta, 2001).

The relevance of this work to planning education and practice consists in providing a methodology for the definition of a land-use and transportation plan as well as a decision support tool for governing the urban transformation processes. In fact, with the aid of this decision support tool, three scenarios for the study case of Municipio station were defined: a "transportation" scenario, an "archaeological" scenario and an "integrated" scenario. This leads to the project of a metro station which is also an outdoors archaeological museum, ensuring the development of the urban environment quality.

2.5.2 Bahn.Ville 2

Bahn.Ville 2 was an application-oriented French-German research cooperation on railway-oriented development in the years 2007-2010. Based on the empirical findings of the preceding project Bahn.Ville, Bahn.Ville 2 aimed at verifying these findings through their successful implementation within two case study projects: the railway corridor between St. Etienne and Firminy in the French region Rhône-Alpes and the German Taunusbahn corridor in the metropolitan region Frankfurt/Rhein-Main (cp. L'hostis *et al.* (2009) for French project; Bahn-Ville2-Konsortium (2010) for German project). Both of these case study projects used accessibility analyses to support the local planning processes.

Methodologically, both teams used quite different approaches. While the French team used a broad set of rather simple accessibility measures (infrastructure and contour measures), the German team aimed at aggregating the available data within one land-use - accessibility index, referring to the Australian Luptai (Land-use and Public Transport Accessibility Index, cp. Pitot *et al.*, 2005). Keller and Leysens (2011) have conducted a comparative review of the two approaches, concluding that accessibility planning frameworks need to deliver differentiated information that are able to provide a "*complete picture of a location's accessibility*" (ibid, p. 20) which can only be transmitted by a set of differentiated indicators. These differentiated indicators should be complemented by "*guidance and methods that assist planners and decision-makers in aggregating and weighting the different aspects of accessibility*" (ibid, p.20). Finally Keller and Leysens (2011, p. 20) conclude that "*such tools and methods could also be useful to develop a "knowledge of cooperation" among the planners and decision-makers because they are easily understandable and facilitate the collaborative work and create a "common language"* ".

2.5.3 Scandinavia

The Denser Stockholm project (Regionalplanekontoret, 2009) is focused on comprehensive planning at the regional level. This uses a densification potential analysis model which can depict how the densification need, densification pressure, densification room, and densification freedom together create the potential for urban development. One of the key analyses for densification pressure potential has been the analyses of spatial accessibility in street networks. The street network links the city's public spaces and is the basic prerequisite for integration and exchange. Streets, not roads, that link urban districts and neighborhoods may present the strongest driver of future urban development. Another key factor has been the accessibility to green spaces which has been a focus question in terms of the Swedish densification debate. When density is increased in urban areas with little green space, such as on brownfield land, parks must be developed to create dense mixed use. Urban nodes that need park development in conjunction with densification are particularly great, due to limited open space and access to parks and nature areas. Peripheral parts of many other urban nodes, however, are areas with very little need for park development when density increases. The accessibility analysis is produced with the place syntax tool, an application to MapInfo in GIS.

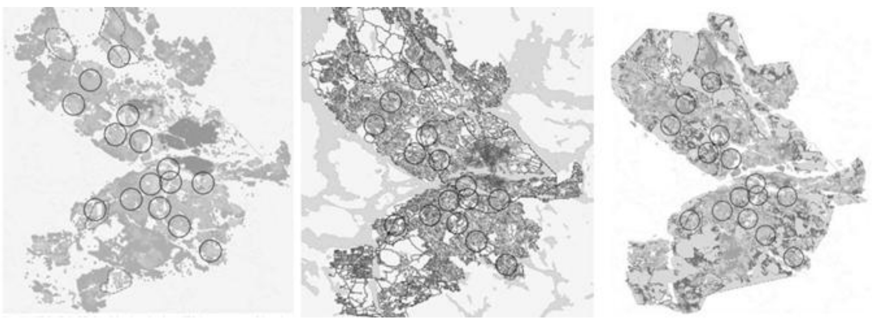

Figure 2.3 - Population density within 1 km /Spatial integration / Park access within 1 km in street network (REGIONALPLANEKONTORET 2009)

Aalborg University have used accessibility to examine the relationships between town, roads and landscape (Nielsen *et al.*, 2005). The project aimed to analyze the changes in urbanization and landscapes following the investments in motorways in Denmark since the 1960´s - and to set up a vision for future developments and spatial relations within motorway corridors. Accessibility analysis has been used to find out how many workplaces that can be reached within 30 minutes by car.

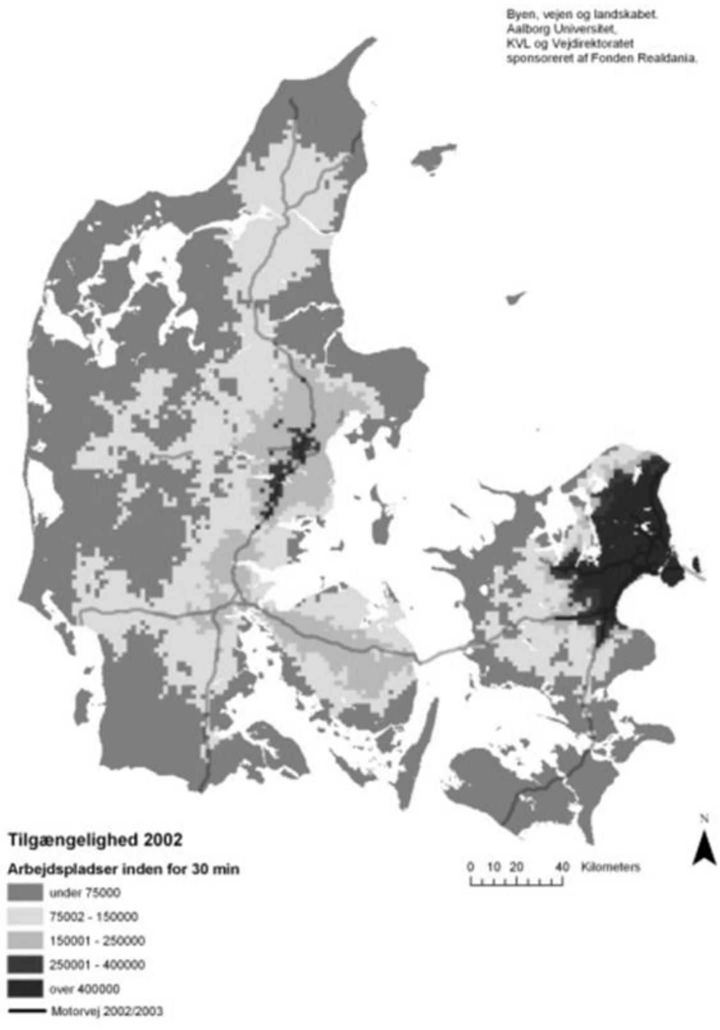

Figure 2.4 - Workplace accessibility in Denmark (Nielsen *et al.*, 2005)

2.5.4 Regional and national accessibility in Spain

There are several cases in Spain (Monzón *et al.*, in press; López, 2009) where some methodologies have been validated to assess the spatial equity or the territorial cohesion impacts of transport infrastructure plans based on the calculation of accessibility indicators.

The authors evaluate different transport infrastructures, such us: High Speed Rail (HSR) extensions or the Spanish Strategic Transport and Infrastructure Plan using different accessibility indicators. The case study applications show that the results are heavily influenced by the selection of the accessibility indicator, each one providing a complementary perspective on equity measurement.

In addition, they evaluate the effects at different planning levels: cities, regions, nations and adjacent regions. They demonstrate that the accessibility improvement and distribution caused by a new transport infrastructure depends on the study area considered.

The procedure uses spatial impact analysis techniques and is based on the computation of accessibility indicators, supported by a Geographical Information System (GIS).

Their main findings are:

The selection of the most appropriate indicator depends on the approach of the study. If the analysis is more focused on the economic implications of equity effects, one should choose an indicator with an economic foundation, such as the potential indicator. If our interest is more inclined towards an evaluation of the transport network quality, we should choose a more infrastructure-oriented indicator, such as the network efficiency indicator.

Accessibility benefits located outside the borders of the country under consideration should not be left out of the planning process. They have shown to constitute important additional benefits, which should justify a co-financing of the corresponding transport infrastructure investments.

In the analysis of HSR networks, there are several variables driving these differences in the cohesion results. First, they are explained mainly by the combination of population density distribution and the location of HSR stations. Second, the relative starting situation – in terms of accessibility – of the area and third, the quality of the access provided by the transport network from cities without a HSR station to the HSR network.

The risk of spatial polarization posed by HSR can clearly be seen in the Spanish case study. After the HSR extension, higher accessibility values are concentrated in the surroundings of HSR stations. The presence of HSR stations causes the existence of ‘‘islands’’ with enhanced levels of accessibility, and shadow areas in isolated locations. The size of these ‘‘islands’’ depends on the quality of the transport network from the surrounding cities to the nearest HSR station.

Other studies (Condeço-Melhorado *et al.*, 2011; Gutiérrez *et al.*, 2011) focus on the issue of spatial spillovers of transport infrastructure investment, where spillovers are defined as those accessibility gains felt in one region due to transport infrastructure built in other region.

The main objective of the study is a methodological proposal to measure spillovers based on accessibility indicators. The methodology was applied to evaluate the impacts of roads foreseen in the Spanish transport master plan (2005-2020). However this methodology can be applied to other transport modes. Impacts of the Spanish transport master plan were evaluated as accessibility gains and monetary gains.

The main results show that new roads in Spain will generate important spillovers, that is, accessibility gains will overpass the regional boundaries were they are allocated. On average 59% of the investment made by the Spanish Government in one particular region is exported to other regions due to spillovers. But spillovers are not homogeneous; their spatial distribution is influenced by several factors, such as:

- Distance to the new infrastructure: spillovers decrease with distance to the new road;
- Orientation of new roads: spillovers follow the direction of new roads, if a road has a North-South direction, the regions in the North and South of the section are better off than those located to the West and East;
- Spillovers of central regions are higher than those of peripheral regions, because the former bear more interregional traffic and benefit more bilateral relationships;
- Spillovers have a direct relationship with the amount invested in new roads:
- The location of the new highways within the region is an important factor. Since spillovers decrease with distance to the new roads, they are higher when roads are located in the regional border.

This tool has been applied in a post evaluation study of the Spanish transport master plan (2005-2020) funded by the Ministry of Public Works (Gutierrez *et al.*, 2010). However this measure has only been applied by academics. In our case we have applied this tool to measure the spillover effects of implementing different toll schemes in the interurban roads in Spain (Condeço-Melhorado *et al.*, 2011) or to evaluate spillovers of TEN-T projects using as case study a motorway linking Poland with Czech Republic, Austria and Slovakia (Gutiérrez *et al.*, 2011).

In every case, results show that investments in one region will generate accessibility impacts outside their boundaries (spillovers). This can be an important issue, especially in decentralized governments, since investment undertaken by individual regions or states may generate spillovers that are higher than the benefits for the region itself. When this occurs, spillovers can be used as a tool to negotiate some kind of national aid or participation of the most benefited regions in funding transport investments.

2.5.5 Space Syntax

There are many urban projects in practice where the space syntax methodology has been applied and even more research projects conducted around the world. Most of the urban projects in practice can be found in the websites of the practice Space Syntax Ltd (www.spacesyntax.com), of the practice Spacescape (www.spacescape.se) and a few in the proceedings of the Space Syntax Symposia (www.spacesyntax.net). Just a few representative ones are cited here.

Jeddah Strategic Planning (conducted by Space Syntax Ltd for the Municipality of Jeddah, Saudi Arabia, source: www.spacesyntax.com):

Space syntax was commissioned by the municipality of Jeddah to create a spatial development strategy for the city. The accessibility analysis aimed towards an evidence-based development strategy of the city by strengthening the city centre and its immediate surroundings by proposing new developments. The analysis helped first of all to identify and to understand the existing patterns of density, land use and socio-economic settlement and second to test different solution strategies and their impact. The outcome was urban design guidelines for each development area. The Strategic Planning Framework has been adopted by the Municipality of Jeddah in 2006 and is part of the emerging Jeddah Plan.

According to Space Syntax Ltd, questions that are addressed in the accessibility analysis for regional and urban projects like this one are:

- How much beneficial movement can be generated to and through the site?
- Which are the key linkages in a site?
- What impact the new development is likely to have on its setting?
- What are the appropriate kinds and densities of new land uses?

Beijing CBD (conducted by Space Syntax Ltd for Beijing CBD Administration Authority Chaoyang District Government, source: www.spacesyntax.com):

The brief for the competition of this project put significant emphasis on the themes of sustainability and people-centred design. The aim of the team of which Space Syntax Ltd was a member was to create a low carbon masterplan for the extension of Beijing's CBD. The problems of the area included high levels of vehicle traffic, high demands on public transport infrastructure, energy-intensive buildings, shortage of public open space and of convivial, non-commercial activities. Space Syntax contributed both visionary design thinking by setting the guiding principles and objective urban evaluation of the proposed spatial layout. The suggested masterplan includes a sustainable transport system in which pedestrian movement, cyclists and public transport usage are encouraged by connecting key routes for different transport modes at every scale.

According to Space Syntax Ltd, the main questions that are addressed in the accessibility analysis for masterplan projects like this one are:

- How should a masterplan design respond to the physical and environmental potentials of a site?
- How should the spatial layout be designed?
- How should land use and density be distributed within this layout?
- How can the social, economic and environmental impacts of development proposals be forecast?

Rotterdam South (Van Nes *et al.*, 2012):

The project presented in this paper is about the southern part of Rotterdam (more problematic, there is no demand for development, high unemployment, immigrant population) where the municipality wanted to test out various proposals for new bridges connecting it to the city's northern (more successful) part. A combination of three spatial analysis tools: Spacematrix (measuring density), Space Syntax (measuring integration) and Function Mix (measuring mix of functions) were used. These were correlated to one another and with socio-economic data through GIS. The analysis of the existing situation showed a correlation between the degree of mix of functions, density and integration meaning that the higher the angular integration, the higher the mix of functions and the density of the built mass. Based on this finding and on the analysis of the existing situation at the city level, the areas which are offering the highest priority for improvements were identified. These were those with high spatial integration of the street network and with low density in built mass. The spatial data of these areas were also combined with social data. Based on all this data a priority map for different types of interventions in each area was defined. Based on this map the location of the new bridge was chosen and this was tested with the same type of analysis to observe the effect it would have in the area.

According to the authors, the planners from the municipality acknowledge that these tools contribute to a much more fine-grained strategic planning for the area than the current Dutch planning practice does (Van Nes *et al.*, 2012, p. 8003).

The main questions that the above presented analysis attempted to address were (ibid, p.8003):

- What are the spatial conditions for the most attractive locations for lively and vital urban areas with a balanced mixture of functions? Which areas are more suitable than others to develop into quiet residential neighbourhoods?
- What are the spatial and functional effects of a new bridge (including public transport) connecting Rotterdam South to the North in relation to the first question? How can it affect the functional and spatial potentials for Rotterdam South?

2.6 Conclusions

While there are plenty of projects that apply accessibility measures in one way or another, the amount of research done on their practical value and their usefulness is still rather limited and fragmented.

While accessibility instruments in general are usually considered to bear the potential of providing a "common language" for planners from different fields, there is still a risk of indicators being too complex, abstract and therefore hard to interpret and comprehend for non-modelers. On the other hand, there is also serious doubt to whether the more simple accessibility indicators can really draw an adequately complex picture of real-world planning problems. In a recent study about the practitioners' perspectives of the use of accessibility measures (Curl *et al.*, 2011), there was recognition that using measures of accessibility only tells part of the story and the real barriers to individuals' accessibility are much more complex and harder to understand and quantify.

Interpretability generally appears to be in conflict with usability and because more complex indicators aggregate more information with more sophisticated mathematical methods, thus making them more abstract and less intuitively understandable. A first goal must therefore be to make these data aggregation methods more transparent as has been suggested by Keller and Leysens (2011). Nonetheless, at some point a trade-off will have to be found between interpretability and complexity of measures as claimed by Geurs and Van Eck (2001): the measures must provide the process with enough input and stimulation to lead to adequate solutions. This can only happen if the measures contain enough methodological substance to cover the relevant dimensions of a planning problem. But it also needs to be understandable and interpretable for all stakeholders involved.

To reach an ideal balance Straatemeier *et al.*, (2010, p.588) demand "that *research in planning should adopt a more experiential case-study design*" which means that planning practice and academia should cooperate in order "*to strike a balance between rigour and relevance, between knowledge that is on the one hand theoretically and empirically sound and on the other hand also useful for and valued by the practitioners who have to use this type of knowledge.*" (ibid, p. 588)

These findings describe the research agenda on how to arrive at useful indicators in the sense of achieving an ideal balance between methodological accuracy and interpretability of accessibility tools and indicators that promise to provide a common language for planners from different fields (e.g. urban, transport, environment). While this is without doubt a very important step towards more sustainable planning practices, several case studies (especially the analysis of the UK Accessibility Planning scheme) have shown that accessibility instruments, like all other planning tools, can also be exploited for individual interests through tactical usage of these indicators in order to support existing positions. A planning tool that can successfully contribute to a more sustainable planning practice will therefore have to address not only planners and experts that may see the world from different professional viewpoints but generally share the objective of working for public welfare; it will rather have to reach stakeholders from the private domain (companies, affected residents), non-profit organizations (environmental or social interest groups) and certain politicians that tend to prioritize individual interests over cooperative solutions that serve public welfare. A useful planning tool will have to be able to make plain to all stakeholders how individual interests can be reconciled with public interests and why cooperative strategies are more beneficial to all involved players than just defending one's own positions.

Engagement with local authority practitioners involved in Accessibility Planning in England (Curl, 2011) has highlighted the importance of understanding the local level, household and individual accessibilities in addition to the aggregate, national or regional picture if we are to properly understand the relationship between accessibility and associated outcomes, and therefore target interventions appropriately. Accessibility instruments and measures that help in different levels of planning can be complementary.

Chapter 3. ACCESSIBILITY INSTRUMENTS

Luca Bertolini (coordinator), Derek Halden, Sanna Iltanen, Bruno Santos

In this chapter, the accessibility instruments participating in the Action are described. As stated in the Memorandum of Understanding, these are the instruments that will be applied and improved in the course of the Action, in order to improve their usability and, with it, the effectiveness of instrumental support for accessibility planning in Europe.

The reports follow a similar format, in response to the guidance that was sent to the participants in the action and which is reported in Appendix A. The authors were asked to report on the background of the accessibility instrument (its scientific and/or practical motivation), its conceptual framework and theoretical underpinnings , operational aspects , relevance for planning practice, and strengths and limitations (with an eye at future improvements). In addition, they were asked to include some representative visualizations of the instrument output. In the last section of the chapter (section 3.23), the instruments y are compared with each other on each of these dimensions in order to identify the most salient similarities and differences and implications for the next steps of the Action. In the concluding part of this report (Chapter 5), these conclusions are integrated with those from other chapters.

3.1 Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS)

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3.1.1 Background

The Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) accessibility instrument was developed to fill a significant gap in planning for accessibility by providing a planning support tool that can be used to inform strategic land use and transport planning. Its first application was in providing a comparison of metropolitan accessibility by public transport for three centres within Greater Perth, Western Australia. Following this use it became clear that our instrument could be applied in a wide range of settings. As a result our research over the past five years has focussed on its use to support government decision making on re-structuring of metropolitan urban form to support public transport (and vice versa) and developing a twenty year investment strategy for public transport services and new infrastructure. To answer these types of questions we realised that the instrument needed to be developed in a way that could forge constructive collaborations between transport and land use planning agendas. The tool needed to have a function of trans-disciplinary communication in order that land use transport integration be fully understood and achieved. A focus on accessibility can introduce land use considerations into conventional transport models, and conversely, land use planning can be enhanced by better understanding of the mobility implications of particular urban forms. It was also important for us to develop an instrument whereby the dissemination of accessibility measures through visual media offered a means to enhance understanding, making a contribution towards a productive discourse on future directions for urban form and mobility, engaging a wide range of stakeholders and thus helping to bring this important challenge further into the public arena.

3.1.2 Conceptual framework and theoretical underpinnings

SNAMUTS is a GIS-based tool to assess the relationship between public transport network configuration, performance and service standards on the one hand, and the geographical distribution or clustering of land use activities across a metropolitan area on the other hand.

SNAMUTS breaks down the land use-transport system into a set of activity nodes and route segments derived from the hierarchy of activity centres identified in strategic planning documents, and the location and service standard of public transport routes. In particular, SNAMUTS makes the following definitions:

Minimum service standard: SNAMUTS defines a *minimum standard* for inclusion of a public transport route into the analysed network, requiring a service frequency of 20 minutes (or better) during the weekday inter-peak period (about 10.00 to 15.00) and 30 minutes (or better) during the day on Saturdays and Sundays. This level has been chosen as it reflects the minimum for public transport to be perceived as having a full-time presence and attracting usage for a variety of both planned and spontaneous journey purposes. More specifically this approach aims to set public transport accessibility on a level playing field with accessibility by car, thus providing the real possibility for the traveller to choose between modes. In so doing this sets a standard for design of the future transport service (and land use patterns) where accessibility by public transport is possible for as many travellers across the metropolitan area as possible (where accessibility by public transport is the objective of governments).

Activity nodes: these refer to the list of higher-order activity centres across a metropolitan area (principal, major and specialised) that appear in strategic planning documents such as Melbourne 2030 and Melbourne @ 5 million or Perth's Network City and Directions 2031. There are also some major transfer points and some linear corridors along high-frequency tram or bus lines captured where they play an important role in the network. In some cases, a designated activity centre may contain more than one SNAMUTS *activity node*.

Each *activity node* is assigned an exclusive catchment of residents and jobs located within walking distance from the associated rail station(s) (800 m) or tram/bus corridors (400 m). Wherever two or more of these catchments overlap geographically, the residents and jobs are distributed in equal parts among the associated *activity nodes*. In effect, every resident and job within walking distance from a minimum-standard public transport service has been assigned to one, and only one, *activity node* catchment.

Travel impediment: SNAMUTS measures spatial separation, or spatial resistance (a proxy value for distance) by relying on the units that are closest to the public transport user experience, namely travel time and service frequency. Each route segment is labelled with an impediment value consisting of the average travel time divided by the number of services per hour, separately for each direction, and multiplied by a factor of 8 to arrive at more readable numbers. The travel impediment (proxy distance) between any two activity nodes on the network is thus made up of the sum of the impediment values on each route segment passed along the path. Another indicator adds to this by considering the transfer penalty on public transport (see below).

3.1.3 Operational aspects

SNAMUTS utilises six indicators (see Curtis & Scheurer, 2010) including:

Closeness centrality describes the ease of movement along the public transport network, in terms of speed and service frequency.

Degree centrality describes the directness of journeys along the public transport network. It is a topological network indicator, measuring the minimum number of transfers between each pair of activity nodes.

Contour catchments measure the combined effect of public transport speed and land use intensity. This index determines the number of residents and jobs within the walkable catchment areas of activity nodes that can be reached within a public transport travel time of up to 30 minutes from the reference node.

Speed comparison measures the competitiveness of public transport against the car. The index determines the travel time ratio between public transport and road travel (in typical congested conditions) for the path between each pair of nodes.

Betweenness centrality captures the geographical distribution of attractive travel paths between each pair of nodes across the network. It shows concentrations of 'movement energy' generated by the travel opportunities the network provides, or in other words, to what extent an activity node is located 'at the crossroads' of public transport supply. It essentially identifies those transport routes that will be traversed the most (cumulatively) by journeys between different pairs of centres after all potential journey combinations are considered.

Nodal connectivity measures the strength of each activity node for (multimodal) integration of services. It captures the suitability of activity nodes for making transfers or breaks of journey with minimal disruption to the flow of movement.

Composite indicator for overall public transport accessibility is compiled from the figures for each of the above indicators. They are converted to a scale from approximately 0 to 10 to afford them roughly equal weighting. Higher values indicate greater accessibility. The composite index is commonly visualised on a scale map of the metropolitan area, highlighting the geographical catchment areas of each activity node in traffic light colours according to their composite score.

Two further measures can be drawn from the SNAMUTS database and are utilised to highlight network characteristics that facilitate comparisons between cities or along time lines within the same city.

Service intensity describes the number of vehicles for each mode that are in simultaneous revenue service during the reference period. It is given as a total as well as relative to metropolitan population. Service intensity is a two-sided measure: it illustrates both the generosity (or not) of a public transport operator or agency to provide operational resources, and the efficiency of their dispatchment. Thus the ratio between service intensity changes and shifts on the accessibility measures can help to determine the efficacy (or not) of initiatives to expand (or cut) public transport services.

Network coverage is an aggregate, network-wide indicator of the previously described contour catchment measure, extracted by overlaying all defined activity node catchments and then counting the percentage of metropolitan residents and jobs contained within them. Network coverage can illustrate the growth (or shrinkage) over time of the proportion of the metropolitan area that is accessible by public transport services of the SNAMUTS minimum standard, and can benchmark this proportion for comparisons between cities.

The evolution of public transport accessibility over time is also captured in the ***global and local efficiency change index***. This index delivers a percentage figures for the improvement (or deterioration) of public transport accessibility at each activity node (local efficiency), as well as for the network as a whole (global efficiency), following changes in service levels, network configuration and/or land uses. It does this by comparing the minimum travel impediment (closeness centrality) for each pair of nodes, weighted by the product of the number of activities (residents and jobs) at either node, before and after the changes.

Most recently, a ***network stress index*** has been developed that takes in the aforementioned segmental betweenness index and draws a ratio with the actual quantitative ability of the public transport service to move passengers. This index is designed to highlight where in the network the concentration of travel opportunities generated by the land use-transport system appears to outstrip, match or remain below the carrying capacity offered by the transport mode(s) and service levels on the route segment in question (Scheurer & Woodcock, 2011).

3.1.4 Relevance for planning practice

SNAMUTS identifies and visualises a land use-public transport system's strengths and weaknesses in a coherent mapping exercise, considering geographical coverage; ability and efficiency to connect places of activity; strategic significance of routes and network nodes; and, speed competitiveness between public transport and car travel.

The SNAMUTS tool has so far been applied in several collaborative ventures with land use and transport planning agencies as well as academic partners in Perth, Melbourne, Hamburg and more recently Porto and Copenhagen (Scheurer, 2009; Scheurer, 2010).

In Perth, the completion of a 72-km radial suburban railway in late 2007 provided an opportunity to test the SNAMUTS model on a real-life, before-and-after comparison of network performance and service levels, as well as the broader role of public transport in the mobility mix of the Western Australian capital. Our analysis demonstrated how accessibility by public transport changed across the metropolitan region, with effects beyond the simple view of improvements along the new railway itself. In addition, the analysis highlighted the way in which improvements to network accessibility open up considerable possibilities to improve land use opportunities at locations with improved accessibility (Scheurer & Curtis, 2008).

By developing an interactive decision tool we assisted in the examination of scenarios for activity centres framed around the accessibility of the transport network and the accessibility of place. Testing these factors through a scenario approach enabled key planning questions to be examined:

- Which activity centres could best be intensified?
- Which centres should perform a regional role and which ones a local role?
- Where should public transport investment (infrastructure, service improvement) go?

The data and ideas being fed into SNAMUTS were drawn from work in progress within the agencies. This research project as well as the earlier accessibility ranking data informed the next iteration of the metropolitan planning strategy and the outcome has been the release of the 'Directions 2031' strategy (Curtis & Scheurer, 2009).

A project for the State Public Transport Authority (PTA) in 2010 employed SNAMUTS to evaluate the PTA proposals) for the next 20 years investment in public transport for greater metropolitan Perth. The PTA in developing their strategy wanted to test how well the proposed network and service performed in relation to enhanced public transport accessibility to key activity centres.

In 2009 SNAMUTS has been used to benchmark public transport accessibility between cities – Melbourne and Hamburg (Scheurer, 2009). SNAMUTS was used to determine how the public transport networks in both cities are configured, how responsive they are to the geographical distribution and concentration of residents and jobs across the urban structure, and how capable to provide accessibility and convenience of travel across the metropolitan area.

SNAMUTS is a tool designed to assess the impact of network and land use changes in the past and the future. This is the case regardless of whether such changes are the outcome of deliberate planning efforts such as policy decisions to expand or cut public transport service or to pursue transit-oriented development schemes, or of self-regulated processes such as the deterioration of service quality due to traffic congestion or market-led urban development along or away from public transport facilities. SNAMUTS was again used as a comparative tool for longitudinal analysis along the recent example of the introduction of an orbital bus service (Route 903) through Melbourne's middle suburbs in April 2009.

3.1.5 Strengths and limitations

The relative accessibility of activity centres and network nodes can be determined by SNAMUTS and used to inform decisions about both public transport network configuration and about land use intensification in the catchment areas of nodes and corridors that gain in accessibility. This tool is well-suited to inform local area planning to add detail to the strategic directions spelled out in a metropolitan planning strategy, and to identify gaps in public transport service that need to be addressed to achieve the congruence of movement and land use the document aspires to. It is also well-suited to inform priorities for the future expansion of public transport infrastructure in the Perth metropolitan region.

SNAMUTS planning decision support tool has been employed by using a discursive approach, in a way not common to the development or use of traditional transport models. Indeed where research has been conducted into the utilisation of knowledge derived from analytic planning techniques it is apparent that there is little evidence of its use or effectiveness by decision-makers (Sager & Ravlum, 2005). In recognising this problem, our aim was to design SNAMUTS in such a way that it could be easily understood and 'owned' by decision-makers as a means to utilisation in decisions. SNAMUTS design, including the simple rationale in measuring the network from the personal traveller perspective and the use of visual mapping outputs, is aimed at promoting deliberative processes that can be appreciated by a wide range of users, not just those with mathematical modelling expertise.

In terms of the usefulness of SNAMUTS, workshop participants have indicated that its value goes beyond simply providing knowledge on public transport networks or future urban form. While SNAMUTS demonstrated the possibilities for measuring public transport accessibility, some of the highest ratings were for the use of the tool in governance—especially the value of the tool in communicating decisions to the public and in aiding collaboration across the professional groups. In commenting on the particular SNAMUTS indicators, workshop participants indicated the two greatest strengths were the visual composite maps (Figure 3.1) and the way in which speed of travel by public transport and car travel can be compared. The interviewees added to this indicating that by seeing accessibility plotted provided the department with measurements, before this they had relied on anecdotal evidence. They also noted that when the transport outcomes were mapped it became clear that there had not been, but needed to be, a land use response where accessibility had not improved.

Participant's also identified—'its ability to explore supply-led scenarios'; the way in which it generates an index of accessibility, noting that this was based on theoretical connectivity rather than actual use; and the way it 'is easier to recalibrate for differing scenarios'. In relation to the traditional transport models, one noted that there was 'no comparison, different purposes'.

We continue to develop the instrument, in particular we are applying it to cities around the world as part of a project looking to inform the Australian government as to an appropriate benchmark for public transport accessibility in order to inform infrastructure investment and priorities.

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3.1.7 Figures

Figure 3.1 SNAMUTS visual output clearly shows accessibility changes with the implementation on a new rail corridor and a bus network reconfigured to act as a feeder service.

3.2 Retail Cluster Accessibility (TRACE)

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3.2.1 Background

The main motivation for developing this accessibility instrument was the need for a new retail policy in Belgium (Flanders). In the past, Belgium used economic restrictions in its retail policy. The European Directive on services in the internal market (Directive 2006/123/EC of the European Parliament and of the Council (European Union, 2006); commonly referred to as the Bolkestein Directive) states that as of 2009 such restrictions are no longer allowed. It is however still possible to use restrictions in retail policy, mainly arguments of spatial planning are tolerated. Such a policy requires intricate insights in the retail landscape. However, current decision taking is limited to a case by case approach based on expert knowledge since the necessary coordination and tools are not available. We therefore designed this tool to analyse the retail landscape of Flanders and as a possible aid for developing a new restrictive retail policy based on spatial planning.

The scientific research questions are how retail spreads along the landscape and why, in other words what are the parameters which determine the location of retail companies. Furthermore the potential influence of policy on retail sprawl is under scrutiny. In the first place we want to test to what extent the parameters of the classic spatial interaction models are still valuable. In this reasoning accessibility to both supply and demand is crucial.

The main planning problem we want to address is the following: there are sound socioeconomic reasons to limit retail sprawl, such as protecting open space (Flemish Government, 2011), sustainability (see for example Newman et al (1995), Banister (1999, 2007 & 2008), Burton (2000), Kennedy et al (2005), Kenworthy (2007) and Glaeser & Kahn (2010) on the sustainability of compact cities), mobility issues (Boussauw et al, 2011), the rise of the knowledge economy and the associated rise in importance of the vibrancy of cities (van den Berg, 1999; van den Berg & Braun, 1999; van den Berg et al, 2004; van Winden et al, 2007; Whisler et al, 2008; Yigitcanlar et al, 2008) and the social role of retail (Harvey, 1973) (particularly food retail, cf. food deserts (see for example Clarke et al (2002), Guy et al (2005) and Zenk et al (2005))). Governments all across Europe want to spatially restrict the sprawl of retail firms (Davies, 1995; Guy, 1998; Péron, 2001). In this regard policy in many European countries has failed (Davies, 1995; Guy, 1998; Péron, 2001). Contrarily, a spatial restrictive policy might lead to a drop in productivity and consumer welfare (Evers, 2001; Griffith & Harmgart, 2008; Haskel & Sadun, 2009; Cheshire et al, 2011;

Matsumura & Matsushima, 2011). The tool can aid in developing a spatially restrictive policy that takes both retail sector productivity and welfare into account.

3.2.2 Conceptual framework and theoretical underpinnings

The retail landscape is the outcome of the location decision of retail companies. This decision process is mainly determined by the accessibility of the available locations (already defined by Christaller (1933)). The government influences accessibility and location decisions via a wide array of policies, ranging from transport and land-use planning to fiscal and social measures. Accessibility can here be defined as the ease of reaching a shop by potential consumers. In general customers prefer a varied supply of shops. As a consequence it is an advantage in the retail sector to locate close to competitors and other retailers (Arentze et al, 2005). Hence, our tool primarily focuses on the delimitation of retail clusters. The location, size and composition of clusters are correlated to the accessibility of the site. Gravity based accessibility measures and infrastructure based accessibility measures seem to be appropriate estimators of the retail landscape since they incorporate population (demand), infrastructure and distance characteristics.

3.2.3 Operational aspects

Given the fact that we have geo-referenced data of shops at our disposal, we can employ a multitude of accessibility measures, including gravity type potential accessibility measures and infrastructure based accessibility measures. In practice we are able to measure the distance of retail clusters to relevant infrastructure, such as the nearest train station and major roads.

The data input from the tool comes from the Locatus database (Locatus, 2012). Locatus data are available for Belgium, Luxemburg, the Netherlands and a selection of major European cities. The databases include information on coordinates and addresses of individual shops, detailed information on the type of retail, the type of road a store borders, the net floor surface of shops (limited) and the type of shopping area. The database for Flanders, Belgium was provided free of charge to the Department of Transport and Regional Economics of the University of Antwerp as support for research for the Flemish Government. Ideally one would use this or similar data as input for the tool. An analysis can already be made using basic geographical information on the location of stores. To fully explore the possibilities of the tool, one would ideally have information on the type of retail and the size of shops or length of the store front.

The tool has been developed using Model Builder in the ArcGIS 10 suit, developed and distributed by ESRI. The first part of the tool (to calculate clusters) requires no further extensions. The second part (to calculate distances) requires the Spatial Analyst extension. Currently the tool works with Euclidean distances. It is possible to upgrade the tool to include real distances. The Network Analyst extension is then required. The tool works best in ArcGIS 10, but has been tried and tested in ArcGIS 9.3 to satisfactory results. To calculate clusters for a set of 34000 records a mid range laptop (PC specs: dual core 1.3 GHz, 4Mb RAM) requires about 1 to 1.5 hours. ArcGIS is not publicly available, and comes at a significant cost, but is widely used.

Both performing the calculations and interpreting the results of the calculation is relatively easy. The tool is very intuitive and user friendly and can therefore be used by anyone with a basic understanding of GIS software. This means that the tool can also be used with limited support by non-professionals in small cities and companies enlarging the chance of a better application of policy on an operational level. More experienced users will find it easy to tweak the tool to fit their specific needs, to adjust the tool to different data, to solve related problems or create interactions with other tools.

It is important to note that in our database no data is grouped into a higher level, i.e. no data is grouped at the statistical ward or municipal level. If this is the case some further statistical methods have to be included, as was discussed by Sadahiro (2003).

3.2.4 Relevance for planning practice

The tool has not yet been introduced in practice, but it has been developed and tested within policy research for the Flemish Government to analyse the retail landscape of Flanders and possibly as an aid and input for a new retail policy. Also lower tiers of governance, such as provinces and municipalities, have shown interest in applying the tool and a few are testing it. We have a great deal of confidence that the tool will eventually be used in practice.

As was said Belgium needs to change its retail policy because of the Bolkestein Directive which aims to liberalise the European services market. We have noticed from an extensive literature review that from a planning point of view spatial restrictions are a good tool and are to be preferred over economic restrictions (see also Davies (1995), Guy (1998) and Péron (2001)). However some cases described in the available literature, in casu the Dutch case, show that a retail policy based on strict spatial planning can lead to losses in sector productivity and possibly a drop in consumer welfare (Evers, 2001). Since Belgium has more urban sprawl than the Netherlands and Germany, a policy based on strict spatial planning in the Dutch or German style may lead to even more detrimental results. The tool is able to show which areas are interesting for retailers to invest in, areas where they can fulfil their economic needs, by linking clusters to socioeconomic location factors. Such locations can then be associated to areas which the government itself wants to develop. Thus the needs of society and the economic requirements of private companies can be matched.

3.2.5 Strengths and limitations

Academic research in retail planning policy has significantly slowed down the last decade. Most of the available literature is thus rather dated. The actual tool will allow further investigation of the location of retail and the influence of planning on the location of retail in the 21st century. A weakness of the tool is that it now only allows for a cartographic analysis. In future updates of the tool more spatial econometric outputs will be calculated.

The most important practical benefit of the presented tool is the ease of use of the instrument and the straightforward interpretability of the results. This means on the one hand that the tool can also be used at the municipal level where the planning policy in Belgium is actually operationalized. On the other hand the instrument is not a black box and allows experienced users to tweak its functionality, which significantly increases the usability of the tool and permits interactions with other instruments. An important hindrance in bringing the tool into practice is the data requirements. As was already explained, the tool uses expensive databases. These databases need to be updated regularly which leads to high fixed costs. Many cities in Europe however have an increasing interest in retail developments as they start recognizing the influence of retail on liveability, both in an economic and social way. As such they are starting to provide data on the matter.

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3.3 Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance (ASAMeD)

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3.3.1 Background

The instruments presented here are: Spatial Integration Accessibility (SIA) and Angular Segment Analysis by Metric Distance (ASAMD) and they both belong to the wider theoretical and methodological field of space syntax developed in the Space Lab of University College London.

Space syntax is both a *theory* of urban planning and design and a software-based *technology*. It is an evidence-based approach to planning and design, with a focus on the role of spatial networks in shaping patterns of social and economic transaction. Through a configurational analysis of a street network, the Space Syntax methodology investigates relationships between spatial layout and a range of social, economic and environmental phenomena. These phenomena include patterns of movement, awareness and interaction; land use density, land use mix and land value; urban growth and societal differentiation; safety and crime distribution. Research using the space syntax approach has shown how: movement patterns and flows in cities are powerfully shaped by the street network; this relation shapes the evolution of the centres and sub-centres that affects the well-being of people in the city; patterns of security and insecurity are affected by spatial design; spatial segregation and social disadvantage are related in cities; buildings can create more interactive organisational cultures (Hillier and Hanson, 1984).

Space syntax methodology analyzes the movement network to quantitatively measure “spatial accessibility”. This approach utilises graph theory indices of accessibility, which measure spatial separation. The key focus is to describe the spatial impedance factors that separate locations, without considering the nature of the activities separated; to measure accessibility from a particular location to either all other locations in the study area or to all other locations that fall within a certain distance from the location under study. All destinations are accounted as equals and land uses are not considered during the initial analysis.

3.3.2 Conceptual framework and theoretical underpinnings

Both instruments are measuring what has been described above as spatial accessibility. However, each instrument is measuring spatial accessibility in a different way. SIA is using a spatial representation called axial line and on the topological distance between axial lines based on the number of steps from one line to the other while ASAMD includes in the axial analysis furthermore the angles of incidence between lines, the segmentation by junction of the axial line and the effect that metric radii would have on the choice of routes and the trips destinations.

SIA is concerned with the number of changes of direction that a journey from one place of the movement network of a city, to another would require. The notion of proximity in general and the perception of a location's accessibility in a network of city streets in particular are affected by the experience of physical travel through an urban environment, which involves much more than a simple distance or time cost of reaching a location. Unlike metric accessibility measures, which rely strictly on distance or travel time, cognitive research on access also accounts for the 'complexity' involved in walking to a place. Spatial integration is considered very important because it measures the complexity of routes within an urban area and takes into account the important *subjective* dimension to accessibility.

Space syntax analysis argues that which locations appear accessible or remote and which paths are chosen to access a place, depend on people's wayfinding skills and mental conceptualizations of the environment. It is suggested that the most accessible locations are not necessarily those closest to all other locations in terms of metric distances, but rather those closest in terms of topological turns (Hillier *et al.*, 2007). From a behavioral point of view, this assumption postulates that the cognitive complexity of the route, described as the number of directional changes on a route, is the primary consideration in pedestrian path choice, even more so than metric distance. Pedestrians are thus expected to prefer routes that involve less turns along the way, rather than shortest routes.

For ASAMD the indicators that are used in addition to the axial lines connectivity and topological distance are: the axial lines segmentation by junctions (segment map), the angularity between axial lines and the metric distance measured on axial lines' segments.

Consequently, this instrument is based on the axial lines segments between junctions; it allows three types (measures) of distance:

- Metric (shortest paths);
- Topological (fewest turns paths);
- Geometrical (least angle change paths).

The instrument then calculates accessibility at different scales (radii), local – intermediary – global, using the different types of distance. The scales (radii) can be assigned by the researcher depending on the research question, so that local can be for example 200m, intermediary at 800m and global at 2000m.

Both SIA and ASAMD calculate two main measures:

- Integration (closeness): how close each segment is to all others under different types of distance and at different scale, this is known as “to-movement”. Integration describes how easy it is to get to one segment from all other segments. In practical terms this would mean that pedestrians would end up to such a space more often and with less effort. This spatial attribute can then define the type of land use that would fit best in this space. (for mathematical formula see Hillier & Iida, 2005);
- And choice (betweenness): how much movement is likely to pass through each segment on trips between all other segments, again using different types of distance and different radii. Choice describes how likely you are to pass through the segment on trips, and so it’s potential as a route, from all segments to all others. Again, this spatial attribute can define the type of land use that would fit best in this space, possibly certain land uses would require spaces with a high integration value. (for mathematical formula see Hillier & Iida, 2005).

3.3.3 Operational aspects

Both SIA and ASAMD measure spatial integration accessibility which is the degree of spatial separation/integration in terms of the number of changes of direction and the angle of change of direction that a journey from one location to another would require. The analytic tool used is the "one-dimensional" or axial organisation: this refers to the global organisation of the system from the point of view of those who move in to and through the system; that is, in terms of its lines of access and sight. Syntactical analysis is commonly based on the axial map, the set of fewest and longest lines of sight passing through every public space in a city’s street network. The map shows the relation of each line to the network of the whole city (‘global’ relations) or the relation of each line to the immediate surroundings (‘local’ relations). Space Syntax researchers measure travel from one line to another across the graph in topological terms, using the count of lines traversed (i.e. changes in direction on axial lines) as a metric of proximity, referred to as *depth*. It is used as a kind of distance measure, which represents the minimum number of axial lines needed to go from an origin to any other segment in the network. The depth measure leads to another central metric: *integration,* which quantifies relative depth from any space to all other spaces (see Hillier, 1996). The integration measure is a relative description of each axial line’s depth with respect to all other axial lines in the graph. It is obtained by repeating the depth measure from each line to all other lines in the system and normalizing the obtained sums for each line by the total number of lines in the graph. The integration measure thus outlines which axial lines require the least amount of connections to access from all other axial lines in the network. Maps are coloured in a scale from red to blue, or black to white in an grayscale map, to indicate the high-to-low range of values (see Figure 3.2 and Figure 3.3).

Data that are required for the calculation both of SIA and of ASAMD is only a vector basemap of the area or the city. If the basemap is on vector format the segment map will be automatically generated but even image files of maps can be adequate, although the segment maps would need to be drawn manually. Research by Turner (2007) which replaced the segment lines with road-centre lines has shown that road-centre lines can work equally well for transport analysis. Furthermore, road centre line data allows for whole regions or even whole countries to be modelled without spending time on the manual production of the axial/segment map. Obviously, the data requirements are at minimum and easily, in most cases available, which count for easy use.

The analysis of the segment map can be produced by Depthmap (Turner, 2001; Hillier, 2009). Depthmap runs on Windows (2000 and XP are the older versions). The software was available only for academic use until recently but now is publicly and freely available and it is provided as open-source.

The calculation time depends on the size of the urban area analysed in combination with the number of lines or segments per map. Usually for small urban areas of a neighbourhood it wouldn't take more than a few minutes. The analysis of a whole city can take up to a few hours depending on the size. The analysis is calculated automatically without any special knowledge or technical expertise by the user. As soon as a correct segment map is imported in the programme it is matter of a sequence of simple commands to produce the model. However, wide knowledge based on the theory of space syntax and on basic principles deriving from it is required in order to interpret the results. Inadequate knowledge of the main concepts behind the analysis can confuse or lead to naïve and simplistic assumptions.

Depthmap also offers the capability of extension through two levels of interface. The first level, a scripting interface based on the Python language, allows researchers to calculate new derived measures as well as to add graph measures, such as circuit lengths, for each of the graph types. It also allows the ability to select groups of nodes according to value or according to simple algorithms. The second level, the Software Developers' Kit (SDK) allows programmers to write new forms of analysis.

3.3.4 Relevance for planning practice

The information that the instrument produces can be relevant for planning practitioners:

- To inform them on the constraints and opportunities of urban areas with regard to the street network and how it can attract or deter pedestrian movement so that land use strategy is better aligned to the pedestrian movement opportunities;
- To offer insights on how the area can be optimised in its context regarding its commercial viability, the potential for retail, the design of sustainable development and the creation of vibrant and lively urban spaces;
- And finally it offers the possibility to test different strategic guidelines and design proposals.

The space syntax approach has been used in practice since 1984, particularly the Angular Segment Analysis by Metric Distance since 2006, in a variety of urban problems in several countries which include the UK, Saudi Arabia, China, USA, Chile and many more, with partners from both the private and public sector. In Greece it has been mostly used for research urban projects and therefore there hasn't been any feedback from applications in practice. At the moment SIA is in the process of being applied in Cyprus through a research project which has been prepared jointly by Nicosia Municipality (planning department) and academics, including the author, from the University of Cyprus.

The instrument addresses a number of issues relevant to the formation of a land use strategy and location: to help boost the economy, to revitalise central areas, to increase social sustainability and to improve cycling and pedestrian access. The instrument offers an evidence-based approach to decision making by informing on the accessibility and walkability of an urban area and by helping to test strategic interventions and design proposals. The value of the instrument in the planning outcome and in the decision-making process is that it gives a scientific and objective tool by which the proposals could be tested and evaluated regarding spatial accessibility and pedestrian movement and how these attract land use.

3.3.5 Strengths and limitations

The instrument is a strong tool for analysis and evidence based design that has been tested both in research and in real practice problems and been proved successful. One of its weaknesses could be considered the fact that it is based on a wide theoretical basis which makes it difficult for someone, in either the scientific or the practical field, to instantly understand and accept. In what follows some of the main positive and negative reactions of planning practitioners to the instrument are presented. These derive mostly from the application of the instrument in countries other than Greece and Cyprus as in these countries it has been only used for research.

Positive reactions include:

- The instrument provides clear and undisputable metrics and therefore it is objective;
- It has been proved very useful in stakeholder negotiations since it can be trusted more than just an architect's or urban planner's experience or intuition;
- It introduces science in the field of architectural and urban design in relation to accessibility, where this did not exist in the past. Traditionally, accessibility was mostly related to transport and land use planning;
- It reduces the risk in strategic or design decisions as it offers an evidence-based assessment regarding the spatial accessibility potential of each proposal;
- It provides very illustrative and easy to "read" visualisation.

Negative reactions are:

- The instrument is not a "theory of everything" as it is many times expected. People have too high expectations and anticipate that it should explain everything. However, the instrument explains pedestrian movement quite well and therefore also land use patterns and to a certain degree socio-economic sustainability;

- The instrument itself and especially the theory behind it are very complicated and take time to understand. This makes it more difficult to use in support of decisions in public engagement situations where time is limited;
- There is very often an overemphasis among urban designers on 'architecture' and 'attractors', so they don't believe that there is a strong connection between accessibility and the functionality of the city;
- There is reluctance among practitioners for the use of models in general. They believe that parties in possession of a model can argue whatever they want because they justify it with the modelling, and they don't seem to always like that.

Criticism of this approach from a scientific point of view is usually based on the fact that all paths/axes are weighted equally in the analysis. So, a street that has no buildings on it is weighted equally with a street that has a number of tall buildings; an area covered with residential land uses is weighted equally with an area full of commercial land uses. Criticism also points out that interpretations of the spatial phenomena need to take into account additional information that is not readily available through a configurational analysis. The method does not account for the three-dimensional geometry of the built environment for example, nor the land use characteristics of the network. The addition of three-dimensional built-form indicators as well as land use characteristics would allow graph measures to capture a more realistic description of the built environment and address some of the criticisms. Research towards these criticisms is in progress (for the three-dimensional built form see Mavridou, 2012; for land use characteristics see Ortiz-Chao, 2008).

3.3.6 References

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3.3.7 Figures

Figure 3.2 Spatial accessibility analysis of Nicosia, Cyprus

Figure 3.3 Angular Segment Analysis by Metric distance of the city of Jeddah, SA (by Space syntax Ltd.).

3.4 Activity based indicators of connections and access needs (ABICA)

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3.4.1 Background

This instrument is not an instrument with the purposefulness and instrumentality that this implicitly assumes, but may be applied purposefully in planning as well as in scientific context. Data visualizations have a long history but visualizations and illustrations of interaction patterns and access needs have generally been limited by access to spatial behaviour data and computation capacities.

Visualizations based on interaction data was included as a prominent part of the first metropolitan planning studies in the US (e.g. Chicago Area Transportation Study, CATS; Detroit Metropolitan Area Transportation Study, DMATS; see Tobler, 1987) as well as in studies surrounding the 'Lund school of geography' (e.g. Lenntorp, 1978; Westelius, 1973) such have, however, until the increase in geo-statistical computation capacities and geo-referenced data in the last decade, been a rare event. The improved access to e.g. detailed, spatially referenced datasets, as well as the spread of spatially explicit survey 'tools' such as GPS provides new possibilities for the representation and visualization of spatial interaction patterns. Such may be seen as a supplement to more normative accessibility indicators and may have a huge potential when it comes to communicating findings and engage stakeholders in discussions on criteria for access conditions.

Representative treatments – i.e. visualisations with the purpose of representing and communicating spatial interactions and thus connections and access needs – have been applied in a number of Danish research projects, including 'Byen, Vejen og Landskabet' (Town, Road and Landscape) and 'Danish Centre for Strategic Urban Research'. This section is based on these experiences.

3.4.2 Conceptual framework and theoretical underpinnings

Activity-based indicators and visualizations of connections and access needs do not define accessibility, but assumes that the spatial connections/interactions can be represented and that lessons of access needs and accessibility may be inferred from such representations.

The lack of definition of accessibility is an important contribution from this indicator. Thus, accessibility indicators will often rest on a normative basis or assumed causalities which may not be relevant under all conditions or applicable to all. Representing 'actual' behaviours can supplement and provide a basis for interpretation accessibility and access needs. The openness to interpretation – the fact that the revealed behaviours represented has developed out of multiple underlying causalities – may be seen as a weakness, but also as a strength as the representation can be accepted by stakeholders in the field.

In the Danish examples visualizations of connections and access needs have especially been employed to measure spatial integration at the regional and national scale. Examples include research into developments along the motorway network as an input to a debate on relations between infrastructure design and land use developments; and elaboration of travel patterns in an emerging polycentric metropolitan area as an input to a consensus based strategic planning process for the whole urban entity. The increase and upscaling of spatial dependencies have been documented and illustrated – a process which is extremely relevant for the consideration of accessibility locally as well as regionally.

Even though data access is improving, data is still one of the main concerns for the development of such indicators. As in many other countries there is a long tradition for collecting commuting data in Denmark, and these have been employed to represent interactions and access needs nationally. However, the prominence of commuting in defining the spatial economy has been decreasing for long and studies relating to consumption patterns more generally are highly desirable. Transportation data may in some instances be used to represent interactions and access needs, and tourism datasets may be used at a larger scale, but the main 'future promise' for such studies would be to employ cell phone datasets or loggings based on build-in GPS devices to represent interactions and access needs for large populations.

3.4.3 Operational aspects

Danish visualizations of connections and access needs have based on either the Danish commuter survey (Statistics Denmark, Registerbaseret arbejdsstyrkestatistik, RAS) or the Danish National Travel Survey. The register based account of commuting generally allows the identification of the location of home and work based on other register datasets, while the National Travel Survey have been collecting detailed data on trip origin and destinations since 1997. In both instances origin-destination links may be mapped as 'desirelines' – an approach developed for transportation planning in the US under the heading of 'coordinate method' in the 1940s. The desireline connections as a basic building block allow for the summary of flows or 'desireline traces' as a property of a location; or to map the activity field or catchment of a given place/location.

Visualisations based on desirelines or desireline traces can indicate loads, demand for capacity, as well as spatial patterns of dependency and centrality. Visualisation of activity fields or catchments also indicates patterns of dependency, but takes the starting point of a place or location. Both are of interest in municipal and regional planning and provide basic reality based outlooks to the location of a customer basis, where a population live their lives etc.

Origin-destination datasets from commuter or travel surveys are the minimum requirement for the indicator and are generally not freely available. Exceptions are the US and UK where efforts have been made to make census data available, but in many countries it is necessary to pay to get access to data (e.g. Denmark, Germany, Sweden) and/or there may be restrictions to access (e.g. Netherlands, France), and of course some countries and regions does not have such data at all.

The processing requirements depend on the format of the data available and whether interaction datasets match available spatial datasets (e.g. maps of boroughs, census tracts, wards or similar). In practise survey data and spatial data are not ‘in tune’ due to timing, updates etc. which then require ‘repair’ of base datasets before analysis.

Most current PCs are able to handle origin-destination datasets from commuter or travel surveys, but software to process large databases, geo-statistics, and maps are required. Commercial software’s, such as ArcGIS, are generally preferred by the practitioners of the field, but open source software (such as R) are becoming increasingly available for spatial analysis and may be able to perform the tasks as well.

Realistically the handling of data and analysis does require some technical expertise, but not to a level where it cannot be included in a general GIS courses. Handling of detailed micro level time-space datasets from e.g. cell phones or GPS will of course increase requirements and require handling outside ‘standard software packages’.

Interpretation of results can take place at many levels. The main issue here is that the representation should reflect the intended application, and the representation comes with a declaration of its content.

3.4.4 Relevance for planning practice

The examples relied on in this chapter has been produced in strategic research projects focussing on the spatial development and upscaling processes, as well as in preparations for a common plan for a metropolitan corridor development.

It is our judgement that it is very beneficial when it comes to describing the ‘planning context’ and especially the dependency or connectedness of the planning unit (municipality) towards other areas.

3.4.5 Strengths and limitations

The main strength of this instrument is that it may be said to represent what people do. On this basis it may gain acceptance and wide application and allow for multiple interpretations.

Experiences with communication to planning practitioners show that the visually appealing image is readily applied in all sorts of communications and presumably creates an interest or awareness around the subject of spatial development conditions. This includes voices that see the map either as representation of ‘doom’, or that dislike the visual representation because of an implicit image of inescapability or givens. So also the representation is discussed.

An important limitation is the lack of causality or explanations. There are many underlying reasons for the spatial pattern of interactions. Ideally visualisations of connections and access needs should be accompanied with a discussion of why and how this is so – scientifically (general) as well as locally in a given planning context (contextually).

An additional limitation is of course also the visualisations are seductive and great care must be taken towards adequacy and explanation.

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3.4.7 Figures

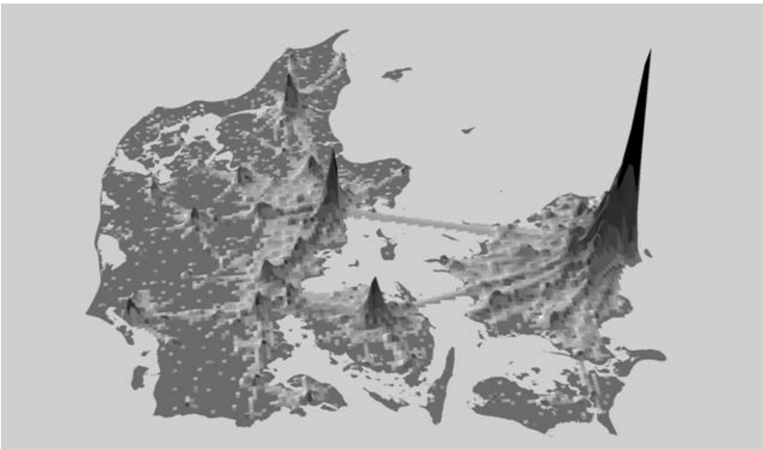

Figure 3.4 Commuter flow or 'desireline traces' drawn from commuting in Denmark. The map is based on origin-destination data for commuting and summarizes the number of commutes passing through any given area. Source: Byen, Vejen og Landskabet (Hovgesen and Nielsen 2005; Miljøministeriet, 2006)

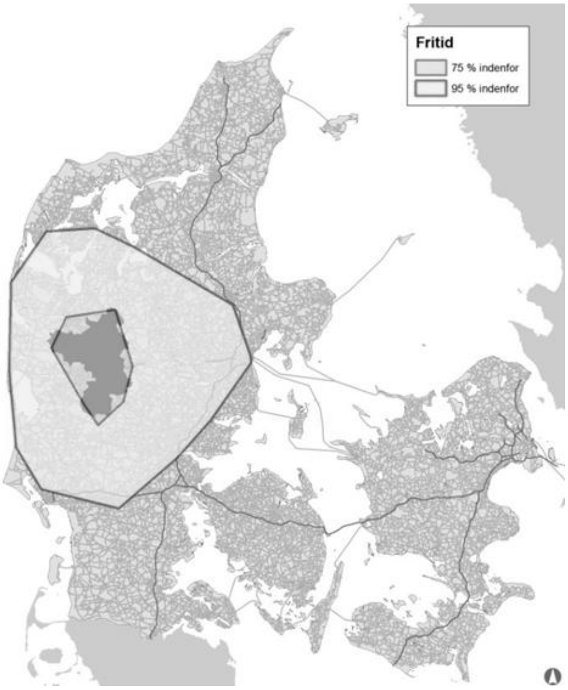

Figure 3.5 Activity fields for leisure activities. The activity fields are drawn to indicate the areas that contain the 75% and 95% of the activity destinations that are closest to home, out of the total number of activity destinations of the municipal population.
Source: Danish Centre for Strategic Urban Research (Nielsen, 2011)

3.5 Heuristic three-level Instrument combining urban Morphology, Mobility, service Environments and Locational Information (HIMMELI)

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3.5.1 Background

This report introduces a spatial simulation model of an urban retail system where the accessibility concept plays a key role in several aspects of interaction. Essentially, the idea is to model the cumulative effects of accessibility and the interaction of urban actors within the physical framework created by the urban structures. The study is focused on retailing which is (and has been) one the core activities of cities and which also is highly competitive and dynamic. The actors in the retail sector continuously search for new locations and modes for production and consumption in order to get comparative advantage. The behaviour and interaction in urban systems have already been interpreted as obeying the principles of complex systems (e.g. Jacobs, 1961; Schelling, 1978; Allen 1981) even before 'complexity theory' (or 'complex systems theory') has been established. The availability of computing capacity later enabled new methodologies like agent based modelling for simulating the complex phenomena.

This continuously changing and complex nature of urban development, which is emphasised in a retail sector but can also be seen in other fields, has raised new paradigms and understanding about planning problems during the last two decades. Widely used traditional planning methods are not fully able to answer the challenges of this new operational environment. This paradigm change and processual approach has created a new demand for planning tools that increase knowledge of the development process and cumulative effects of individual interactions. New planning instruments should be able to reveal causal relations and boundary conditions that can lead to system phase transitions and additionally show whether they lead to more fluctuating or stable development paths. Modelling tools can work as useful instruments in discussions between private and public sectors in planning processes and particularly in situations where tensions exist between different interest groups. The model presented here is still in a test phase and requires still improvements in order to serve in real planning contexts.

3.5.2 Conceptual framework and theoretical underpinnings

The focus of the modelling tool is to observe how different accessibility factors influence on a spatial organization of retail units and how this process can be simulated by using agent based modelling methodologies. The objective is to find out how the selected boundary conditions effect on the location choice of retail units on the regional scale. These boundary conditions in the model include accessibility measures, the properties of infrastructure as well as the features of urban actors and objects like households and retail units. The model emphasises the spatial aspects of the self-organising phenomena. All this is related to the network city theory in a way that the overall model structure follows Gabriel Dupuy's theoretical three level framework of urban networks (Dupuy, 1999).

The simulation model comprises all the three level elements of Dupuy's model: (1) infrastructural networks, (2) networks of production and consumption and (3) agent level networks. However, all the elements are reduced for the purposes of the retail model. Households - as the operators of level three - create the connections between the operators on level two by forming their spatial territories. As the focus of the model is on the dynamics between the three elements it also gains from the tradition of spatial interaction modelling (e.g., Batty 1976; Wilson, 1985). Approaches from different theoretical backgrounds are combined and the interest lies on the process in which the competing retail units act as independent agents and locate themselves in urban structure. The objective is to approach the concept of accessibility not only by reducing problems into smaller parts but observing it as a part of a larger entity.

Since the model approaches the retail system as spatial and morphological phenomena, accessibility is also mainly defined in terms of the structural properties of the urban environment. However within the model different components of accessibility (Geurs & Wee, 2004) are related to interactions, namely land use, transportation and individual components. The accessibility is taken into account when defining the agglomeration advantages of retail units and when households select their shopping destinations based on utility measures. The accessibility measure which is based on network properties is utilised in the process of locating new retail units generated during the simulation process.

3.5.3 Operational aspects

The model consists of two major modules: (1) an initialisation module and (2) a simulation module. The initialisation module includes all functions that read all the input data for the model. The input data includes information concerning households, retail services and transportation system. The actual processing of the data then happens in the simulation module which runs the given number of simulation cycles.

A more accurate description of the model can be seen in a model flow chart represented in Figure 3.6. The model utilizes accessibility measures in multiple ways during the simulation cycle. At first it calculates the accessibility measure from every retail unit to every other retail unit (Acc R-R) which indicates the degree of clustering of each retail unit. In the second step, the model calculates the utility of each retail unit for every household and their shopping orientation is based on this ranking of retail units (ordinal utility). The utility function includes an accessibility factor which is based on the travel cost from household location to the retail unit locations (Acc Hh-R). After every household has selected their shopping destinations, the purchasing power of every household is allocated to retail units and retail unit accounts are updated. Every retail unit type has a certain revenue limit that they have to reach in order to survive to the next simulation cycle. If a retail unit does not achieve the revenue limit, it goes bankrupt and is removed. At the end of each simulation cycle new retail units are created to replace the unit that went bankrupt. The location of the new retail units is based on the accessibility of the network (Acc Network) within a given radius. The new generation of retail units created at the end of each simulation cycle initialises the next cycle and the series of these generations form the development path of the system.

The formulas for calculating the accessibility and the utility measures

Accessibility from a retail unit to every other retail unit is defined as:

$$Acc_{R-R} = A_u = \frac{1}{n} \sum_{u=1}^{n} T_{uv} \quad (3.1)$$

where T_{uv} is travel cost from retail unit *u* to retail unit *v*.

The clustering indicator of the retail unit *u* is then defined as

$$C_u = c_t A_u \quad (3.2)$$

where c_t is coefficient which controls the magnitude of clustering for each retail type. The effect of the size of each retail unit is defined as

$$R_u = s_t S_u \quad (3.3)$$

where s_t is coefficient depending on the unit type and S_u is size of the retail unit. Similarly the accessibility for a household in segment *i* to retail unit in segment *j* can be formulated as follows

$$Acc_{Hh-R} = A_{ij} = t_t T_{ij} \quad (3.4)$$

where t_t is coefficient depending on unit type and T_{ij} is travel cost from segment *i* to segment *j*. Finally these can be combined into utility function. The utility of a household in segment *i* for retail unit *u* in segment *j* is defined as

$$U_u = \frac{C_u R_u}{A_{ij}} \quad (3.5)$$

New retail units generated at the end of every simulation cycle are located on the basis of network level accessibility within a given radius *R*. The network accessibility measure for each segment *i* is defined as

$$Acc_{Network} = A_i = \frac{1}{n} \sum_{i=0}^{n} T_{ij} \quad (i, j \in R) \quad (3.6)$$

where the T_{ij} is the travel cost from segment *i* to segment *j*.

The case study of the test phase is executed in the Helsinki City region in Finland. The model currently uses the census database of households. The original database includes the number of households (three income brackets) in grid format but for the model the information is linked to the road network database. The model also utilizes a company register database which includes the classification of companies based on the company size and branch. The retail typology is derived from the classification which is based on the national version of Statistical classification of economic activities in the European Community NASE Rev.2. Hitherto the model has been tested only with the data sets from Finnish sources, but there are no restrictions to use other data sources available.

At the more general level, the urban environment is represented in this study as a set of discrete spaces including information from one discrete space to every other discrete space. This representation can be defined also as a generalized travel cost matrix. As it can be noticed from above that the travel cost matrix used in current simulations is based on the representation of the topological road network structure where one road segment corresponds to one discrete space. However, the model structure allows the travel cost matrix to be based on any other relevant transportation means or spatial entities e.g. public transportation or lots.

Technically, the model is running in 64-bit Windows environment with Microsoft .Net Framework and MapInfo GIS-software. The actual code is written in MapBasic (programming language for MapInfo) and in C#. The calculation time for the dataset of ~ 20000 road segments is currently about 50 minutes and the memory usage is approximately 6 GB. Thus the implementation of the model requires some basic knowledge about MapInfo software and some general understanding of programming.

3.5.4 Relevance for planning practice

The model increases knowledge about the relationship of retail dynamics and the structural properties of the urban physical environment e.g. transportation networks. The simulations will produce the series of different development paths of spatial self-organisation of retail units. These development paths can reveal the phase transitions that are related to the boundary conditions defined in the model. The model enables the observation of factors behind the location choice that take into account consumers' shopping strategies as dependent on urban structure. Thus, it enables observation how the distribution of retail units emerges from individual agents’ decisions which are based on several accessibility measures.

The model will also help the assessment of planning scenarios e.g. how new road alignments or new residential growth affect service locations. Generally, the tool can avail planners to approach their task of controlling the development as a process instead of an attempt to define the end result without knowing the process.

3.5.5 Strengths and limitations

From the scientific point of view the model offers new methodology to analyse interaction within an urban system as a self-organising far-from-equilibrium phenomena instead of using the equilibrium based land-use transportation models or spatial interaction models. The agent based modelling methodologies and the availability of more detailed data enable less aggregated representation of the system objects and more powerful tools for representing behavioural mechanisms compared with the tradition of spatial interaction models.

Currently, the model is still in a development phase and needs more testing and validation in order to serve as a serious and credible tool in real planning contexts. One of the next steps should be development of a calibration process through which a "best fit" parameter combination that corresponds to a historical development in a given area can be found. One of the strengths in real planning contexts is the knowledge that the model can produce concerning the feedback loops and causal relations between changes in infrastructural or other attributes and the reactions or the behaviour of urban actors from individuals to institutions.

One of the key future improvements of the model would be the inclusion of public transportation. The travel cost matrix which currently is based on a road network (i.e. private transportation) could be extended to cover public transportation services. This requires the data of public transportation and the methodology how this data can be processed into travel costs.

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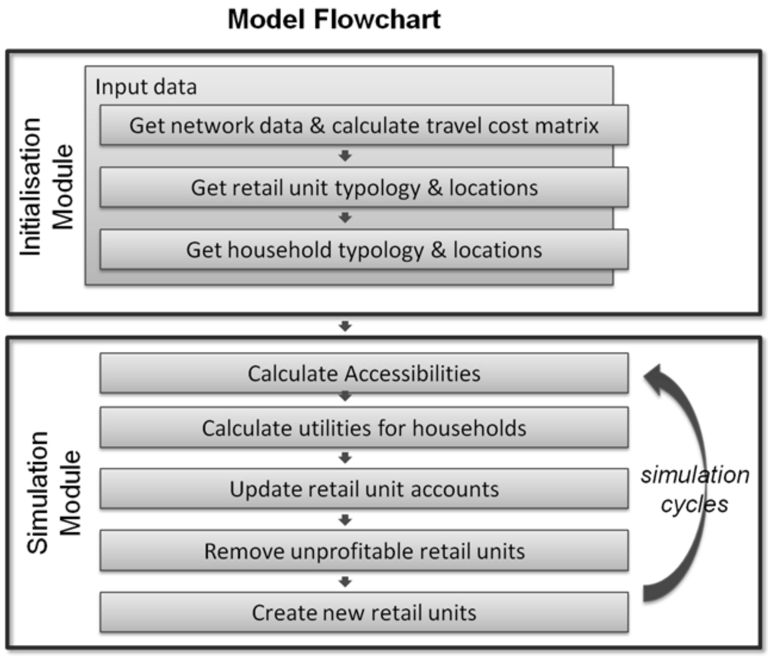

Figure 3.6 The simplified model flowchart

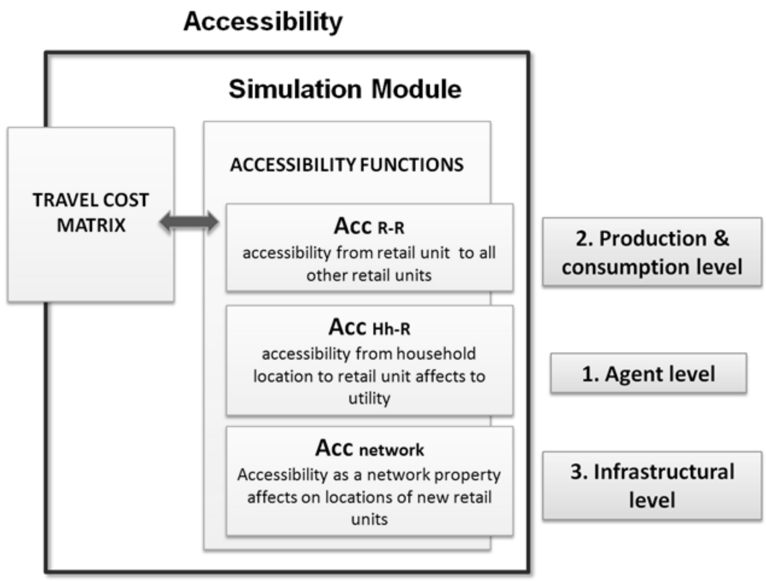

Figure 3.7 Different accessibility functions of the simulation module

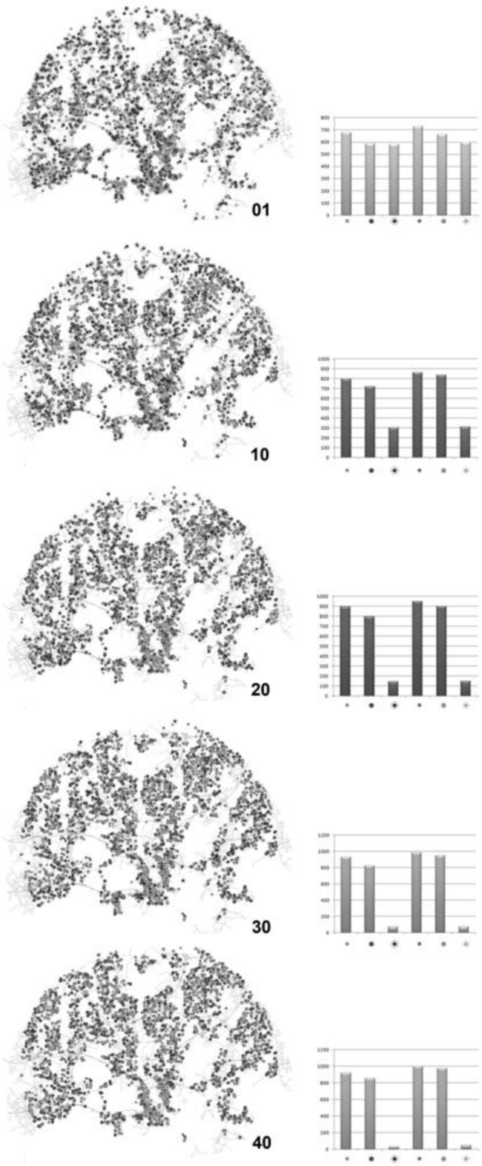

Figure 3.8 An exemplar of the simulation development path in Helsinki city region. Starting from a hypothetical random distribution of retail unit types, the charts (right) show the quantity by type

3.6 Contactability

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3.6.1 Background

This contactability indicator was developed from a vision of networks from the theoretical geography tradition and in reaction to the classic accessibility indicators, which emphasize too much the quantification of a level at the expense of understanding the network view of the access conditions.

The scientific question was to supplement accessibility indicators with a complementary view that would allow for a better understanding of how transport networks contribute to the local level of accessibility.

The planning issues to be addressed are associated with the objectives of spatial cohesion such as they are enunciated in the ESDP (European Spatial Planning Perspective): Which degree of cohesion in a city network? Which level of contactability for cities and metropolitan regions? What are the missing links in the transport network to favour a better spatial integration of a city network?

3.6.2 Conceptual framework and theoretical underpinnings

Metropolises have become the focus of contemporary economic development. They constitute a type of settlement organising both the short distances of co-presence and the long distances of telecommunication and transport through the mastering of fast transport systems. Despite the rise of telecommunications, it is acknowledged by many analysts in the field of innovation, that face-to-face contact remains a key element. The analysis of professional mobility shows those contacts are dominantly performed through single day trips.

Time-geography (Hägerstrand, 1970) provides the theoretical and conceptual framework still suitable for analysing this type of metropolitan mobility. In that it considers the space-time individual constraints as key parameters in the measurement of the access conditions. The main indicator is contact potential (Erlandsson, 1979), also called contactability (Haggett, 2001). It measures the possibility to realise a trip to a distant location respecting the time-space prism.

Accessibility is defined in the contactability indicator as the potential, for somebody in a location, for having face-to-face contact with somebody else in a single or a group of distant locations.

The measure of accessibility is Boolean for each O-D pair considered: is it (YES) or is it not (NO) possible to perform a contact under some time constraints? Departure not earlier than 5am, return not later than 11pm and a minimum period of time of 6 hours for a contact are leading criteria, while connection times are also considered (see details in Figure 3.9).

3.6.3 Operational aspects

The type of accessibility that the indicator measures is “travel times using public transport”.

Contactability is measured by associating two optimal transport chains corresponding to a return trip. Fast transport systems -by rail and air - are operated with timetables. To reach a certain level of realism, and to consider intermodality in a satisfactory way a scheduled minimum path must be computed (L’Hostis and Baptiste, 2006). Therefore timetable information must be collected and manipulated in a large database.

Data is available by purchasing the OAG [1] database for flights and by automatic queries of the public website DieBahn.de for the train timetables.

The data has been stored on a mysql database. Timetables and nodes (the graph) must be put in the database, and then the minimum paths are processed through the database. The minimum paths have been computed with the Musliw software (not publicly available, developed by P. Palmier from the Centre d'Etudes Techniques de l'Equipement Nord-Picardie). The degree of technical expertise is high for performing the calculation and processing the information, because of the mass of information it involves.

Tasks and time consumption:

- selection of the cities to be considered;
- 1 month for gathering railway information with an ad hoc java web capturing tool developed at the IFSTTAR;
- 3 days for formatting transport supply information under the form of a graph;
- 3 days week for modelling the full graph in a GIS environment with pedestrian connections for intermodality;
- 2 x 4 hours for computing minimum paths with Musliw (roughly 1 million minimum paths for 200 cities);
- 5 days for processing minimum paths in the database;
- 1 day for realising the cartography;

The degree of technical expertise for interpretation is low.

[1] http://www.oag.com/

3.6.4 Relevance for planning practice

Contactability indicators are particularly suitable in the frame of the polycentrism option for organising the territory with city networks.

It has been used in the frame of the European Spatial Planning Observation Network (ESPON) for proposing European cities competitiveness indicators (Lennert *et al.*, 2010) as can be seen on Figure 3.10 and Figure 3.11. Furthermore, it has been used by BBR[2] in the ESPON Atlas [3] to propose the constitution of Global Integration Zones outside of the pentagon [4], as stated in the ESDP polycentrism option.

Coupled with the classic accessibility indicator developed by Spiekermann and Wegener (Spiekermann and Wegener, 2007) it allows for a better understanding of the levels of accessibility by identifying the top level contactability link.

It has also been used for clustering European cities in a research for the French DATAR (project ACME 2011).

3.6.5 Strengths and limitations

Strengths

- it allows for the identification of links, existing or missing, as opposed to the simple identification of high or low accessibility locations;
- it measures the possibility to realise real daily trips as opposed to the measure of an abstract level of accessibility (as in classic accessibility indicators), which helps the interpretation of the cartography.

Limitations

- it operates a selection through the full timetable information, therefore focuses on a limited type of mobility needs, and does not account for the full transport supply between two cities. For this reason, it is a complementary indicator to classic accessibility indicators (there is no way to overcome this limitation which is inherent to this type of indicator);
- the indicator measurement is highly dependent on the choice of cities; this step, the choice of cities, must be thus made on a clear and sound basis and is not an easy task at the European level (by experience the city list is often provided by the commissioner of the work i.e. Urban Audit cities chosen for the “Future Orientations for Cities” ESPON project).

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[2] The German federal Planning office “Bundesamt für Bauwesen und Raumordnung”.

[3] ESPON and BBR, *ESPON atlas, Mapping the structure of the European territory* (BBR, 2006).

[4] The pentagon formed by the cities of London, Hamburg, Munich, Milan and Paris, concentrating population (40 %) and wealth (50 % of GDP) on a limited surface (20 %).

- the most recent implementation combines air and rail transport; the next step will be to integrate transport by road in a full multimodal and intermodal approach
- In the context of a planning discussion the experience is that this type of indicator is not easily readable at first sight, but once explanation is given, the stakeholders can clearly understand the type of mobility involved and represented. The representation of the indicator has required extensive work on graphical representation both schematic and cartographic;

3.6.6 References

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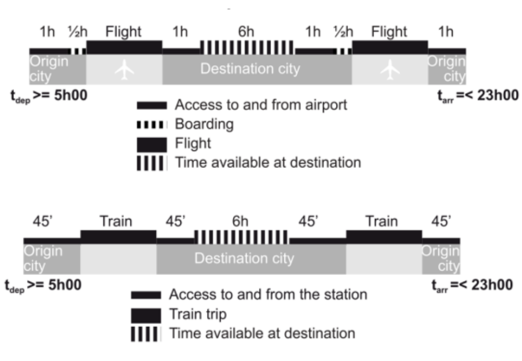

Figure 3.9 Structure of the air and rail return trips for computing the contactability indicator (author: A. L'Hostis)

Figure 3.10 Contactability by monomodal and intermodal transport chains between European cities in 2009 (author: A. L'Hostis)

Figure 3.11 Contactability level by city and by monomodal and intermodal transport chains in 2009 (author: A. L'Hostis)

3.7 Erreichbarkeitsatlas der Europäischen Metropolregion München (EMM)

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3.7.1 Background

Accessibility is at the heart of the research approach on sustainable mobility. The TUM department of urban structure and transport planning is developing suitable instruments and tools with manifold partners of the Munich metropolitan region and beyond. Since 2007, the EMM accessibility atlas has been conceived and developed as a strategic tool for analysis and planning, across all transport modes and on various spatial scales. The main objectives are to investigate, understand and visualize the potentials and risks of land-use and transport development on a local level in order to improve regional governance and decision-making processes.

3.7.2 Conceptual framework and theoretical underpinnings

The 'Erreichbarkeitsatlas der EMM' is mainly a database of structural (population, employed people, motorization etc.) and transport supply data (road networks with relevant attributes, public transport stop and line model with timetables) that covers the geographic area of the European Metropolitan Region of Munich (EMM, www.metropolregion-muenchen.eu): an area with a diameter of approximately 170 km and a population of 5.5 million. The structural datasets are incorporated in the database on the spatial level of municipalities with a further differentiation on city district level for the three largest cities in the area (München, Augsburg, Ingolstadt).

This database is the platform for regional accessibility analyses. It is also the starting point for the development of sub-models that can analyze smaller parts of the EMM with a higher degree of detail.

Per se, this accessibility modelling platform does not pose any limitations on the methodological framework, as long as a selected methodology does not require data other than the aforementioned structural and transport supply datasets (which however can be extended flexibly with according data surveying efforts).

Practically, the 'Erreichbarkeitsatlas der EMM' has been developed with a focus on implementing variations of isochrone and gravity accessibility measures, since these are both relatively easy to implement as well as to interpret and therefore appear to be most useful within strategic transport and land-use planning processes (Geurs and van Eck 2001).

Beside these classical accessibility measures, other measures have been used e.g. network analysis indicators based on the methodological framework of Multiple Centrality Analysis (Crucitti *et al.* 2006, Curtis and Scheurer 2010).

The underlying assumption is, that accessibility is a complex, multi-dimensional concept that cannot be captured by one or few indicators, but needs to be analyzed with a variety of indicators, each of which is specifically designed to explain one specific aspect of accessibility.

A future goal in the development of the 'Erreichbarkeitsatlas der EMM' is the specification of location-specific accessibility profiles that bring together these separate issues of accessibility, thus providing a multi-faceted overview of how a certain location performs with regard to the different aspects of accessibility (Keller and Ji 2012).

3.7.3 Operational aspects

On the regional level, the 'Erreichbarkeitsatlas der EMM' has been used for analyzing accessibility indicators for car and public transport. These indicators include travel time analyses (isochrones) to different locations of regional interest (e.g. airport, long-distance train stations, universities, major leisure facilities) and the development of an accessibility index that calculates population and job potentials that can be reached from every municipality in the study area. This index implements a gravity accessibility indicator in which spatial resistance is defined by travel time.

In the local accessibility analyses, the degree of spatial resolution is strongly improved, a larger variety of indicators is being implemented and cycling and walking are included in the analyses. Accessibility differences within a municipality are analyzed, e.g. by analyzing access and egress to public transport stations; and by determining network-based catchment areas of points of interest (health-care, shopping, services etc.). Public transport service quality is determined on the basis of an index that combines the aspects of travel time, service frequency and numbers of transfers. Public transport accessibility levels of locations are compared with land-use density levels to determine areas with accessibility deficits. Further indicators are under development. The goal is to categorize and later aggregate very specific indicators to a lower number of generalized indicators (categories to be specified, e.g. 'local public transport accessibility', 'regional public transport accessibility', 'non-motorized neighbourhood accessibility'). These aggregated indicators can be used for the development of a location-specific accessibility profile. Such an accessibility profile could be used in assessing land-use plans with regard to 'sustainable accessibility' by applying it to every block of a planning scheme and assessing it against land-use-type-specific benchmarks.

As mentioned in Figure 3.13, all aforementioned accessibility analyses are based on firstly structural datasets and secondly transport supply datasets. The main structural datasets are population and employment. In Germany, these datasets are publicly available from the statistical administration of the German states with a spatial resolution of municipalities. To arrive at more detailed structural data, disaggregation methods based on land-use density estimations are used. This is currently done by using CORINE Land Cover data (http://www.eea.europa.eu/publications/COR0-landcover), but is intended to be refined by additional datasets in the future.

The analysis of travel times for car, cycling and walking on a network basis is done by using the OpenStreetMap network (www.openstreetmap.com). OpenStreetMap is a user generated world-wide map ("Wikipedia-principle") that can be used without cost for any purpose.

Public transport timetable data is generally publicly available (internet, timetable booklets) but its implementation in the database requires a lot of work unless a study area is covered by an already existing transport model, as has been the case in all applications of the 'Erreichbarkeitsatlas der EMM' so far.

To date there are no automatic routines for calculating the different accessibility indicators, therefore the tool can only be used by experienced modellers who have been made familiar with the database. Advanced GIS skills are indispensible. The time required for calculating different indicators varies but is generally quite high (several hours to several days).

Beyond this modelling database, a prototype of an online tool of the 'Erreichbarkeitsatlas der EMM' has been developed. This online tool covers a few basic indicators on the regional level. The underlying data is static, but users can specify which specific datasets are to be visualized, e.g. by specifiying a time budget for an isochrone analysis. No technical skills are required for using the webtool, but its applicability for actual planning purposes is very limited. After a short testing phase the webtool is currently not publicly available due to technical problems. The future of the webtool mainly depends on whether more funds for its development will be available in the future. The functionality of location-specific accessibility profiles could then be integrated in the webtool.

3.7.4 Relevance for planning practice

The instrument (local accessibility model) is currently being applied for the first time in a real-world planning context: a climate protection concept for a county near Munich. Within this project, the tool is mainly being used to determine potentials for transit-oriented development, promotion of neighbourhood mobility and strategic land-use planning. The project is still at an early stage and the local modelling environment is still in the build-up phase. Therefore, no experiences on usability, effectiveness or outcomes can be reported at this time. The project will be completed in mid-2012.

Beyond this planning application, the tool is used in different research projects. Most noteworthy is a French-German cooperation project on "Stress-tests for sustainable mobility – an accessibility approach". Within this project accessibility indicators are combined with other socio-economic and demographic data to establish an area-wide vulnerability index, which examines a municipality's vulnerability in the face of potential energy cost increases due to peak-oil developments and/or stricter CO_2 emission regulations/trading schemes. This project is perceived with high interest by regional planning professionals but since it is still under development it is not possible yet to assess its impact on decision-making or usability.

3.7.5 Strengths and limitations

The most important strength of the 'Erreichbarkeitsatlas der EMM' is its flexibility in incorporating a large variety of indicators. It has not been designed to calculate one very specific kind of indicator but to provide a data platform suitable to handle all major state-of-the-art accessibility modelling techniques.

Another major strength of the tool is, that all core datasets are available free of charge. Therefore, the instrument can be set up in any German region and could probably be transferred to many parts of Europe (with minor adjustments according to the availability of structural data). It gives public bodies with limited financial and personal resources a possibility to develop a quantitative evidence-base for the purpose of integrated land-use and transport planning.

Its major limitation is that it is not a tool that can be used by anyone. It clearly needs time and expertise to develop the model for a specific region and equally to calculate specific indicators. The further development of the online prototype is an option but cannot be advanced without a strong funding base.

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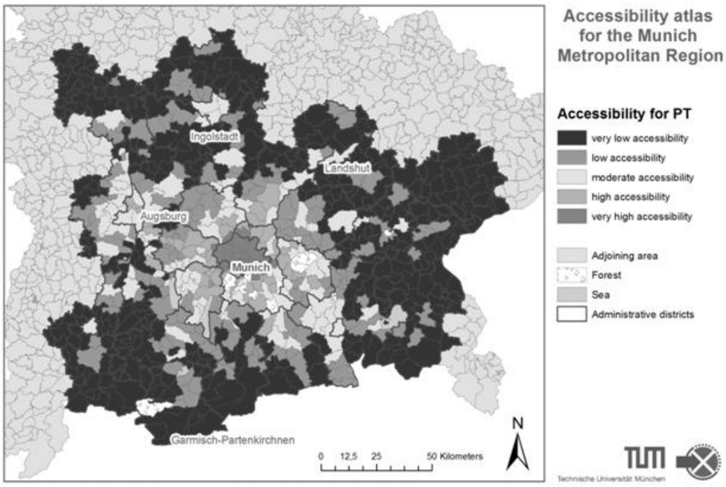

Figure 3.12 Public transport accessibility in the EMM (gravity accessibility indicator)

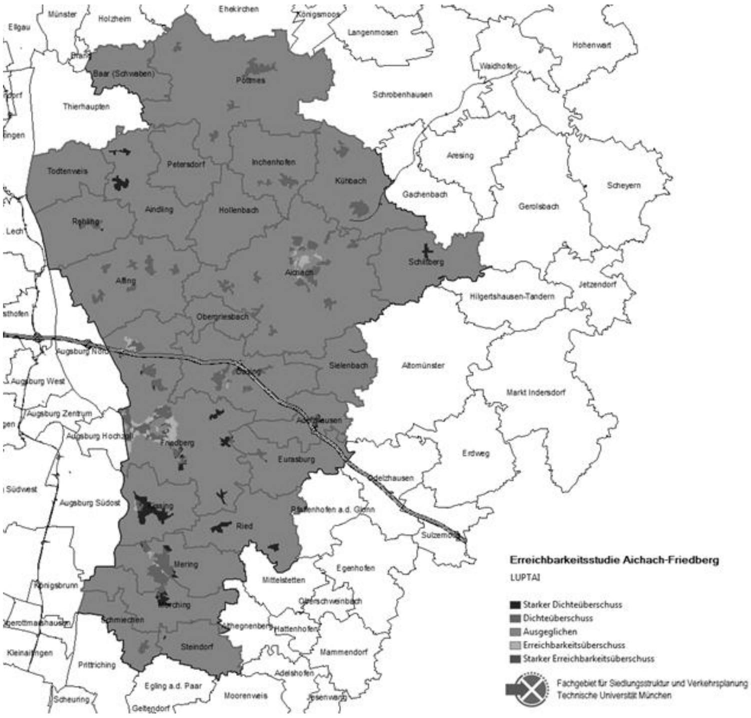

Figure 3.13 Land-use and public transport accessibility index: population density vs. Public transport accessibility

3.8 The German Guidelines for Integrated Network Design– binding accessibility standards (RIN)

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3.8.1 Background

The "Guidelines for Integrated Network Design" (RIN) formulate standards for all transport modes and for all spatial levels reaching from the macro level of connecting agglomerations to the micro level of securing a local supply of infrastructure for pedestrian, bicycle, public and car transport. The RIN mainly focus on passenger transport. This includes car, public transport (railways, underground rail, tram and bus), bicycle and pedestrian transport modes as well as the design of linkage points for intermodal transport (Park+Ride, Rail+Fly and Bike+Ride). The RIN orientate these standards directly towards the system of central locations identified as suitable bases for the spatial components of a basic accessibility. Additionally, the RIN are an attempt to integrate scientific knowledge of transport planning into a highly binding planning guideline.

The backgrounds are target values for journey times between central locations. They are derived from spatial planning considerations and have been used in German transport planning for many years. Figure 3.14 shows these target values. Journey time includes getting to transport from home, waiting and travel time, and getting from transport to final destination. The listed target values are not a quality criterion for transport planning on their own. However, they form the basis for assessing the quality of infrastructure supply with the help of speed-based target values for specific network elements and for assessing the quality of complete transport routes between central locations.

3.8.2 Conceptual framework and theoretical underpinnings

The RIN suggest targets for connecting central locations to each other and to residential areas. The following are goals of the RIN:

- Guarantee the supply function for people living within the catchment areas of central locations;
- Guarantee the exchange function between central locations;
- Support the development of population structures that are concentrated on the system of central locations;
- Support the special importance of the interconnection between national and international agglomerations.

The RIN are assigned the highest category in the publications of the German Research Society on Roads and Transport (FGSV) and are thus strongly binding for German authorities and transport planners. They were announced by the German Federal Transport Ministry with the request that they be applied to trunk roads. The RIN are the first part of a highly complex set of guidelines that sets standards for all steps of infrastructure design; from network design to the alignment and assessment of specific street sections.

3.8.3 Operational aspects

The starting point for the RIN is the system of central locations. The combination of this system and the target values for journey times between central locations and residential areas builds the basis for the functional structuring of the transport network. In addition, it is the basis for the development of quality requirements for the transport networks and linkage points in the RIN. Each network section is classified according to:

- Its importance: level of connector function (LCF), and;
- Its function (road category).

The LCF is derived from the level of central locations to be connected. Six levels of connector function are defined to describe the significance of connection routes. These levels are valid for all modes of transport as long as they are relevant for the respective mode. The importance of a connection results from the importance of the locations to be connected. The RIN distinguish between connections related to the service functions for residential locations in catchment areas and connections that enable exchange between central locations.

In the second step a road category is assigned to each network segment in addition to the LCF. Roads may have combinations of functions imposed on them in terms of the expectations set by the adjoining land-uses. A road category is assigned to each road section in accordance with the following criteria:

- Road type (motorways, country roads, urban roads);
- Location (outside built-up areas, bordering built-up areas, within built-up areas);
- Type of adjoining land-use (non-built-up, built-up);
- Main road or access road;
- The RIN develop similar categorizations for Public Transport, bicycle and pedestrian traffic.

Central locations are connected by a series of network elements that together form a transport route. The quality of the transport route can only be improved by upgrading the compositing elements of the route. Quality requirements for specific network elements can be derived from target values for the transport routes. The RIN operationalize these quality requirements by standard distance ranges and target values for car, public transport and cycling travel speed on the network elements. These requirements are formulated at a micro level of specific network elements. Nevertheless, they help to guarantee the exchange function and the supply function of central locations as they are derived from spatial planning considerations. In addition to the criteria that are related to specific network sections, the RIN introduce criteria for assessing the service quality of complete transport routes between central locations and between central locations and residential areas. The goal of these criteria is to obtain a picture of the overall quality of the network for different transport modes. Relevant criteria for connection quality at this macro level are journey time, costs, directness, temporal and spatial availability of transport services, reliability, safety and comfort. The RIN set target values especially for journey time and directness and work with the six levels of service quality from A to F like school grades.

3.8.4 Relevance for planning practice

Transport policy should not concentrate primarily on improving traffic, but rather on the underlying purpose, that is, on the activities that can be carried out with the help of transport and on the needs that can be satisfied by those activities. The definition of the concepts of basic needs and basic mobility is a normative task and changes over time and between regions. However, this definition is required to formulate concrete standards that guarantee the satisfaction of certain needs, the basic necessity of which is beyond dispute.

These standards should describe opportunities provided by the transport and the spatial system as well as specific needs of certain groups of people. Accessibility standards are a suitable means of describing these components of basic mobility. The system of central locations is an appropriate basis for designing the spatial components of the standards system. It must be broken down into spatially low levels of centrality to guarantee the local supply of daily goods and services. Standards are necessary for the system's structure and the facilities of central locations.

These standards are set with the RIN. They are binding for the whole country and are used in transport planning processes especially on the federal and regional level. While the standards concerning connections by car are set very near to the current situation the main focus of the RIN is enhancing the quality of public transport and of the "slow modes" (pedestrian and bicycle) with the aims to enable all people to make use of the standards and to reduce the environmental impacts of transportation.

3.8.5 Strengths and limitations

The RIN are a successful example of designing the transport components of such a system of accessibility standards. The RIN deal with the design of transport networks for public, private motorized, bicycle and pedestrian modes of transport. Firstly, the RIN establish the functional structure and hierarchy of the transport network. Secondly, the RIN develop quality requirements for the development of specific network elements. These are derived from the general requirements, which result from spatial planning considerations and functional structuring of the transport network. Standard distance ranges and car speeds are used as criteria to describe these quality requirements. Thirdly, the RIN develop indicators for assessing the service quality of complete transport routes (connections between central locations and to residential areas). Service quality levels are determined for point-to-point speed and the ratio of private to public travel time. This approach allows the transport routes to be assessed as "good" or "bad" from the user’s point of view. It has been applied in planning practice like in Transport Plans for the region of Stuttgart (Figure 3.14), Rhine-Main-Area or Thüringen.

Hence, the RIN shows that it is possible to develop a comprehensive system of standards that is not only clear and pragmatic, but that also includes all transport modes and all spatial levels from a detailed micro level to the macro accessibility of agglomerations. As such, the RIN are an important component of basic mobility and thus form an important component of sustainable transport development. This component must be supplemented with criteria for the spatial elements of basic mobility and by criteria for the environmental and economic aspects of sustainable transportation development.

So far this system is limited on passenger transport. An implementation of standards for freight transport modes will be developed in the next years. It could be used easily so that there are no limitations. One lack at the moment is that this guideline is recognized by traffic planners but not very well known by geographical or spatial experts.

3.8.6 References

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3.8.7 Tables and Figures

Table 3.1 Target values for accessibility to central locations from residential areas

Central Location	Journey time [min]	
	Car	Public Transport
Basic centres (BC)	≤20	≤20
Mid-level centres (MC)	≤30	≤45
Upper-level centres (UC)	≤60	≤90

Source: FGSV (2008)

Table 3.2 Target values for accessibility to central locations from neighbouring central locations

Central location	Journey time to nearest neighbour [min]	
	Car	Public Transport
Basic centres (BC)	≤25	≤40
Mid-level centres (MC)	≤45	≤65
Upper-level centres (UC)	≤120	≤150
Agglomerations (A)	≤180	≤180

Source: FGSV (2008)

Table 3.3 Categories for bicycle infrastructure and target values for travel speed for daily traffic

Category		Sub-Category		Standard range [km]	Target speed [km/h]
AR	Outside built-up areas	AR II	Interregional bicycle connection	10-70	20-30
		AR III	Regional bicycle connection	5-35	20-30
		AR IV	Local bicycle connection	Up to 15	20-30
IR	Inside built-up areas	IR II	Inner-municipal express bicycle connection	-	15-25
		IR III	Inner-municipal standard bicycle connection	-	15-20
		IR IV	Inner-municipal bicycle connections	-	15-20
		IR V	Inner-municipal bicycle connections	-	-

Source: FGSV (2008)

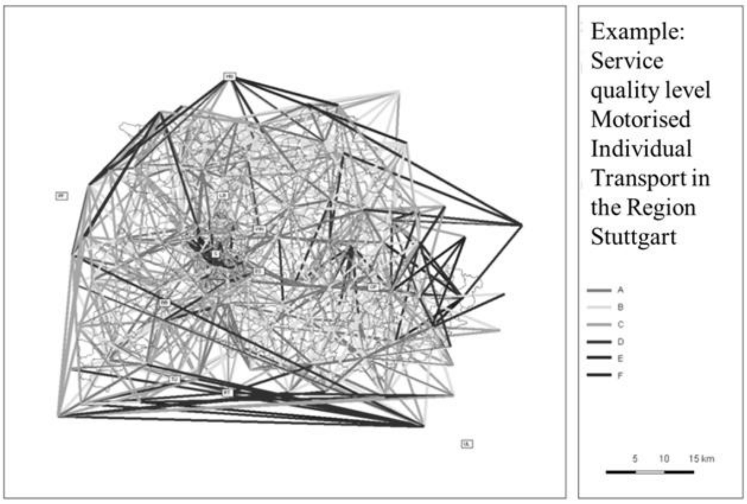

Figure 3.14 Example of the Stuttgart Region: Quality Levels from A to F for the accessibility by motorised individual transport.

3.9 Measures of Street Connectivity: Spatialist_Lines (MoSC)

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3.9.1 Background

How individuals move and interact between places is related to the spatial form of these places. Spatial form in cities can be conceived in terms of networks of streets and related routes, open spaces, clusters of land parcels and buildings. This physical infrastructure both accommodates and shapes circulation of different kinds (pedestrian, vehicular, public transportation). Therefore the form of physical infrastructure can either facilitate or impede this circulation and consequently human presence in public space.

Spatialist_Lines has been developed within the broader context of syntactic studies. Syntactic studies argue that the spatial structure of urban areas plays a significant role in pedestrian movement and land use distribution. Originally in space syntax the focus was on links that are defined as lines of sight or as lines of unobstructed movement (axial lines). A unit distance was associated with a link between one axial line and another, and thus the accessibility between streets was measured as a count of links that need to be crossed to move from one axial line to another. The actual length of a street is irrelevant as far as it can be represented by one line of sight. In this sense, the connectivity of the network was defined topologically and distance had no meaning.

Spatiality_lines introduces metric values into this framework so that the proposed measures combine topological and metric properties. It aims at contributing a way of measuring how a street grid becomes metrically denser or sparser, more or less intelligible and more or less easily accessible.

This approach might help to bridge the gap between understanding urban structure, urban design, and urban regulation. One practical outcome is to support the appropriate design of streets as part of urban developments. For example it can inform us on how the street network can be designed so as to ensure that some places, intended as retail hubs, business cores or local centres, will be more likely to attract higher densities of movement, whereas others, intended for residential uses, will remain quieter (Hillier, 1993).

3.9.2 Conceptual framework and theoretical underpinnings

One can distinguish four different approaches regarding description and evaluation of street connectivity (Ozbil *et al.*, 2011).

The first one resorts to typological distinctions between rectilinear, curvilinear and cul-de-sac layouts. These distinctions are supported by measures of the average properties of street networks, such as the number of intersections or cul-de-sacs by unit area.

A second one directly discusses the connectivity of street networks as a factor that affects accessibility and walking. The measures used include density of street intersections per area, block size per area, cul-de-sacs per area, proportion of four-way intersections, the ratio of intersections to cul-de-sacs, the links–nodes ratio, or the average distance between intersections.

A third approach uses measures that can characterize a particular location within a network such as the walking catchment area around a destination of particular importance or the directness of available routes from various surrounding origins to destinations of importance.

The fourth one takes a configurational approach and it is associated with space syntax studies. It involves measuring the accessibility of all parts of a network under consideration from each individual street element. The intent is to provide a generalized description of spatial structure and connectivity hierarchy without making assumptions about desirable or typical trips.

Following this last, syntactic approach, Spatialist_Lines defines accessibility in terms of *street connectivity as a* specific form of relatedness that arises according to the structure of street networks. Street networks are mechanisms that serve the purposes of connectivity in the broad sense. Connectivity is comprehended as a generator of urban potential. Urban potential can be thought of as the quantity of destinations that is available within a given distance of movement from a point. From the point of view of movement, potential access is the fundamental form of spatial relatedness.

3.9.3 Operational aspects

A research team from Georgia Institute of Technology has proposed three measures of street connectivity that can discriminate between the connectivity potential of individual road segments in adjacent or proximate positions. These are Metric reach, Directional reach and Directional distance (Peponis *et al.*, 2008). When averaged over an area, they provide robust measures of overall connectivity. In other words, the three aforementioned measures can be used to describe the aggregate connectivity differences between urban areas, as well as the internal spatial structure of a single urban area.

Stated simply, metric reach (Figure 3.15) measures the length of street which lies within a parametrically specified network distance from a point.

Directional reach (Figure 3.16) measures the length of street which lies within a specified number of direction changes from a point, with a specification of the minimum angular threshold that defines a direction change. While metric reach “grows” around a root point equally in all available directions, directional reach is “biased” according to the linear alignment of streets.

Directional distance measures the average number of direction changes, subject to a parametric angular threshold, that are needed in order to access the parts of a given metric reach. In order to characterize a network, the measures are applied to the mid-points of all road segments in a system. In principle, they can be applied to a more limited set of chosen points (for example to the entries to schools or shops) or to a larger set of points (for example to all street intersections in addition to all road segment mid-points).

Spatialist_lines is a JAVA-based software which has been developed at the Georgia Institute of Technology by Peponis, Bafna and Zhang, and is currently available “as is” upon request addressed to john.peponis@coa.gatech.edu without technical support other than provided in a simple manual originally intended for distribution to new members of the Georgia Tech research team. The software operates as a plug in to ArcView GIS.

The software takes as input street centre line information from standard GIS street network data bases or CAD files in DXF format. It provides as output the measures of metric reach, directional reach and directional distance. Results are also displayed in colour street maps.

Time length of calculation ranges from seconds to few hours depending on the size of the street network and the available computer power. A basic knowledge of GIS software is required to perform the calculation. Visuals maps are easy to be comprehended and there is no need for technical expertise to understand the differentiations and hierarchies of the urban grid in question.

3.9.4 Relevance for planning practice

The approach can inform urban design decisions in creating new streets or realigning existing ones. The notion that street layout can and should serve planning aims is an old one. What have been missing are measures of street connectivity that can support decisions about street layout design. The proposed measures are useful in this context. They mediate between urban planning and urban design. Urban planning is oriented towards principles of general applicability and tends to be concerned with the average or aggregate properties of areas. Urban design is concerned with the internal structure of areas and with the way in which street layout impacts the nature, orientation and performance of building developments for which it provides the context. Walking is, after all, a pre-eminently context-dependent activity, one that occurs according to the fine grain of environment, as well as its larger scale structure. This is why we need enriched models of street layout and urban form in order to better design for walkability. The fact that direction changes are as important as metric distance in describing street connectivity points to the role of cognitive factors. Traditional models of movement patterns are based on the consideration of distance and time, but they do not take into account the intelligibility of urban form. Integrating considerations of intelligibility can lead to enhance models of urban form and function (Ozbil *et al.*, 2011).

Spatialist_lines has been used to support design and planning decisions in practice. In summer 2010, the software was used to assist Perkins and Will in the master-plan for the King Abdullah University of Science and Technology Science Town (KAUST) [5]. This is to be developed in Saudi Arabia, on a 790 acre site, north of Jeddah.

The Georgia Tech research team worked with the urban designers to ensure that the main road network, the linear pedestrian spine and the master-plan stipulations would work together as an intelligible, flexible and effective framework for the growth of a vibrant research, development and business community. Specific programmatic aims served by road and path connectivity include the support of serendipitous interaction and communication as well as the provision of an accessible and intelligible system of support functions such as social meeting places, retail, cultural centres, restaurants and other amenities.

The process of consultation included a design guideline which was discussed with urban designers in the beginning of the design process; analyses of the proposed network to confirm that it took the best possible advantage of connections to the pre-existing context (Figure 3.17) and that its internal structure was suitable for the phased development of the town ; proposals of specific urban elements (such as the "research souk") which would enhance the emergent pedestrian circulation system and finally calibration of the location of local hubs (such as open spaces, incubator complexes, or specific buildings), that will punctuate movement over the network of streets and paths.

3.9.5 Strengths and limitations

From a scientific point of view the proposed *connectivity measures* enrich a considerable body of literature that points to a relationship between the distribution of pedestrian movement and the spatial structure of street networks. They underline the importance of the street network as the long-term framework that impacts the evolution of important aspects of urban function, including walkability, and patterns of land use that benefit from walkability. Furthermore they are sensitive to the geometry and the metric properties of the spatial structure of street networks.

From a practice point of view the proposed *connectivity measures* are critical for understanding the relationship between urban network design and practical consequences. Measures that emphasize the average properties of areas can be useful in supporting general guidelines and policies, but cannot inform design decisions about alternative street alignments or alternative ways of fronting and orienting developments. The specific measures of connectivity affect the interface between urban design and urban planning. Understanding how pedestrian movement is distributed over an area is important to urban development and urban design, because it helps the design team determine the potential character of individual streets.

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[5]http://www.perkinswill.com,
https://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=17428

Planning practitioners adopted the proposed consultation process and measures with no negative reactions. More than that, it seems that their original decision to adopt the specific consultation process was mainly based on the academic performance of the method.

This argues against the underlining idea that the academic and the professional environments are two separate areas with completely different requirements and goals. On the contrary it seems that academic performance influences professional choices.

Accessibility in urban context is a complicated issue. All accessibility instruments are limited in the sense that they focus on specific aspects of the problem and consequently they cannot explain everything. Spatialist_Lines have not been tested extensively in practice as it is a new instrument. Judging from its nature and background we can anticipate that negative reactions probably will be similar with those concerning space syntax instruments (i.e., practitioners having too high expectations of the results, or being unable to translate results without a theoretical background). For the time being developers are testing the instrument in academic research

3.9.6 References

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3.9.7 Figures

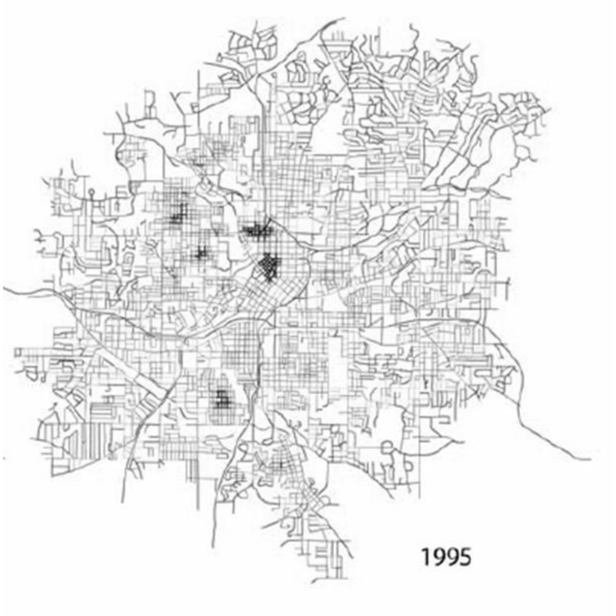

Figure 3.15 Metric Reach Map of Atlanta. The 10 interval colour range red-blue represents the spectrum from higher to lower values. (Source: Haynie *et al.*, 2009)

Figure 3.16 Directional Reach Map of Atlanta. The 10 interval colour range red-blue represents the spectrum from higher to lower values. (Source: Haynie *et al.*, 2009)

Figure 3.17 Directional Reach Map of KAUST . The 10 interval colour range red-blue represents the spectrum from higher to lower values. (Source: KAUST Masterplan guidelines)

3.10 Interactive Visualization Tool (InViTo)

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3.10.1 Background

The instrument developed by SiTI, called InViTo (acronym of Interactive Visualization Tool), aims to provide a visual interactive support to large scale planning processes. The tool is intended to provide an effective basis for sharing information and enabling discussion among different actors such as planners, stakeholders and, in general, non-expert people within focus groups, workshops, participative and collaborative processes.

The decision to develop this instrument stems from the need to analyse the relations between urban development and spatial elements, such as transport facilities or landscape issues. Since accessibility is one of the factors which most influence location choices, a specific study has been dedicated for its investigation.

The main strength of InViTo is represented by the possibility of managing interactive and dynamic scenarios, in order to visualize in real time the effects of decision making on urban form and to support the planning processes. Due to its flexibility, the tool can be used for several applications and in different fields of research which need to visualize geo-referenced data on maps. In this COST Action, InViTo is presented as a tool for calculating and visualizing accessibility in real time during participated planning processes.

3.10.2 Conceptual framework and theoretical underpinnings

InViTo has been designed to support urban planning processes. It aims to improve the cognitive process through an interactive framework, which combines different data in a complex structure of relations and connections. A specific spatial behaviour can be assigned to each data. Each behaviour can be described through a mathematical function, providing a spatial effect on settlements. For example, a new subway line interacts with the suitability of residential zones as well as the localization of a railway station modifies the perception of the area (Pensa *et al.,* 2011).

All the mathematical functions can be activated and modified in real time during the participatory process by the participating actors, who can operate on the following elements:

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[6] SiTI – Higher Institute on Territorial Systems for Innovation - is a non-profit association, set up by the Turin Polytechnic and the Compagnia di San Paolo in order to produce research and training orientated towards innovation and socio-economic growth.

Mathematical functions. For instance, if experts do not agree on the catchment area of a railway station, they can change the values assigned to the specific element.

Weights among the spatial elements. Users can define the singular weights which correlate to different spatial elements.

Outlines of routes. For example, it is possible to change the path of a public transport line in the project.

Due to its characteristics, the tool is particularly suitable for measuring accessibility, here intended as the walking time to the nearest public transport access points (e.g. bus stops or railway stations). Walk distances are calculated on the pedestrian network, as shown in Figure 3.18, and then divided on the average walking speed.

3.10.3 Operational aspects

Nowadays technology provides different solutions to visualize data and relate them to specific features of the object of study. For this reason, existing software have been investigated in order to find the most useful and appropriate for the specific tasks. In particular, this software should be a single tool able to manage and display data, variables and outputs with the possibility to customize it. Furthermore, it should be able to work in real-time relating choices and areas of interest and creating immediate outputs. Finally, it should allow the construction of a method replicable and easily fitting to different sorts of case studies.

The chosen software has been Rhinoceros combined with its free plug-in Grasshopper. The former is a commercial 3D modelling tool developed by McNeel & Associates, while the latter, Grasshopper, is a plug-in that allows users to create shapes using generative algorithms that can contain different kind of input including numeric, textual, audiovisual and so on.

Normally this software is used at the furniture or building scale in industrial design and in the architectural field, but Rhino and Grasshopper are here used in an innovative way to study and analyzing spatial issues in large area decision processes.

First of all the combined use of these two pieces of software creates a generative instrument, that allow the drawing of shapes without modelling. Other benefits are related to their parametric features, which allow each data to be associated with one or more mathematical equations and create relationships among them for defining shapes and their behaviours. It is dynamic, so that the choices of users modify outputs in real time according to rules described with algorithms. Furthermore, it is easy to customize using common scripting languages like C#, Python or VB.

The availability and costs of databases depend on the specific case study. Road networks are freely available from open source web sites as “Open Street Maps”, but InViTo can use different kind of sources.

Finally, taking advantage of the possibility to describe feature behaviours in a parametric way, the tool can be also used for reproducing the dynamics of various assessment methods, providing interactive visualizations for different purposes. For example, the tool has been applied to reproduce the ANP assessment technique and support collaborative processes (Lami *et al.*, 2011). In this case, it has been used to build dynamic maps showing costs and benefits of different scenarios concerning the improvement of railway infrastructure in three different areas along the corridor 24: Rotterdam - Genoa.

In the application of InViTo to accessibility, the main purpose is the evaluation of planning options, which concern the localization of new public transport lines. Therefore, accessibility is calculated as walk time from the nearest public transport access points with reference to the pedestrian road network . The output of this calculation is a map which defines point by point the level of accessibility to different public transport modes (Figure 3.19) such as bus, subway and railway or all of them (without considering, at this step of the research, different weights associated to different modes depending on their level of service).

Results can be displayed in different ways, according to audience and level of expertise. To simplify the understanding of the output, we chose to work on bi-dimensional maps which lay on the studied area directly in Google Earth virtual globe. Each map shows point by point the level of accessibility through a colour gradient based on a red-yellow-green scale: red corresponds to worst value while green represents the best one.

3.10.4 Relevance for planning practice

The first application has been a pilot study on Northern area of Turin (IT). The test intended to investigate the transformation effects of the new subway network on the redevelopment of areas of interest.

In particular, the first application concerns the study of the relationship between facilities and settlements, in order to define how public transport facilities influence the localization of new settlements as a consequence of accessibility. This relation is useful for the definition of the route of the new subway line, mapping the difference between existing and future accessibility to public transport and defining the area which could be advantaged or disadvantaged from the realization of a project option. The comparison among different scenarios and the possibility to modify some element of the project as well as their influence, provide data which can be used to build a discussion on a shared basis of information.

A second application concerns new settlements on dismissed brownfields in the city of Asti (IT) as a part of the European project “CircUse” (Circular Flow Land Use Management), a Central Europe Programme co-financed by the ERDF. The tool has been used for analyzing the suitability of different possible new functions for these former industrial areas on the basis of reclamation costs, landscape issues, accessibility, localization of green areas, transport and commercial facilities. As for the Turin case study, the tool has shown to be useful in the evaluation of alternative planning options.

3.10.5 Strengths and limitations

This tool’s main strength lies in its possibility of being adapted to different uses and purposes, which can act on different scales. Each component of the model can be evaluated and changed in real time on the basis of the considerations of experts, thus providing scientific validation to the functioning of the model.

This tool facilitates the communication of information, providing a shared basis for enabling discussions. Relations among data and their weights can be modified by users and displayed in real time, allowing a full interaction between users and needed information.

Another interesting aspect is represented by the possibility of visualizing the effects in Google Earth. It, thus, allows non-expert users the possibility to visualize outputs in a well-known environment, and with a user-friendly interface.

Further developments can be carried out.

First of all, the use of public transport changes city by city. In literature, different studies can be found, but usually the peculiarity of each case makes complicated the identification of the real behaviour of people. The next step will concern the definition of the weights related to the different transport modes in order to obtain a general accessibility to public transport. A further step will be the definition of accessibility as perceived by people, which could be investigated and defined through specific studies or surveys. This information will be useful to understand the quantity of people who will potentially use the new transport line.

Secondly, the interface for changing the input values are not so user-friendly, so the presence of a technician for the tool managing is required.

Future improvements concern the updating of the tool on the basis of feedback received during workshops and focus groups, especially on the choice of the visualization modality. The interface will be modified in order to be more user friendly.

3.10.6 References

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3.10.7 Figures

Figure 3.18 Northern metropolitan area of Turin: Pedestrian road network (white lines) and the new subway line in project (grey lines) with new access points (black and white dots)

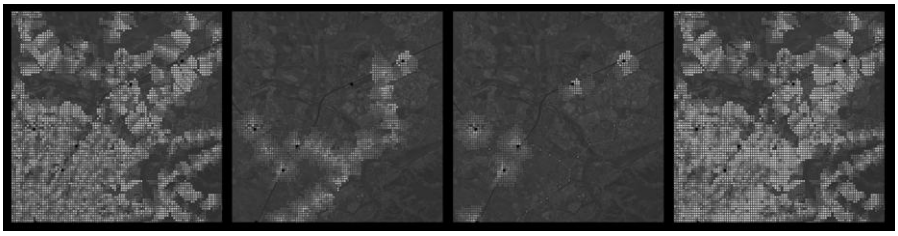

Figure 3.19 Accessibility on the Northern Turin area visualized through a Green-Yellow-Red Gradient Map.

(Note: From left to right the figure illustrates the accessibility to bus stops in the first image, to subway stations in the second and to railway stations in the third. The fourth one is the sum of the three, considering all the different transport modes with the same weight.)

3.11 Gravity-Based Accessibility measures for Integrated Transport-land Use Planning (GraBAM)

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3.11.1 Background

In transportation planning a paradigm shift is occurring: from mobility-oriented analysis (which evaluates transport system performance based on quantity and quality of physical travel) to accessibility-based analysis (which considers a broader range of impacts and options) (Litman, 2010). The instrument described in this paper, is an example of this shift which gives to accessibility measures a central role in transport and urban planning.

Such accessibility instruments have been developed both for scientific and planning motivations. In the academic field the important role of transport infrastructures for spatial development is well recognized: areas with better access to the locations of input materials and markets will be more productive, more competitive and hence more attractive than remote and isolated areas (Linneker, 1997). However, the impact of transport infrastructures on spatial development has been difficult to be verified empirically; in fact, modeling analysis, such as those based on accessibility measures, is necessary to investigate these impacts and to analyse the effects of transport infrastructure and service improvements on the spatial distribution patterns. In other words, the scientific question the accessibility instrument here presented, wants to answer is "what are the impacts on the land use induced by changes in the transportation system?"

The scientific question has direct implications for planning, related to the distributive issues of transport interventions: the goal of the accessibility instrument is to assess and to value the benefits of changes in either the land-use or the transportation systems, as a performance indicator of integrated land-use and transport planning. In other words, the question the instrument wants to address is "who reaps the accessibility benefits from investments in the transport system and where are these located?"

3.11.2 Conceptual framework and theoretical underpinnings

The accessibility typically measures “the ease and convenience of access to spatially distributed opportunities with a choice of travel” (U.S. Department of Environment, 1996). Several definitions, and related measures, can be found in the literature. Here we propose a “gravity-based” measure of accessibility, so called “gravity-based” since it can be derived from “gravity-type” trip distribution model (see Hansen, 1959); this has been used in various analyses (Geertman and Ritsema van Eck, 1995).

Starting from the general definition of “gravity-based” measures, two types of accessibility have been considered, referred to as “active” and “passive” accessibility (Cascetta, 2009). The active accessibility of a given zone *i* is a proxy of the ease of reaching the activities/opportunities located in different zones *j* of the study area for a given purpose (e.g. workplace, shopping) moving from *i*:

$$A_{act,i} = \quad _j g \;\; W_j \;\; f(c_{ij}) \qquad (3.7)$$

where W_j is the activity/opportunity to reach in zone *j*, and c_{ij} is the generalized cost of reaching zone *j* from zone *i*.

On the other hand, the passive accessibility is a proxy of the opportunity of an activity located in a given zone *i* to be reached from the potential “consumers” coming from all the other zones *j* of the study area for a given purpose (e.g. the clients of a shop):

$$A_{pas,i} = \quad _j g \;\; W_j \;\; f(c_{ji}) \qquad (3.8)$$

where W_j are the potential “consumers” of the activity/opportunity to be reached in the zone *i*, and c_{ji} is the generalized cost of reaching zone *i* from zone *j*.

Such definitions do consider the accessibility of a given zone as a sum of the generalized travel costs between zones itself and the other zones of the study area, weighted by an attraction term representing either the opportunities to be reached in the other zones (in the case of the active accessibility) or the potential “consumers” of the opportunity located in the given zone (in the case of the passive accessibility). The weights are typically powered by an exponent greater than one to take into account the agglomeration effects (if any), whereas the impendence function, $f(c_{ij})$, typically includes the travel time in a negative exponential form, based on the assumptions that: the attraction of a destination increases with size and declines with distance or travel time or cost (i.e. the gravity-based assumption).

In doing so, the accessibility measure can include both the effects of changes in the transportation systems, captured by means of the function $f(c_{ij})$, and in the land use patterns (captured by the weights Wj).In that, gravity-based accessibility indicators are more powerful than travel time accessibility indicators [7] and daily accessibility

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[7] measures the accumulated generalised travel costs to the set of destinations: all destinations in the set get equal weight irrespective of their size and all other destinations are weighted zero (the activity function is rectangular).

indicators [8]; moreover, they are founded on sound and consolidated behavioral principles of the Random Utility Maximization (Ben-Akiva and Lerman, 1985).

3.11.3 Operational aspects

The accessibility indicators we have tested are:

- the active accessibility of the residents towards the workplaces of a study area;
- the passive accessibility of the economic activities with respect to the residents of a study area.

The active accessibility measures have been calculated as:

$$A_{act,i} = \sum_j E(j)^{\alpha_1} . exp(\alpha_2 . C(i,j)) \qquad (3.9)$$

where: *E*(*j*) is the number of workplaces in the zone *j*; *C*(*i,j*) is the generalized travel cost (i.e. weighed sum of the travel time and travel costs) between zone *i* and zone *j*; α_1 and α_2 are parameters to be calibrated (see Coppola and Nuzzolo, 2011).

The passive accessibility measures have been calculated as:

$$A_{pas,i} = \sum_j Res(j)^{\gamma_1} . exp(\gamma_2 . C(j,i)) \qquad (3.10)$$

where: *Res*(j) is the number of people residing in zone *j* (i.e. the potential clients of the economic activities in *i*); *C*(*j,i*) is the generalized travel cost between zone *j* and zone *i*; γ_1 and γ_2 are parameters to be calibrated.

The above definition of the accessibility measures requires the subdivision of the study area (and portions of the external area) into a number of discrete geographic units called *traffic analysis zones* (TAZ's) and the definition of the relevant infrastructures and services (Figure 3.20). All trips that start or end within a zone are represented as if their terminal points were in a single fictitious node called *zone centroid.*

To physically delimit the zones, the criterions generally adopted can be summarized in respect of (Cascetta, 2009):

- the physical geographic separators placed on territory as railways, rivers, etc.;
- the official administrative limits as census sections, municipal borders, etc.;
- homogeneity: the land use, socioeconomic characteristics, and their accessibility to transportation facilities and services.

In general the number of the zones inside the study area is closely connected to the end-users' level to be achieved. In our case study, the Regione Campania has been subdivided into 383 "homogeneous" traffic zones with respect both to their land-use characteristics (e.g. level of population and economic activities) and to their accessibility

[8] Based on the notion of a fixed budget for travel, generally in terms of a maximum time interval in which a destination has to be reached to be of interest.

to transportation networks. A traffic zone represents either one municipality, or a group of municipalities (typically the small ones) or part of a municipality (this is the case of the large cities).

Zoning is related to the subsequent phase of selection of the relevant supply elements and the definition of the transport supply graphs. By means of these graphs the OD travel costs and travel times needed for the computation of the generalized travel cost can be estimated.

The datasets used in the accessibility instrument here presented include:

- Origin-Destination (OD) tables for inter-zonal travel time and travel costs;
- Demographic and socioeconomic data (e.g. the employment distribution) by each zone;
- Zone geographic boundary files.

Socioeconomic data (workplaces and resident per zone) are typically available and acquirable from the National Institute of Statistics (e.g. the ISTAT in Italy). The implementation of the transport supply model is more complex, in that it requires the collection of the characteristics of transportation infrastructures and services in the study area, and the implementation of such elements into a simulation software package. In our case, the data have been processed using the "TransCAD Transportation GIS Software", that require a medium-high degree of technical expertise to perform the calculations and for the interpretation of results.

The calibration of the parameters, which might represent the mayor difficulty of the accessibility instrument, requires the estimation of a gravity-based trip distribution model using a survey carried on in the specific case study, or, alternatively, adapted to the case study from similar ones.

3.11.4 Relevance for planning practice

The above accessibility instruments can be used to measure the distribution of wider economic benefits of alternative transportation projects. Furthermore, by working with data in a GIS environment, the spatial distribution of current accessibility levels as well as future changes in accessibility can be displayed (Figure 3.22). Accessibility levels and changes can be associated with socioeconomic data available at the zone level to estimate how current accessibility and benefits may vary by socioeconomic group.

Furthermore the accessibility indicators can be also calculated for a specific transport mode (road, rail, multimodal transport), for a precise trip purpose, for a particular economic activity category and/or for a specific social group of residents.

These accessibility measures can be used in a variety of operational planning and public involvement activities of transportation agencies where it is necessary to evaluate how the impacts of new infrastructures and transportation services are distributed. Moreover, they could be integrated in a more complex Land-Use Transport Interaction (LUTI) modeling structure (see for instance Figure 3.21), to simulate the impacts of changing accessibility on the residential and economic activity spatial distribution, as well as on dwelling prices (see for instance Coppola and Nuzzolo, 2011).

In this respect, they are useful in the Land-Use/Transport decision making process to identify an interrelation between the accessibility and the changes in the population and economic activities spatial distribution pattern, as well as on the dynamics of the real estate market.

In this respect, they have been already used in several applications in transport planning processes, in different feasibility studies for transport infrastructures assessment, and in Transport Masterplans at different scales (urban, provincial and regional). One of the latest applications regards the Regional Metro System Plan (RMS) of the Campania Region (South-Italy), which is an integrated land-use, infrastructure and operational plan, including Naples and the whole Campania Region (see Cascetta and Coppola, 2004; Cascetta and Pagliara, 2008).

It's important to stress that these measures in the Italian context are not the common practice used in city and urban planning tools; they are mainly used in transport planning decision process.

3.11.5 Strengths and limitations

From a scientific point of view, the described instrument has a strong theoretical base, which is well accepted in transport planning field. Furthermore the modeling framework takes into account the spatial interaction between the distribution of the demand and the accessibility level of opportunities (competition effects). Moreover this accessibility measure, in principle, can take consideration of the variations across individuals; in other words the measure could be specified differently according to the characteristics of individuals for whom the accessibility is being estimated.

From a practice point of view the complexity of the model framework might require high hardware and software requirements and a certain degree of technical expertise to perform the calculation. Accessibility calculation is immediate once the Level of Services - LOS values have been defined, but LOS calculation for large networks can take excessive time in execution. For example in the described application, where the Campania Region road graph consisted of 1.900 nodes and 650 links, the LOS values calculation time can vary from 15 to 60 minutes (in large part to write the OD tables on the hard disk) according to whether a congested or not congested network assignment model is used. In terms of memory usage the proposed instrument uses minimum space during computation.

The proposed instrument can be easily integrated with GIS in order to create and customize maps, build and maintain geographic data sets, and perform many different types of spatial analysis. According to this further improvements of the instrument can provide a more clear visualization module that could facilitate feedbacks in the consultation process with local authorities and economic stakeholders. It is necessary, in fact, to better disseminate and visually represent accessibility measures that could significantly enhance understanding, and engage a wide range of stakeholders and thus help to bring this important challenge further into the public arena. On the other hand, the possibility of a multimodal transport analysis can provide insights into the equity of alternative transportation investments.

3.11.6 References:

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3.11.7 Figures

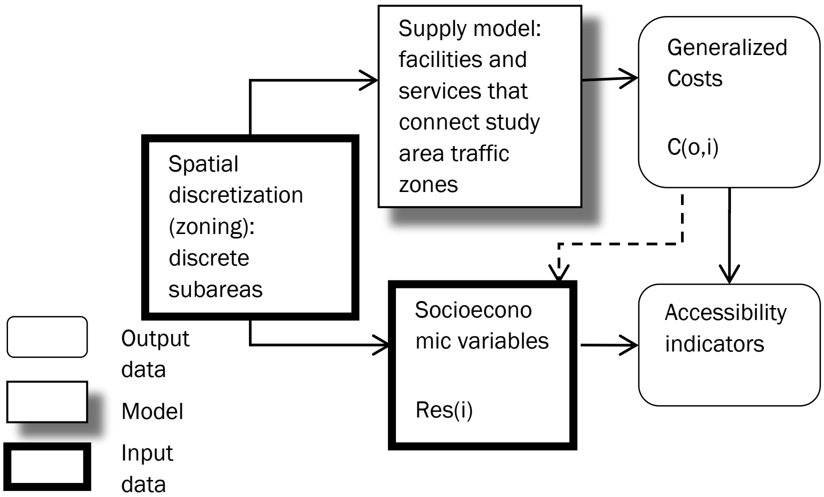

Figure 3.20 The calculation of generalized travel cost zone accessibility indicators in the present scenario

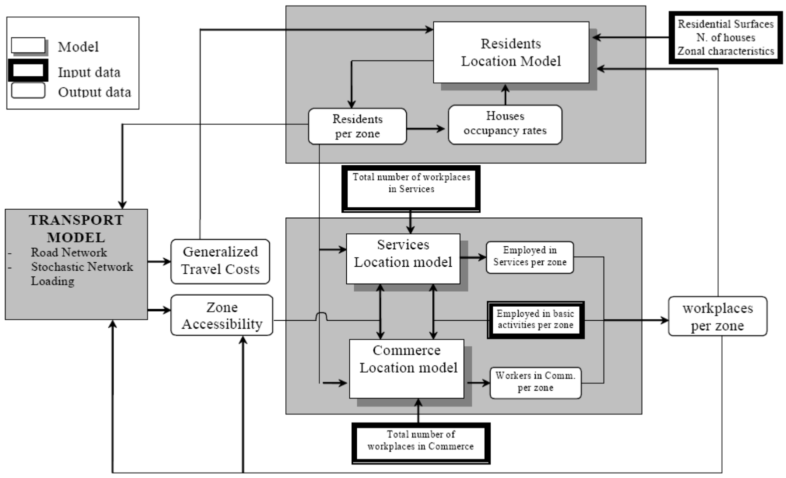

Figure 3.21 The accessibility measure as input data in LUTI model structure

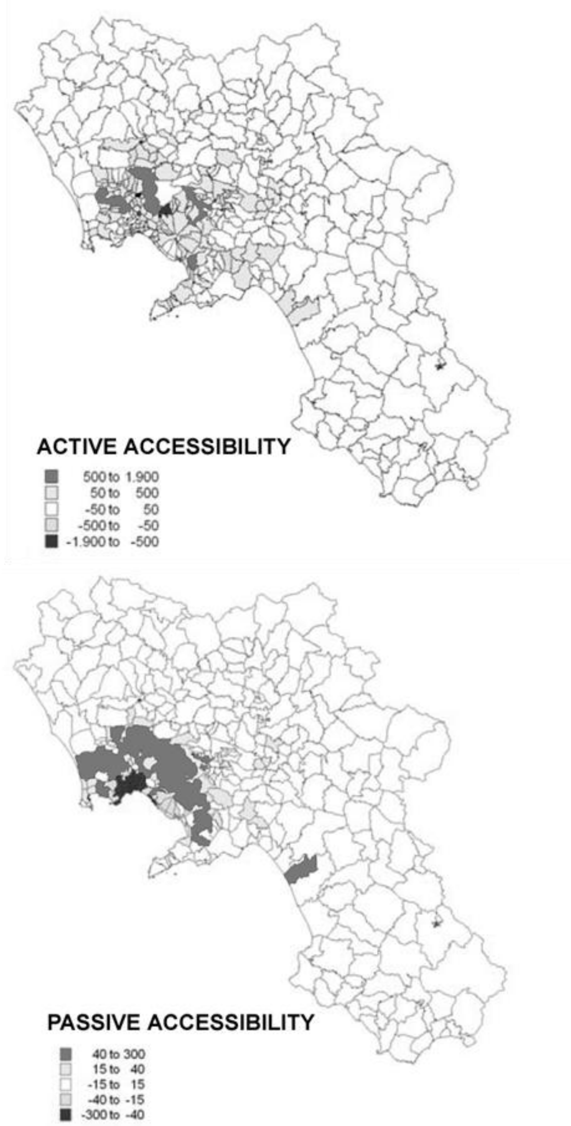

Figure 3.22 An example of representation of active and passive accessibility in Campania Region (Nuzzolo and Coppola, 2007)

3.12 Joint-accessibility Design (JAD)

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3.12.1 Background

In both the scientific and professional community the need to integrate transport- and land use policies in order to achieve more sustainable mobility patterns is widely recognized. However, in practice these integrated strategies are hard to come by. The concept of accessibility provides a basis for making trade-offs between land-use and transportation policies that has been sorely lacking, since it relates to features of the transport system (e.g. speed, and travel costs) as well as the land-use system (e.g. densities and mixes of opportunities). It is a well-known and studied concept within the scientific literature, but its use in practice however is still limited. The motivation for developing the accessibility instrument was to support integrated transport and land-use strategy making in planning practice. The scientific questions where threefold:

1. How to measure accessibility to support integrated transport and land-use strategy making?
2. How to use accessibility measures in integrated transport- and land-use strategy making processes?
3. Does the use of accessibility measures in planning practice lead to more integrated transport- and land-use strategies?

It is important to highlight that the measure that is chosen depends on the planning process for which it is used.

3.12.2 Conceptual framework and theoretical underpinnings

We defined accessibility in zone x as the opportunities in all other zones that can be accessed within a certain travel time and cost. In other words this means that accessibility indicates the potential space for action that people and firms located in a particular place have to engage in spatially and temporally dispersed activities. Using this definition accessibility cannot only be directly related to the qualities of the transport system (e.g. travel speed or costs), but also to the qualities of the land-use system (e.g. densities and mixes of opportunities). It thus provides planners with the possibility to understand interdependencies between transport and land-use development, and thus support the exploration of the scope for joint action.

There has been little attention within the scientific community for the application of accessibility in planning practice. Handy and Niemeier (1997) are a welcome exception. As Handy and Niemeier (1997, p.1182) signal: “The trend in transportation planning literature has been towards more disaggregate and complex representations of accessibility." However, more complex accessibility measures, such as utility-based measures, while more sophisticated from a theoretical point of view, also require more analytical skills from the participants making it harder to use such measures in practice. In order to be useful for practical planning purposes, an accessibility measure must meet two basic requirements: on the one hand it must be consistent with the real accessibility needs of the relevant social actors (people, firms); on the other hand it has to be understandable to policy makers (Bertolini *et al.*, 2005). In this respect two hypotheses are advanced. The first is that it is not possible to use complex measures in the phase of policy design. The second hypothesis is that relatively simple measures can already provide insights that can help develop more integrated transport and land use policies.

3.12.3 Operational aspects

The exact accessibility measure is different in each application, since the measure is developed together with planning practitioners and to address a specific planning problem. The accessibility measures are related to societal goals, such as social cohesion, economic competitiveness and sustainability (see Table 3.5). Accessibility is a way of relating transport policies to societal issues. A potential accessibility measure is always the starting point. In the section for illustration the measures that have been developed in the case of Almere are described.

The accessibility analysis was carried out using a potential accessibility measure with a distance decay function. This means opportunities that are closer are given a stronger weight than more distant opportunities. Table 3.4 shows the different impedance functions depending on the spatial scale and the mode of transport. The travel times shown in Table 3.4 indicate the turning point in our impedance functions, or the travel time where there is a 50% trip likelihood. These travel times where estimated with the use of the 2007 national travel survey (Mobiliteitsonderzoek Nederland/MON). Travel times and accessibility scores were calculated using a combination of a multimodal local and regional transport model. Travel times by car were calculated for the inter-peak period. Travel times for public transport include waiting time and time needed to travel to and from the station. The local model has 600 zones for Almere and has detailed data on inhabitants, jobs and services. Depending on the planning goal access to different type of opportunities was measured. To improve social cohesion we measured access to basic services (shops, health care, education etc.), while for economic competitiveness access to jobs on a regional level was measured (see Table 3.5, Figure 3.23 and Figure 3.24).

Each zone of the model has between 50-2.000 inhabitants. The local model was used to calculate the accessibility measures on neighbourhood and city level. To calculate the metropolitan accessibility scores the local model was combined with the regional model. This model has much less detail outside Almere (1.000-20.000 inhabitants per zone).

The spatial and travel time data is not freely available but owned by the municipality. They make the data available to researchers or consultants if they think this is useful for a particular project. When you have obtained the travel times the accessibility analyses are relatively easy to carry out using GIS. Basic GIS skills are sufficient. Calculation time for the transport model is one-day, once the travel times are loaded into the GIS set-up. The actual production of the accessibility maps itself takes 15 minutes per map (in this phase the impedance function can be adjusted, or the type of activity).

3.12.4 Relevance for planning practice

The joint-accessibility-design framework has been used in three cases in the Netherlands, they were applied to real planning problems and developed with planning practitioners. It is important to highlight that the set-up was more of an experiment outside the real planning process. However, results of the analysis have been used in the real planning process in all the cases.

The limited number of participants in each of the cases forces us to be humble about generalizing our conclusions, but we discovered some interesting benefits of using accessibility as a concept to design integrated transport and land-use strategies:

- Accessibility strengthens the knowledge about the geographical distribution of opportunities and how these are influenced by interventions in the transport and land-use system;
- It increases awareness about the development potential of locations and how well different activity patterns can be served in a particular location.
- It is important to have a multidimensional perspective in your accessibility analysis since accessibility can differ quite a lot depending of the mode of transport or type of opportunities you look at;
- Accessibility makes it possible to develop transport strategies that improve the accessibility of locations you want to develop and/or develop a land-use strategy that takes into account the development potential of locations given their accessibility;
- Accessibility can lead to different transport and land-use strategies compared to a planning process in which only mobility impact analyses are done;
- Accessibility makes it easier to relate transport policies to wider societal goals;
- Accessibility is just one of the factors that influence development at a particular location, but it seems to be an important precondition. If the accessibility needs are not met it is very difficult to get development going;
- To come up with the most suitable transport and land-use strategy it is important to combine accessibility analyses and mobility impact analyses.

3.12.5 Strengths and limitations

During the cases it became clear that using simple accessibility measures, such as the cumulative opportunity measure, already requires quite some explanation especially for land use planners. It was thus decided to stick to a cumulative opportunity measure and increase complexity only by placing different cumulative opportunity maps on top of each other, or use a distance decay function if practitioners where able to understand it.

Sometimes complexity that was lacking in the accessibility indicators was added during the discussions. Despite the problem of interpretation there were several indications that accessibility does have the potential to be an integrative concept. A transportation planner stressed the fact that “These accessibility maps were very helpful to me in discussing the opportunities and threats of different spatial policy options with land use planners”. On the other hand a land use planner noticed that with the help of the maps a transportation planner took a much more active role in signalling opportunities for economic development, rather than just pointing, as more usual, at mobility management issues.

Questions were also raised about the kind of data that had been used. The traditional four step transport model is designed to calculate the level-of-service on the regional road system, while for calculating actual travel times a much more detailed road network would be a better input. Data on travel time by public transport or slow modes is also of low quality in traditional models. Next to this, the spatial data on the distribution of activities was not always available on the same level of aggregation as the zones of the transport model. As a result, when the accessibility maps were examined in detail participants sometimes noticed things, which conflicted with their perception of the actual situation. This made it hard for them to accept the information unconditionally.

During the process, participants became more and more familiar with advantages and drawbacks of the use of the accessibility maps. Most clearly was this the case with the land use planners who were closely involved in all the workshops part of the strategy making processes. They seemed to undergo a learning process, which was different, and much more thorough, than that of those who just attended some of the workshops. This suggests that involving participants in the production, not just the use of the information could be an important success factor. In all instances it appeared crucial to collectively decide what type of information to use in the accessibility analysis and make clear what the drawbacks were of the use of a particular model. In other words, accessibility measures have to be developed with the participation of those who will use and learn from them, similarly to what has been found for other indicators.

Improvements of the instrument depend to a large extent on the context in which it is being used, since the type of indicator depend on the planning problem being discussed and the practitioners at the table. However improving the geographical representation of the accessibility indicators is something that makes the maps easier to understand for planners. The sometimes weird shapes of the transport model zones, especially the large zones in rural areas, dominate the picture and hamper the interpretability. The speed of the transport model to calculate different scenario is also something we look to improve. Ideally, we would like to show the effects of a different transport and land-use scenario during the course of one workshop. Figure 3.25, Figure 3.26 and Figure 3.27 show the results of analyzing different transport scenarios on the accessibility of Almere.

3.12.6 References

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3.12.7 Tables and Figures

Table 3.4 Travel times with a 50% trip likelihood

Spatial scale	Bike	Public Transport	Car
Neighbourhood	10 min.	10 min.	-
City	20 min.	20 min.	15 min.
Metropolitan	-	45 min.	30 min.

Table 3.5 Accessibility needs and planning goals

Goal	Spatial scale	Accessibility needs	Preferred modes of transport
Social Cohesion	Neighbourhood City	Access to basic services (child care, health care, daily shopping, social services and sporting facilities)	Bike and public transport
Economic competitiveness	Metropolitan	Access to labor force Access to international Airport	Car and public transport
Variety in living environments	City Metropolitan	Access to restaurants, bars, cultural facilities and non-daily shopping Access for people	Different combinations of car, Bike and public transport
Sustainable growth	City Metropolitan	Access for people	Ratio Car / Public transport

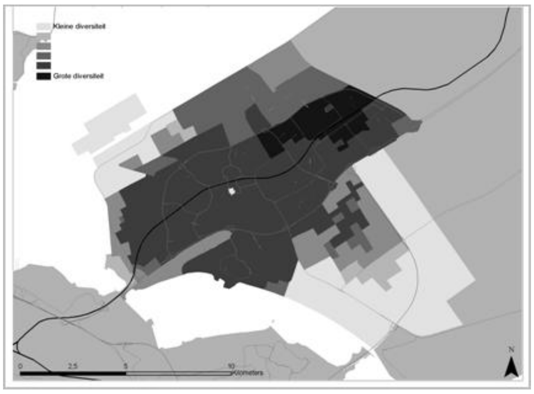

Figure 3.23 Access to basic services Bike (10 min.)

(Note: Darker colours indicate higher accessibility)

Figure 3.24 Access to bars, restaurants, non-daily shopping and cultural facilities, Transit (20 min.)

Figure 3.25 Access to inhabitants Car (30 min. inter-peak)

Figure 3.26 Access for inhabitants Car (30 min. inter-peak) - Scenario Hub and Spoke

Figure 3.27 Access for inhabitants Car (30 min. inter-peak) - Scenario Metropolitan Connectivity

3.13 Method for arriving at maximum recommendable size of shopping centres (MaReSi SC)

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3.13.1 Background

This instrument has been developed by the planning authorities in Oslo, in order to help dimension shopping centres in the municipality in accordance with their overall plan for development of shopping and services (Municipality of Oslo, 2003). A description of this plan and the system it is embedded in is attached as appendix. The planning authorities apply the method, together with the plan itself, to calculate the maximum size for new shopping centres or extensions of shopping centres in specific locations, in order for the centre to serve a population about equal to the number living in walking- and bicycling distance from the centre. The instrument and the plan are interrelated. I don't think a tool like this can be applied if not rooted in an overall plan. Further, the plan and the method are in accordance with state-of -the-art knowledge in coordinated land use and transport planning, and there are strong local and more general empirical evidence for the main assumptions.

The sector plan for retail development in Oslo aims at a retail development supporting and strengthening the existing retail structure. This is characterised by many smaller retail centres, located in densely populated areas which are well covered by public transport services, and with only the main city centre as a regional or city-wide centre. This structure ensures that most people in Oslo have walking distance to their nearest centre, which among others contributes to good accessibility to shopping and services, low car shares on shopping journeys and to short shopping trips. Fewer and bigger centres would increase the average travel distances from the homes to the nearest shopping opportunity, and hence reduce accessibility and increase car use on shopping journeys. This strategy has been followed for a long time in Oslo, and have resulted in a 'many and small' centre structure.

When the planning authorities give advice to developers and to decision makers regarding the size of new retail centres, they calculate the maximum dimension of the shopping centre based on the number of people living in the actual walking and bicycling distance from the centre in the future, defined as within one km and between one and two km. I refer in the following description to the plan and the method in general (Municipality of Oslo, 2003), to research by Tennøy *et al.*, (2010) regarding methods for analyses in planning for relocation and dimensioning of shopping centres, and to Tennøy's (2012/forthcoming) case studies of application of this method in a particular zoning plan process.

3.13.2 Conceptual framework and theoretical underpinnings

In the overall plan and the description of this instrument (it is not defined as an instrument, it just explains how the planning authorities assess the shopping centres with respect to localisation and size), accessibility to shopping and services is understood and measured in terms of walking distance to the nearest shopping and service centre from the inhabitants' dwellings.

There are no references to grand theoretical underpinnings for this way of understanding accessibility, unless the general understanding that the longer the walking distance, the fewer can and will walk. This is particularly so when discussing older people and people that for any reason have trouble walking. This is empirically substantiated in the background report to the overall plan. It is not explained why they chose these exact definitions etc.

3.13.3 Operational aspects

Accessibility is measured as real walking distance from dwelling to shopping centre.

In the Økern case, the number of people living within one km and two km real walking distance of the site today and in 2025 was defined with the help of geographical information systems (GIS) and data of location of residences, as well as known plans and probable developments in the area, and population extrapolations. Thorough knowledge of the existing retail structure is mandatory (context). This was combined with empirical data regarding average spending in these kinds of centres (with the rest being spent in the city centre). The future turnover of the centre was calculated based on this.

Turnover (NOK) within walking and bicycling distance = number of people within 1 km and between 1 and 2 km from the centre (persons) x percentages of spending at this centre [9] (%) x spending per persons in such centres (NOK/person)

Figures for average turnover per square metre for such centres was collected (register data), and the size of the future centre – given that it served people in walking and bicycling distance, and have somewhere near average turnover per square metre – was calculated:

Centre size (m^2) = Turnover (NOK) within walking and bicycling distance/Average turnover in similar centres (NOK/m^2)

This is a simplified description, but it includes the main concept.

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[9] The share of their spendings will vary, depending among others on location and content of nearby shopping centers. In this case, people living within 1 km were supposed to spend all of their shopping money (except what is used in the city centre) here, while people living 1 – 2 km from the centre would spend 30 % of their shopping money here and people living more than 2 km from the centre would not spend money here. This is obviously a simplification of reality, but it is well explained in interview why it is reasonable to do it.

By not allowing the centre to be bigger than this, one ensures that the centre does not need to draw customers from outside walking and bicycling distance, and also that it probably will not be attractive for people living other places to travel the extra distance in order to do their shopping at this centre rather than at the centre closest to where they live. It does not ‘steal’ customers from other centres and affect those centres negatively. Still, it will be big enough to serve the local market and the majority of the population will have shopping and services nearby.

The data required is the number of people living within one and two kilometres real walking distance from the site of the proposed centre, as well as existing and expected retail structure. GIS, maps, accessible population data extrapolations, and known plans are relevant data, as are average register data for spending on shopping in such centres and for necessary or average turnover per square meters in shopping centres.

The planning authorities emphasise that this method is not very time-consuming. The calculations are straightforward, and no advanced model needs to be developed and maintained. It requires mainly data that are available in a plan-making process anyhow.

Most planners should be able to carry out this analysis. Planning knowledge is the main competence necessary. Only a very limited *technical* expertise is required.

3.13.4 Relevance for planning practice

The output of this instrument/method is the size of a new retail centre proposed in a certain location that is necessary in order to be big enough to serve those living in walking and bicycling-distance from it. The concrete output is the number of m^2 necessary and recommended. The planning authorities recommend to not build larger centres, since that may ruin the structure of provision from many and smaller centres. This would cause reduced accessibility to shopping and services, as well as increase car dependency and traffic volumes.

The instrument has been applied by the planning authorities in Oslo for some years. I have studied the use of the method as part of the analyses for the zoning plan process for Økern centre (Municipality of Oslo 2010, 2010a).

In this case, the initiators proposed to build a 60.000 m^2 shopping centre as part of a 160.000 m^2 project in a transformations area about 4 km from the city centre of Oslo. This would be the biggest centre in Oslo, and only three centres are more than half the size of the proposed one. The planning authorities applied this instrument/method to arrive at the appropriate size according to overall plans, and to explain to the initiators, the district politicians, the public and the decision-makers how and why a shopping centre this size would affect the existing infrastructure negatively and contribute to increased car dependency and traffic volumes.

With the help of the described instrument, they calculated the optimal size of the shopping centre to be about 25.000 m^2 in 2030 (of the total 160.000 m^2). The instrument was hence useful in the decision-making by allowing the planning authorities to take a stand and explain why the proposed project is not in accordance with overall plans, and to recommend the decision-makers to reject it. By these simple calculations, they defined in a logical and easy to understand way what the right size of the centre would be, if the project was to contribute to the defined objectives in the overall plans. This also allowed relevant regional authorities to file formal complaints. This means that the case will be decided by the Ministry of Environment rather than the City Council.

If this instrument had not been used (in combination with the overall plan), it would be harder for the planning authorities to demonstrate the discrepancies between the overall plan and its objectives, and the proposed project and its consequences. This would also make it harder for the regional authorities to file formal complaints.

3.13.5 Strengths and limitations

The planning authorities claim that this method is understandable, transparent and requires less work than other methods. Hence, all involved parties can apply it, understand it, and contribute in the discussions regarding retail development.

In interview, the senior planner responsible for shopping and service development plans explained that the planning authorities are pleased to have established a way to calculate the size of new shopping centres that is rough, clear and understandable, and that is firmly rooted in the overall plan.

The basic, simple and logical principles of the overall plans and the methodological simplicity of the instrument are important. The overall plan contributes to the further development and strengthening of the centre structure, and that there is no unnecessary competition between the centres. The present method is simple, the underlying assumptions are easy to understand, and the computation/analysis is not very labour intensive to carry out. This is considered important and necessary because the planning authorities in Oslo deal with many such cases and cannot have a tool that is too labour intensive to use.

The developer and consultants can also make such calculations, and it is important that the principles are clear and simple. Complicated and detailed analyses do not necessarily offer more and better information to decision- and policy-makers. In Oslo, the planning authorities see no need to do this in more detailed ways.

It is emphasised that the overall plan is the main steering tool. Such analyses are nevertheless useful in planning processes, particularly because those working in the planning authorities have different competences and expertise in this field. The analyses help to clarify the consequences at the overall level and at the project level.

Tennøy *et al.*'s. (2010) evaluation of 'retail planning' in the 13 largest cities in Norway, found that the combination of Oslo's binding sector plan for retail (required at county level in Norway) and the described method for dimensioning the centres meant that Oslo had 'the best' planning practice for retail developments. This was especially so for the dimensions of ease of understanding and transparency.

In an analysis of national travel survey data, Engebretsen, Hanssen and Strand (2010) found strong support for people normally choosing the closest opportunity for especially daily retail and services, and that shopping centres become more car-based the bigger they are.

So far, the plan and the instrument have worked well in Oslo. The plan and calculations have been respected by developers and decision-makers, according to interviews with the planning authorities (Tennøy *et al.,* 2010). In the ongoing zoning plan process discussed above, however, the City Council have adopted the plan in spite of the planning authorities' recommendations not to do so. Because of formal complaints from two regional authorities, the final decision needs to be made by the Ministry of Environment. It will be interesting to see how this case ends.

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3.14 Geographic/Demographic Accessibility of Transport Infrastructure (GDATI)

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3.14.1 Background

The motivation for using previously known demographic and geographic indicators for assessing the accessibility of existing public transport systems in cities as a whole was to use them to examine and assess smaller regions, districts, neighborhoods or other spatial entities e.g. post code areas or regular grids. In this way, simulation models allow the calculation of indicators for smaller areas of the city and to compare accessibility of public transport systems in their areas, identify areas of low accessibility and areas attractive in terms of accessibility.

The development of the instrument was focused on several questions*:* Can city-scale accessibility indicators be used to assess the accessibility of micro-scale (region, district, housing complexes, post code areas or regular grids)? Could this be a tool for identifying areas for development due to good public transport accessibility? Could this be a tool for identifying areas with poor public transport accessibility? Could this be an instrument for determining the quality of life for residents in the area of the city?

The planning problem is to understand the accessibility of specific areas within big cities by public transport. The instrument is focused on public transport only, and depends on the availability, and collection, of service data at the requisite scale.

3.14.2 Conceptual framework and theoretical underpinnings

The instrument determines the accessibility of public transport system in the area (Kozlak, 2008) as:

1. Geographical density of public transport network (G^{K}_{p}), which is defined as length of roads where the public transport operates, on the area of 1 km^2 of city area.

2. Demographic density of public transport network (G^{K}_{p}), which is defined as length of roads where the public transport operates per 10 000 inhabitants.

3. Average density of the public transport network (G^{K}_{pd}), which is defined as length of roads where the public transport operates, referring to the size of the area as well as to the population.

4. Geographic density of stops (G^{J}_{p}) which defines number of stops in the area of 100 km^2.

5. Demographic density of the stops network (G^J_d), which is defined as a number of PT stops per 10 000 inhabitants.

6. Average density of stops (G^J_{pd}) – to calculate this indicator both: size of the area as well as population is used, and those values are related to number of stops.

The Instrument GDATI measures accessibility by comparing demographic (population) and geographic (size of area) data with the length of the transport network and the number of stops.

The concept of accessibility in the Polish context is defined in terms of service quality in the collective public transport system (EN 13816: 2002 "Transportation – Logistics and Services – Public passenger transport – Service quality definition, targeting and measurement"). This normative definition includes 8 categories of service quality criteria for public transport. The two first categories refer to accessibility, describing in general the existing public transport characteristics. These are:

- spatial-temporal accessibility – within the area where the service is provided, referred to in terms of geography, time, frequency and means of transport;
- functional accessibility – in terms of access to the system, including connection to other transport systems;

Values obtained from the simulation model can be compared with other values, eg. values resulting from the standards.

In Poland, these measures are used to assess the accessibility of public transport systems in cities. They are described in the literature (Bryniarska and Starowicz, 2010; Bieda, 2002; Bieda, 2011) and widely used.

3.14.3 Operational aspects

The instrument GDATI measures geographic and demographic accessibility of public transport linear and punctual infrastructure.

$$G_p^K = \frac{K}{a} \qquad \frac{km}{km^2} \tag{3.11}$$

$$G_d^K = \frac{K}{b} \qquad \frac{km}{10000\ inhabitants} \tag{3.12}$$

$$G_{pd}^K = \overline{G_p \cdot G_d} = \frac{K}{a \cdot b} \qquad \frac{km}{km^2 \cdot 10000\ inhabitants} \tag{3.13}$$

where *K* is the length of roads where the public transport operates [km], *a* is the area [km^2], *b* is the number of inhabitants.

$$G_p^J = \frac{J}{a} \qquad \frac{stops}{km^2} \tag{3.14}$$

$$G_d^J = \frac{J}{b} \qquad \frac{stops}{10000\ inhabitants} \tag{3.15}$$

$$G_{pd}^J = \overline{G_p \cdot G_d} = \frac{J}{a \cdot b} \qquad \frac{stops}{km^2 \cdot 10000\ inhabitants} \tag{3.16}$$

where *J* is the number of stops, *a* is the area [km^2], and *b* is the number of inhabitants.

Geographic and demographic data may be obtained easily if they relate to the boundaries of the city area. For smaller areas (regions) data may be obtained by using GIS maps. Information about the length of the public transport network may be obtained by using the public Internet tools, transport service deliverers can provide such data or auxiliary data for subsequent detailed calculations. Data on the number of stops may be obtained easily from the organizer of transportation in the city. Stage of data collection is the most time-consuming.

The model under development will use the available tools. Processing will be in the form of interactive involvement of the user. Equipment used for processing will be readily available.

After collecting relevant data, the calculations are not time-consuming.

To perform the calculation technical knowledge at the basic level is required.

To interpret the results technical knowledge at the advanced level is required.

3.14.4 Relevance for planning practice

Information about the level of accessibility of public transport system in the area and its relationship to the quality of life of residents in the area is useful for planning practitioners; although this instrument has not yet been used in the context of planning.

The instrument has previously only been used for the evaluation of existing public transport systems in urban areas (how they ensure the accessibility of the system). Detailed examination of areas with poor and good accessibility in order to understand why has not been carried out. Understanding of these issues currently depends on expert intuition.

In the areas, where weak geographical and demographical accessibility is detected, policy measures should be enhanced in order to increase the level of accessibility (more PT routes, more PT stops). In the areas, where good accessibility is identified, land uses that rely on accessibility investment/development may be introduced (new housing development, new business areas and firms locations).

3.14.5 Strengths and limitations

The instrument has several strengths, including relatively easily available data, simple calculation, and using the same data, you can specify other properties, e.g. average radius or time reaching the stop. The main weakness is the focus on the availability only public transport services with no reference to other features of the public transport system (e.g. frequency).

The instrument has not yet been used in the actual planning context.

We expect that using a simulation model as an interactive package (slide decision), the instrument can support the development of planned areas where there is the demand for transport infrastructure, and for understanding wider spatial development issues (Bieda, 2002).

We are planning improvements to instrument from the scientific and practical point of view. We think that it is possible to include the identification of service frequency into the current instrument at the disaggregated scale of smaller city districts. We are planning to include in the instrument the relationships between indicators of accessibility and quality of life. The instrument will be made available to local government to use the results of the accessibility level assessments and to link them with the quality of life.

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3.14.7 Figures

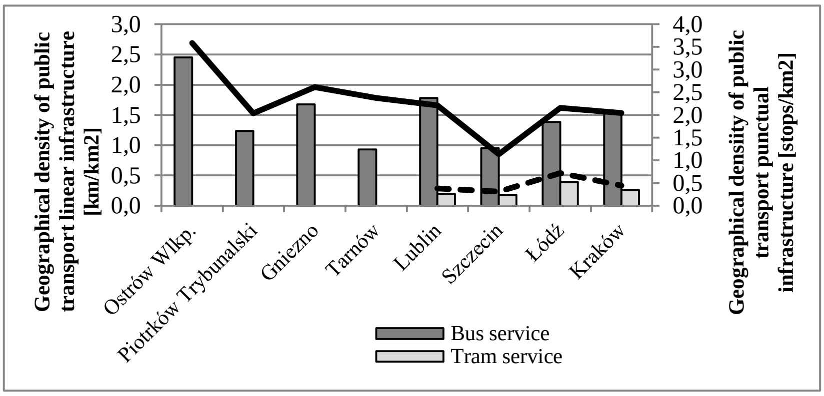

Figure 3.28 Geographical density of public transport network infrastructure accessed by stops/ kilometre

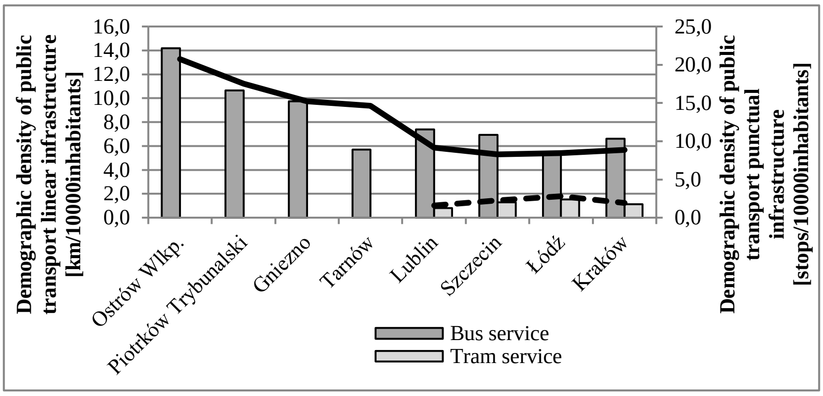

Figure 3.29 Demographic density of public transport infrastructure based on stops per 10,000 inhabitants

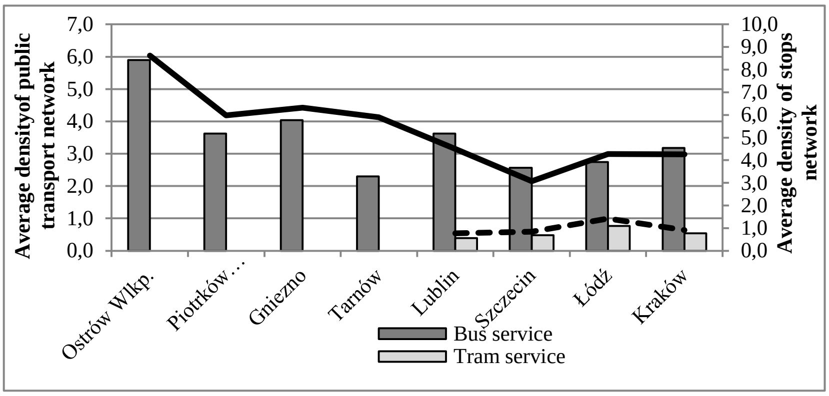

Figure 3.30 Average density of public transport stops in the network

3.15 Structural Accessibility Layer (SAL)

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3.15.1 Background

Urban mobility problems, such as congestion, have been threatening the quality of life, competitiveness and sustainable development of urban areas. The need for an integrate approach to land use and transport in mobility management has been widely recognised. Accessibility measures are believed to provide a useful framework to support this integrated approach. We believe that measures of comparative accessibility by transport mode can operationalise the accessibility concept for this purpose. The comparative accessibility measure proposed here is the Structural Accessibility Layer (SAL). This instrument reveals how the urban structure enables or disables travel choice, i.e. how urban structure constraints mobility into a range of potential mobility choices (more specifically mode choice). Thus, the focus here is to understand what mode choices are made available by the urban structure in contrast to the mainstream research focussed on understanding how urban structure influences travel behaviour. Thus, distinction is made between the potential for travel provided by the urban structure and the effective travel choices made within these conditions (wider influenced by far more than the availability of choice).

SAL was developed as a design support tool for integrated land use and transport planning providing foresight for how specific land use and transport policies constraint travel choices of inhabitants and thus enable or limit particular choices. This foresight is relevant in the planning of specific issues such as new development (zoning), development density, land use mix and location of activities for master plans or other land use plans in connection to transport planning regarding, network design and reach, service level and price.

3.15.2 Conceptual framework and theoretical underpinnings

The Structural Accessibility Layer (SAL) is a geographical representation of comparative accessibility levels by types of transport modes to different types of opportunities generating travel (Silva, 2008). It is based on the concept of Accessibility defined as the extent to which the land use and transport system enable individuals to reach different types of opportunities (adapted from the accessibility concept presented by Geurs and Eck, 2001; 36). More specifically, the SAL proposes the concept of Structural Accessibility assessing how urban structure constraints travel choices (Silva and Pinho, 2010).

The SAL includes two main accessibility-based measures: the *diversity of activity index* and the *accessibility cluster* (the comparative measure). The first measures the accessibility level by each transport mode (non-motorized, public transport and the car), counting the number of the most relevant travel generating activity types that one can reach from a given origin (using contour measure based on the 'dissimilarity index' of Cervero and Kockelman, 1997). The accessibility cluster uses the results of the previous index to develop the comparative analysis of accessibilities by transport modes, identifying the mode choices made available to inhabitants by local land use and transport conditions.

The scheme in Figure 3.31 summarises the conceptual choices made in the development of the SAL with regard to the balance between soundness and plainness of the accessibility measure, central to the development of the conceptual framework of the SAL. Soundness of the basic contour measure was enhanced by using disaggregated spatial analysis (at the census track level, or grid based of at most 1km^2) of accessibility levels by different transport modes to several types of activities. These choices (which to some extent are case-specific) provide the necessary detail for the thorough modulation of small scale variations of local land use and transport conditions for mobility. Aggregation of accessibility measures is used, on the other hand, to recover simplicity and the communicative qualities of the measure.

The high level of disaggregation by scale is complemented by a general indicator of accessibility for the entire study region. The range of disaggregation of activities is made usable and understandable by the measure of diversity of activities. Finally accessibility levels by transport mode are combined through a comparative measure.

3.15.3 Operational aspects

As referred to above the SAL compares the variety of travel generating activity types reachable by different transport modes within a giving travel time and travel price limit. Activity types considered should at least include, employment, schools, leisure, shopping, healthcare and other activities, but ideally with higher levels of disaggregation across these activity types. Accessibility limits are defined by cut-off criteria such as, travel time, travel price and travel cost limits (chosen and calibrated by, for instance, political choice or user survey).

The diversity of activity index provides an average of the number of activity types accessible, weighted by the potential frequency of use [10]. Results of this index range from zero (no accessible activities) to one (all activities are accessible).

The general form of the diversity of activity index is the following:

[10] The access to activity types with higher frequency of use provides higher values of diversity of activities than the access to activity types with lower frequency of use.

$$DivAct = \frac{\sum_{y}(Act_y * f_y)}{\sum_{y} f_y} \qquad (3.16)$$

Where, y is the activity type, Act_y a value representing the existence or not of the activity type y inside accessibility boundaries ($Act_y \in \{0; 1\}$) and f_y the potential frequency of use of the activity type.

The results of the diversity of activity index are then used to develop the comparative analysis of accessibilities by transport modes, identifying the mode choices made available to inhabitants by local land use and transport conditions. The different combinations of accessibility levels by transport modes are grouped into 7 accessibility clusters according to the mode (or modes) choice which is considered to be favoured by land use and transport conditions:

- Cluster I - NM modes;
- Cluster II - NM modes and PT;
- Cluster III - all modes;
- Cluster IV - NM modes and car;
- Cluster V – PT;
- Cluster VI - PT and car;
- Cluster VII – car.

The use of a particular transport mode is considered to be favoured by the urban structure when accessibility levels by that particular transport mode are perceived to be high, i.e. when an acceptable range of activities can be reached making its use competitive in comparison to the other modes. The choice of this threshold (one of the many case-specific choices of the SAL) is based on the potential use frequency of activities considered unnecessary according to the local perception of high accessibility levels (which can be calibrated through, for instance, political decision or surveys).

The data requirements for the implementation of the SAL include:

- Georeferenced data:
    - Population, Employment and presence or absence of each of the activity types considered, by census track;
    - Transport infrastructure layout, service level (capacity, speed, slope, frequency, etc.) and price.
- Other data such as basic data on travel behaviour (travel frequency by trip purpose, travel time by mode, O/D matrix, etc.).

This data is generally purchased (or even produced) by local land use and transport authorities and thus available.

Computation of SAL can be processed with any GIS software able to develop network analysis (measuring accessibility areas along transport infrastructure), with several free and licence products available in the market. However, in the absence of specific processing scripts, advanced technical expertise in GIS is required to operationalize SAL concepts into GIS measures. In this condition, calculation times may reach out to weeks (depending on the size of the study area). On the other hand, results of the SAL are easy to understand and are very intuitive, considering both the perceptions used for accessibility and the map representation process.

3.15.4 Relevance for planning practice

The main outcomes of the SAL are the diversity of activity index maps for each transport mode and the cluster map (comparing accessibility levels by all transport modes). These maps identify small-scale variations on accessibility conditions provided across different census tracks of the study area. Diversity of activity maps provide important information on availability and service level and quality of each transport mode across the territory. This information provides information on spatial inequalities with regard to land use and transport opportunities with potential role in the development of public service standards for public transport, in the identification classification of the hierarchy of urban centralities, or in the definition of priorities for mixed development strategies. The cluster map provides the baseline information on potential mode choices, categorizing relative competitiveness of different transport modes and thereby identifying areas where inhabitants clearly have no competitive alternative to the car. For illustrative purposes, see Figure 3.33 providing the relative competitiveness of the car, public transport and walking for the Greater Oporto.

So far, the SAL has not been used in planning practice, having been applied within research contexts to analyse accessibility conditions of Greater Oporto (Silva, 2008; Silva and Pinho, 2010) and Copenhagen Metropolitan Area (Pinho, 2010). The first application, to Greater Oporto, was designed to test and validate the SAL for planning practice, both for improving the understanding of accessibility conditions and for supporting the development of planning strategies. Research results obtained were validated through expert interviews with very positive results. The second application was within a research on the influence of urban structure on travel behaviour were the role of urban structure as constraint and influence of travel behaviour was analysed comparing monocentric and polycentric urban structures. The diversity of activity indicator was shown to have significant influence on travel behaviour in multivariate regression models considering urban structure and personal characteristics as independent variables of travel distance and mode share. In addition, the results of this research reinforced the concept of structural accessibility put forward with the SAL, revealing the role of urban structure in constraining travel choices, enabling and, in particular, disabling particular travel choices.

3.15.5 Strengths and limitations

The SAL was built with high concerns on usability taking into consideration the 'rigour-relevance dilemma' (see for instance, Hoetjes, 2007; Brömmelstroet, 2007). Figure 3.33 summarized the main debate around potential and limitations, in theory and practice, of the SAL regarding the main choices made in its development. So, the use of special representation (via GIS) and of a regional scale of analysis are responsible for providing an integrated approach and view on the urban structure at the same time surpassing administrative boundaries and enabling the picturing of small scale variations. However, the regional perspective of the tool disables micro scale analysis in spite of the ability to identify small scale variations. Another important choice within the rigour-relevance dilemma was the use of a simple accessibility measure (contour measure) providing a tool which is easy to communicate and understand but does not consider some of the complexity of accessibility such as distance decay or competition effects. This choice is balanced with the high disaggregation level of analysis (regarding, spatial scale, transport modes and activity types) which enhances the understanding of the urban structure conditions, but, at the same time limits the simplicity of the tool. Again, the complexity introduced by the high disaggregation level is reduced through the introduction of an aggregate measure (the accessibility cluster comparing accessibility across transport modes) which synthetises much of the disperse information and provides a framework for thought facilitating the development of objectives and the testing of different scenarios. Finally, the SAL is highly adaptable to local conditions since it leaves a large number of issues to be defined and fine-tuned locally, when calibrating the case specific SAL, however, this adaptability and the disaggregation level of the tool are highly dependent on the availability of data which may limit its use.

So far, the SAL has not been used in planning practice but its potential has been assessed resorting to semi-structured interviews to experts in related core fields (Silva, 2008). This assessment aimed to discuss the *robustness* as analysis tool, the *usefulness* as design support tool; and, the *applicability* by local planners and politicians; in summary the potential of the SAL for planning practice. The main advantages of the SAL referred to by experts were the ease of use, understanding and communicating of the tool and the coherence of the measures. Some authors recognize the ability to support thought for policy development, especially with regard to integration. The main advantage of the SAL was ascribed to its synthesising capacity as a diagnosis tool and to the ability of testing different policy scenarios. Many of the aspect referred to as advantages are also responsible for some disadvantages. For instance the capacity of synthesising information of the diagnosis tool is responsible for the loss of important detail. The regional scale of analysis limits micro-scale approaches. Finally the SAL is data and time consuming and therefore expensive, being out of reach of average local authorities.

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3.15.7 Figures

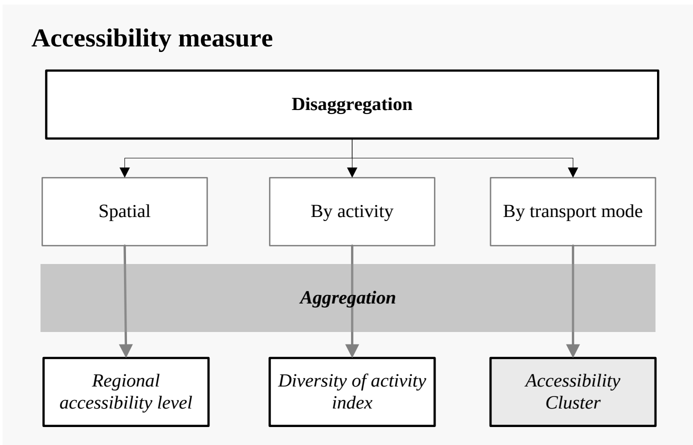

Figure 3.31 Balance between soundness and plainness of the accessibility measure (Source: Silva, 2008)

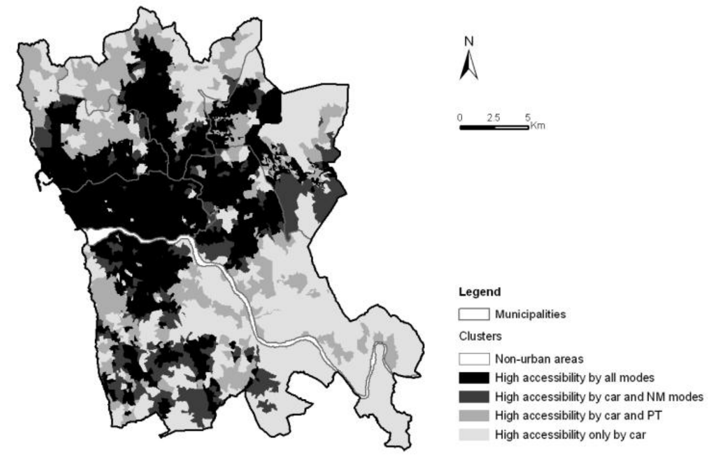

Figure 3.32 Clusters of accessibility in the Greater Oporto

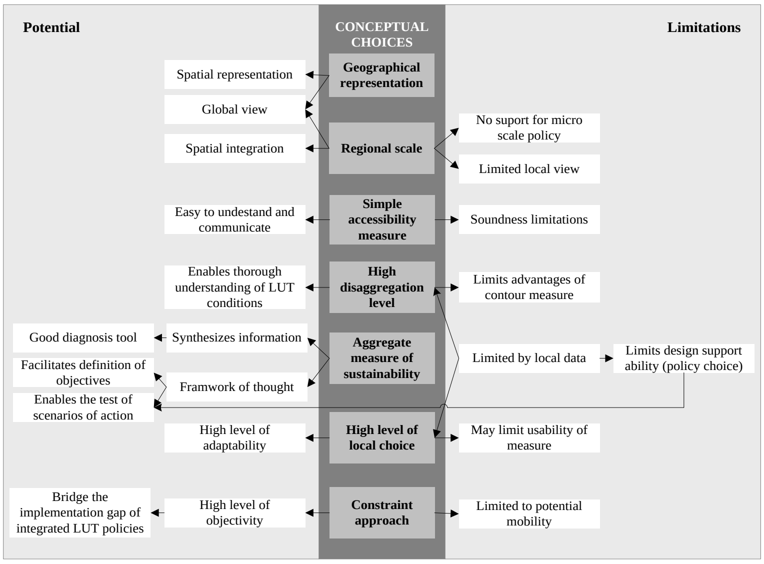

Figure 3.33 Potentials and limitations of SAL (Source: Silva, 2008)

3.16 Cellular automata modeling for accessibility appraisal in spatial plans (UrbCA)

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3.16.1 Background

The interactions between land use and transportation are one of the most addressed topics in planning and transportation, both from the academic and from the practice standpoints. The use of computers to simulate these interactions is also a very important research topic since the early 1950s when computers were introduced to civilian research and large scale urban models were developed and applied to several urban areas. With the development of the personal computer in the mid 1980s, which led to the democratization of its use in planning research and practice, land use simulation models gained an even greater attraction, as every researcher could develop, at very low cost, solutions to support planning practitioners in their decision-making processes.

Cellular automata (CA) models were introduced to urban studies at that time and are, since then, among the most popular modeling concepts used to simulate land use change, taking into account the influence of transportation and accessibility in a more or less explicit way. This report will present a CA model that uses some innovative concepts to simulate land use change taking into account accessibility by including this driver as an endogenous phenomenon, allowing a simulation that effectively conjugates land use change and transportation.

3.16.2 Conceptual framework and theoretical underpinnings

The use of dynamic models such as CA is often considered a powerful tool to simulate and understand complex systems and complex behaviors of stochastic nature which depend on different variables and have different temporal and spatial scales. With regard to accessibility, the CA model reported aims to simulate in a single simulation environment the effects of transport systems (from which accessibility is evaluated) as one of the main drivers of land use change. The main goal is to capture the effects of accessibility in land use by parameterizing some traditional transportation models (e.g. the gravitational model) in conjugation with other parameters regarding other drivers, such as land use interaction/neighboring effects, or land suitability. The interdependences of all these drivers, which are important features of the complexity of urban phenomena, are taken into account so that all the partial parameters can be calibrated under the influence of all the observed phenomena.

3.16.3 Operational aspects

UrbCA is a dynamic model that simulates land use change over a space divided into irregular cells designed from the traditional census blocks. Cells have at each moment a given cell state (or land use) from a finite cell of cell states which change through time taking into account the cell states of a given number of neighboring cells. This evolution is provided by a set of transition rules that parameterize the behaviors of all the drivers at stake. The calibration of the model is done using an optimization procedure that provides an efficient search of the space of solutions for the optimal set of parameters of the model. The very simple concept of CA allows the creation of a very powerful tool to capture complexity and emergence from simple transition rules that can be easily linked to common planning rules and restrictions. UrbCA incorporates some innovations when compared with the ones reported in the literature. Irregular cells are drawn taking into account both urban form and the information that is spatially referenced to them. The neighborhood size is a calibration parameter and not an input value defined by the user. The effect of the transport system (and accessibility) is explicitly considered.

The evaluation of the influence of accessibility in land use change is made by considering that land use change occurs as a consequence of a set of transition rules that accounts a transition potential for each cell (each location in space) in every moment in time. This potential is a function of the land use drivers, such as accessibility, land use suitability, or neighborhood effects. The model calculates accessibility taking into account the road transport network for private car mode. Although possible, the consideration of other transport modes is not yet implemented in the model (it will probably be implemented by the time the WU will have their workshops during 2013).

Detailed information about the modeling concepts, options, and formulation of UrbCA can be found in Pinto and Antunes (2010).

The use of UrbCA in the appraisal of accessibility in planning focuses on the possibility of simulating different planning solutions under different planning parameters taking into account different accessibility conditions, which are a result of the investments on the road network. Rather than focusing on measuring accessibility as a primary goal, the model simulates the direct effects of accessibility in land use. The model provides the calibration of some accessibility parameters, as the friction parameter of a gravity transportation model, along with the calibration of other land use parameters. The model is also able to simulate future land demand values by simulating future demographic and employment distributions. Input data includes the transport network configuration and attributes, as long as data on land use, demographics, employment, and other relevant data to constrain land use change. All the datasets refer to a common spatial structure based on irregular cells that take into account urban form. All these datasets are made publicly available by traditional data providers such as municipalities or statistics agencies.

UrbCA is implemented as a stand-alone software application developed in Visual Basic to run in Windows-based machines. The running time for a standard problem vary from a few hours to one and a half days, depending on the configuration of the dataset and on the desirable threshold for calibration. Some GIS expertise is required to preprocess data in order to create the datasets for the UrbCA. No specific expertise is needed to interpret the results as the model provides a fully descriptive set of easy-to-use text files that only contain readable information.

3.16.4 Relevance for planning practice

The use of modeling in common planning processes is many times a very demanding task as both common planning offices and practitioners are not technically prepared for it or do not have the necessary budget to acquire sophisticated consultancy support that could provide this kind of approaches. There is also a latent tension between modelers and practitioners, on the one hand, and between modelers and decision makers, on the other hand. Traditional practitioners (planners, architects, and also engineers) are many times suspicious of the capacities of models to effectively provide any kind of valuable help, which many times undermines the possibility of using sophisticated modeling approaches. Decision-makers, by the contrary, tend to be very keen of having solutions provided by advanced tools that help them to support their decisions by using state-of-the-art knowledge.

The main goal of UrbCA is to simulate different planning scenarios of land use evolution taking the influence of the transport system (and therefore accessibility) explicitly into account. This simulation is expected to help practitioners to evaluate these scenarios under different parameters in order to test their feasibility and to inform both the citizens in the participatory process and decision-makers in the planning process itself. UrbCA aims to be a simple-to-use, simple-to-understand decision support tool that can be used in any kind of planning process by any planning structure, regardless of financial or even technical requirements. It is designed to be a simple tool that can be used by planners with no specific background on modeling, by decision-makers who are not necessarily skilled to understand the mechanics of the model, and also by citizens who are also not skilled in participatory processes for evaluating different planning scenarios.

This modeling approach to planning is therefore relevant for providing informed solutions to different stakeholders at various stages of the planning process.

CA models have been used to support planning processes, being one of the most used models the MOLAND model which is used by the Joint Research Center of the European Commission to support long term regional planning under the influence of climate change. UrbCA was not yet fully used in real-world planning processes, as it still is under development. It was already used in a research context for providing a test-bed for strategic scenario planning in a research project that included several planning officials from different planning agencies. The Action will provide the proper test-bed for its application to a real world planning process in conjugation with the Coimbra municipal planning department. The model is expected to evaluate, within the work of the Action's Working Unit of Coimbra, the impacts of new transport investments and the consequent new accessibility conditions in municipal plans.

3.16.5 Strengths and limitations

The use of CA models for assisting planning processes is useful as they allow the simulation of prospective planning scenarios under a fairly good variation of the parameters that are considered by the model. The calibration of the model allows planners and decision-makers to understand the main drivers and the main trends that took place in their territories, which is very useful for cross analysis with other kinds of quantitative and qualitative indicators that are usually part of the planning toolsets. The use of this model is expected to be very suitable to forecast feasible and plausible future land use/transportation scenarios rather than to point out what will be future urban design solutions. The model is very good at identifying areas of potential change rather than indicating what are the exact plots which will be developed. These models are also strongly linked to GIS which allows a good use of visualization techniques, a powerful mean to explain different options to non-skilled interlocutors.

UrbCA was already used in a research project that simulated a practice environment in which several practitioners and decision-makers were present. Simple outputs of the model were very useful for launching the discussion over very simple planning options, proving the value of the model.

There are, however, important limitations as the application of any kind of models has always some degree of limitations. Models are meant to capture trends that are more or less accepted as good descriptors of a given reality under a very well-known set of conditions. The ability to simulate futures based on the calibration of models is always dependent of the capacity of researchers and practitioners to understand the complexity of systems making use of some abstraction. Many assumptions must be made in order to be able to work with available data, to feasibly model a given phenomenon, or even to be able to identify the proper scale of simulation. Models are many times not able to cope with decisions that break up historical trends, which reduce their use especially when practitioners are not properly informed about the use that can be made of the model.

The underlying complexity of the model is many times referred as a potential problem. The CA concept is, nevertheless, quite easy to understand and very intuitive in the way it models reality. The natural sense of complexity associated with this model may be reduced for elucidation purposes by (1) taking into account only variables which depend on available datasets which are commonly used in planning (mainly from censuses), and parameters which are simply to understand by the agents to understand by the agents and (2) by strengthening the visualization capacities of the outcomes of the model, explicitly linking the results to maps and associated data.

UrbCA is under development and the main goal is to create a low cost tool that is expected to be used in common planning processes by a wide range of planning agencies, from municipal departments to regional/national planning agencies.

3.16.6 References

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3.16.7 Figures

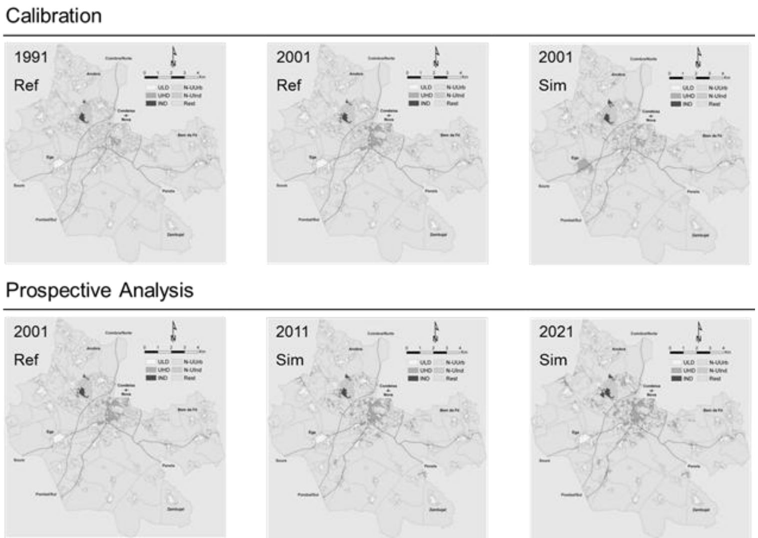

Figure 3.34 Application to Condeixa-a-Nova, Portugal

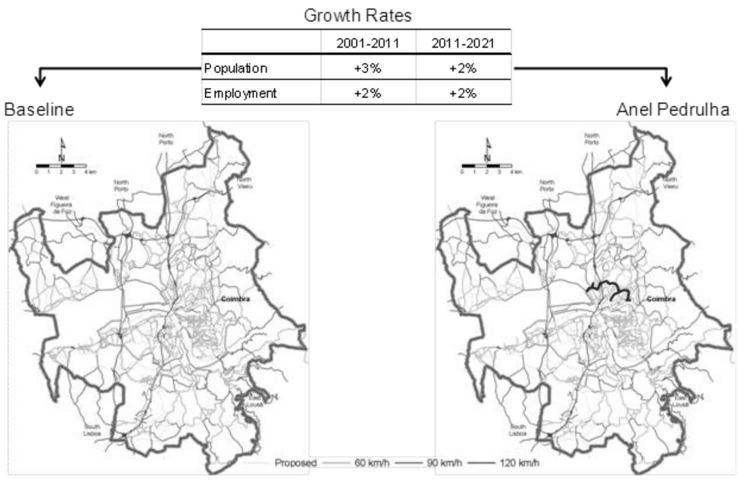

Figure 3.35 Alternative scenarios for road investment in the municipality of Coimbra

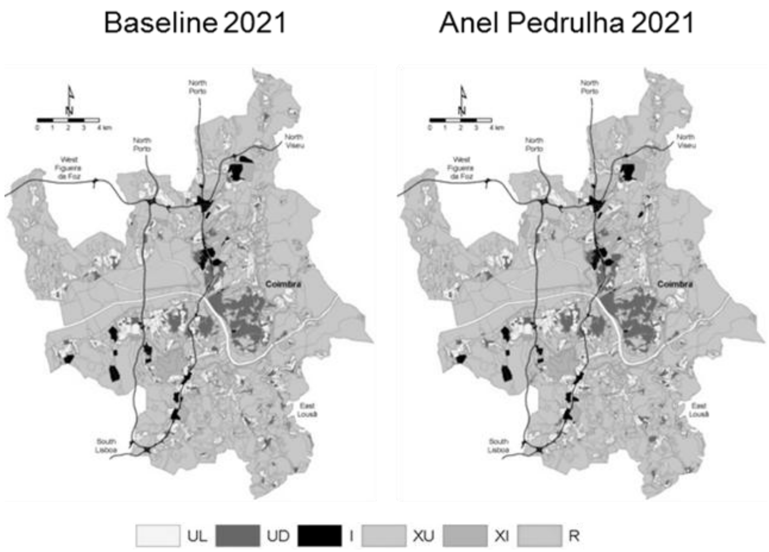

Figure 3.36 Land use maps for alternative scenarios for road investment in the municipality of Coimbra

3.17 From Accessibility to the Land Development Potential (ATI)

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3.17.1 Background

In the Republic of Slovenia, the methods of land use planning have been so far focused in particular on the physical balancing of land surfaces for a particular type of land use, and do not take into account the economic aspect in preparing the basis for land use decision-making in the process of spatial planning. A consequence is the irrational use of land. Therefore, the procedures and basic documentation for the decision-making on land use and on the restriction of land use in the spatial planning process need to be improved (Šubic Kovač, 2004).

Urban development is directly interconnected with the construction of technical infrastructure. Housing construction can take place on developed land only. Construction of technical infrastructure, however, is linked with the relatively high (direct) costs. The question is which method of urban development and/or land use zoning is conditioning the lowest land development costs (costs of technical infrastructure) over the long-term period? By the long-term policy of construction, and thereby, of land development (technical infrastructure), housing construction may be adjusted in such a way that the additional social costs of land development, at certain social benefits and in a certain long-term period, are minimised. To this end, we will need to define the appropriate factors and indicators, on the basis of which we will define the impacts of technical infrastructure on land development potential and on the additional social costs and social benefits of construction (Šubic Kovač, 2008).

The accessibility to technical infrastructure is only one factor that has to be incorporated in the model of land development potential, which can be used in the spatial planning process. Taking into account the known land developmental potential under condition of sustainable development and by an appropriate model we may transparently decide on the land use.

In the research only public utility infrastructure (technical infrastructure) defined by Spatial Planning Act (2007) will be included:

- public roads (including drains and public lightening);
- water supply (drinking water supply and (sewage) waste water treatment);

- energy services (supply) (electricity, district heating and natural gas supply).

3.17.2 Conceptual framework and theoretical underpinnings

The accessibility to technical infrastructure is defined in terms of the physical and cost accessibility to the technical infrastructure.

The accessibility to technical infrastructure is measured as the accessibility of the provided land use at the local level, taking into account the capacity of the existing technical infrastructure and the distance from the existing technical infrastructure.

The results of the research by the Municipal Economic Institute of Ljubljana show, that the capacity of the existing technical infrastructure and the distance from the existing technical infrastructure are the most decisive factors defining accessibility to technical infrastructures (Klemenčič, Rakar, Šubic Kovač). Also other authors argue that for the definition of the accessibility in spatial planning it is important that in addition to the spatial dimensions, we take into account the physical and socio - economic aspects of accessibility (Lotfi, Koohsari, 2009; Bisht, Mishra, Fuloria, 2010). In addition also the political goal of the European Communities is that the municipal services ought to provide the needs and expectations of users of public services that are based on: universal access for all citizens and high quality services at affordable prices while ensuring the protection of the environment, care for vulnerable groups and access to municipal services regardless of the allocation of the settlements in the region.

Under the current legislation of the Republic of Slovenia, the technical infrastructure design generally follows the spatial plan implementation, when it is already too late for the more effective and sustainable planning. The proposed instrument will define the costs and benefits of providing technical infrastructure at the strategic level of planning.

Legal provisions and practice in Slovenia do not promote the observance of the actual costs of technical infrastructure in the planning and implementation phase of land development. Because of that it is necessary to improve the situation and to analyse the accessibility as described above.

3.17.3 Operational aspects

Type of accessibility:

- physical distance, and;
- capacity of the existing and proposed technical infrastructure.

The accessibility instrument is determined by:

- the distance in M/KM, and;
- the capacity expressed by physical indicators of various technical infrastructure elements, and;
- finally in costs.

The distance between the public lines of technical infrastructure and a final consumer (private connectors to a private residential building) indirectly depends on the housing construction typology, settlement density, subdivision of land and, last but not least, on land ownership. The capacity of technical infrastructure depends on the specific technical characteristics, as the width and flow of public roads, quality of and pressure in the drinking water network, free capacities in the sewage systems, voltage conditions, hydraulic and heat conditions in the district heating systems, etc. There are tremendously varied indicators, and certain parameters are relevant for the specific natural conditions only within the studied area, whilst others are relevant for a particular population density only. Thus, we would limit ourselves to defining the key physical indicators for a variety of technical indicators, expressing the capacity with comparable units of measurement.

Finally we will define the social costs and benefits of (non-) providing access to technical infrastructure, taking into account the sustainable development.

The data required are:

- the land use type;
- settlement density;
- housing construction typology;
- land subdivision;
- public/private land ownership;
- technical infrastructure data;
- the distance from the existing technical infrastructure;
- the capacity of technical infrastructure;
- and others.

The majority of the information is directly available for free in public records (for example, in the cadastre of public technical infrastructure); some of data will be obtained indirectly by calculation and some will be based on a survey of different stakeholders in the process of spatial planning and land development. The data will be acquired also in the workshops, some of them from the case study.

Quantitative analysis will be made with specialized computer programmes working by using numerical data. Spatial analysis will be produced in an environment of geographic information systems. They will mainly include working with vector objects while the fuzzy logic methodology is based on the raster objects. Since we already have the appropriate licence for ArcGIS® Spatial Analyst 10, which includes some methods of fuzzy logic, we will test our accessibility instrument in that programme.

In comparison with other methods of so-called soft intelligence the establishment of the input data requires intensive scientific research work (Aliev, Aliev, 2001), while the application in place is simpler and already built into newer programmes to work in an environment of geographic information systems (Boroushaki, Malczewski, 2010). This makes it more useful for other stakeholders in spatial planning practice. For the verification of results we will prepare a workshop for spatial planners. Within the framework of the workshop, the participants will be familiarised with the project and the model, presenting the results of the envisaged project by ICT technologies, and asking the participants for their respective opinions on the value of the results.

We will define the basic input data (fuzzy membership functions), then the further empirical calculations can be made by spatial planning practitioners. Since the basic assumption of our model is ensuring the transparency, it will also be easier to interpret the results. The interpretation will be understandable to other stakeholders in spatial planning like municipal managers and public.

3.17.4 Relevance for planning practice

The accessibility instrument will define the location of different degrees of accessibility ranked between 0 and 1. The results will be presented separately (for example accessibility to water services) or they will be combined. The final result will be the expertise basis to help the stakeholders in spatial planning to determine the appropriate planning zones for residential land use.

Analysis within the research will be conducted at the level of individual parcels, whilst the final accessibility instrument will cover the level of the entire municipality. The expertise basis can be used for the strategic and implementing phase of the municipal spatial plan.

The proposed accessibility instrument is under the construction and has not yet been used.

In Slovenia, the methods of land use planning have been so far focused in particular on the physical balancing of land surfaces for a particular type of use, and do not take into account the economic aspect in preparing the basis for land use decision-making in the process of spatial planning. The accessibility to technical infrastructure will be applicable in Slovenia and elsewhere in Europe, where the factors incorporated into the project impact on the social costs and social benefits of different land use in the same way.

In Slovenia, land use modelling and simulation have not been carried out yet. A consequence is that certain vacant plots of building land are not interesting for private investors, whilst certain land uses are causing exceedingly negative external effects, which had not been foreseen at the spatial planning phase. The land use modelling and simulation including the accessibility to technical infrastructure are going to introduce a dynamic model of decision-making on land use in land use planning, based on the land development potential, determined by the (social) costs and (social) benefits.

3.17.5 Strengths and limitations

The developmental potential of land could be determined also by including the factors and analysis of impacts on the social costs, and on social costs and social benefits which ensue from a certain land use type. In the research specific focus will be on the analysis of social costs and social benefits of the residential areas with the differing level of land development (technical infrastructure). In recent studies in the field of cost benefit analysis, the authors argue that the key problem is the underestimation of the investment value and an overestimation of social benefits. Also the social rate of return is not adequately defined (Korthals Altes, 2010). There is also a dilemma whether and to what extent the results of the analysis of social costs and benefits of specific infrastructure projects are suitable at certain stage of spatial planning (Faludi, 2000; Korthals Altes, 2010). The authors conclude (Lichfield, 1964; Evans, 2004) that social costs and benefits are relatively simple to identify, but difficult to financially quantify. Another problem is the changing attitude of the stakeholders toward individual solutions over time.

Within the recent studies of fuzzy logic it was found out, that these studies included the environment protection and the process of "thinking" of all participants in spatial planning (Galderisi, Ceudech, Pistucci, 2008; Phills *et al.*, 2004; Yanar, Akyurek, 2004; Fernandez Ruiz, 2009). According to the comparison of different methods of so-called soft intelligence, the benefits of the methods of fuzzy logic are: the possibility of interpreting the results, the transparency, the gradual process, and the tolerance to imprecise input data. As the only drawback the amount of knowledge needed to create the input data and the impossibility of learning the system is mentioned (Aliev, Aliev, 2001). We believe, however, that the inclusion of several parameters, according to Fernandez and Ruiz (2009), can cause the loss of transparency and monitoring the impact of each indicator. Other research shows the benefit of a small number of key indicators of the accessibility (Bisht, Mishra, Fuloria, 2010).

In Slovenia, the technical infrastructure is designed according to the land use area types in the spatial plan. Therefore social costs and benefits will be determined approximately. The proposed instrument will encourage the analysis of land use decision making and at the same time the transparency, and more effective and sustainable spatial planning.

We are preparing several empirical analyses in order to define the usability of the instrument within the spatial planning practice. The results of the empirical analysis will help to upgrade the scientific and practical aspects of the proposed accessibility instrument.

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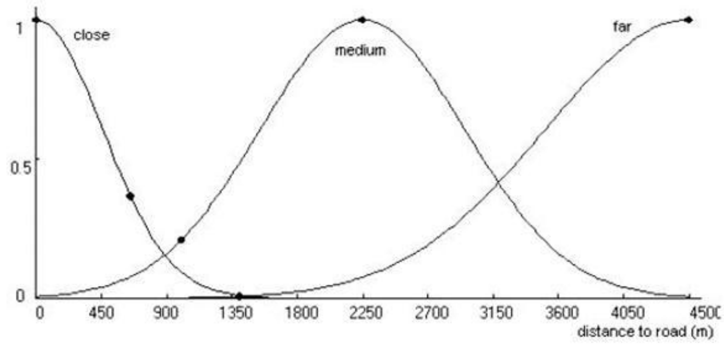

Figure 3.37 A case of fuzzy membership function according to the distance to the road when defining new locations for industrial sites (Source: Yanar, T.,A., Akyurek, Z. 2004. The enhancement of ArcGIS with fuzzy set theory. ESRI International User Conference, 30. June 2004: 16 str. http://proceedings. esri.com /library/userconf/proc04, 15.12.2010)

3.18 Isochrone maps to facilities. Shopping centres in the Metrosur influence area (IMaFa)

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3.18.1 Background

MetroSur is the name of a new metro line developed in recent years in Madrid. MetroSur's area of influence is located in the southern outskirts of Madrid's metropolitan region. This area is characterized by the presence of densely populated cities such as Alcorcón, Getafe, Leganés, Móstoles and Fuenlabrada, and has one of the highest concentrations of shopping centres in the region of Madrid. These centres make up new centralities in these peripheral areas –attracting traffic flows– and are linked to new urban developments. They are situated in spaces with good accessibility by private transport but, in some cases, with poor accessibility by public transport.

The study area has seen a constant rise in congestion levels, and there is therefore an increasing need for the provision of good quality public transport. The mobility changes induced by the shopping centres in the area (with increasing number of customers, coming from longer distances), and the difficulty of access for a significant portion of the population (those without private cars), creates a need for public transit provision.

One of our main motivations for developing this accessibility instrument was to assess the level of service of public transport when accessing shopping centres in the MetroSur influence area. However isochrone maps can be applied to other type of facilities (health care, education, etc.)

The main research question to be addressed is whether shopping centres in the study area can be accessed easily by public transit.

3.18.2 Conceptual framework and theoretical underpinnings

Our instrument of isochrone maps defines accessibility as the opportunities for ease of access and takes as a case study the access to shopping centres by public transit.

The accessibility instrument is measured as the process associated with getting to and from the shopping centres by public transit.

The theoretical underpinning of this accessibility instrument is that the more accessible the selected shopping centres, the greater the likelihood that they will be accessed by public transit (Murray *et al.*, 1998).

This measure is therefore relevant from several points of view:

1. To owners / operators of public transport services and urban planners, who can assess the level of service for the MetroSur influence area, regarding the access to the main shopping centres;
2. From an environmental perspective (emissions of pollutants) (Keijer and Rietveld, 2000). Accessibility by public transport is a critical issue from the point of view of both sustainable mobility (Black, 1996) and sustainable accessibility (Weber, 2006).

Because it is a simple measure, isochrone maps are easy to communicate and easy to interpret by decision makers and transport planners alike, as well as by the rest of the stakeholders.

3.18.3 Operational aspects

The accessibility instrument presented here measures the travel times by public transport to shopping centres.

Isochrone maps are drawn using the network coverage analyses included in a GIS. Given the spatial nature of network coverage analyses, GIS have become useful tools which provide capabilities for data collection, data management and handling, spatial analysis, network analysis, and cartographical presentation of results (Zhu and Liu, 2004).

Coverage or service areas can be delineated by GIS through the creation of buffer areas (bands) around shopping centres, based on Euclidean (straight-line) distance or travel times along a network. The choice of the distance calculation method significantly affects the final results. For a given distance threshold (for example, 0.25 km), service areas are larger using Euclidean distances than network distances, since the first method overestimates the size and the population of the service areas (Gutiérrez and García-Palomares, 2008).

In our case, we decided to use buffer areas considering distance along a public transport network, through the quickest network paths. The population covered in each buffer area was then estimated following previous studies (Gutiérrez *et al.*, 2000; Murray, 2001; Murray *et al.*, 1998).

The input required is a digital public transport network, providing information on travel times, type of mode (train, metro, bus) and transfer times between transport modes, which is combined with a street network to calculate pedestrian access times from the stations/stops to the shopping centres also through the quickest network paths.

The location of the shopping centres and the metro and train stations and bus stops are also required as input data.

The population data available at census track level (0.25 square kilometres on average) are used to calculate the population covered within each buffer area.

We use the EMME3 traffic assignment model which gives us travel time matrices by public transport. A commercial GIS –and specifically its network analysis capabilities– is then used to calculate distances between public transport stops/stations and shopping centres through the street network, simulating the real routes followed by the population on their way to those shopping spaces. The EMME3 model was chosen because this is currently being used by the Public Transport Authority of Region of Madrid. However other software can be used if they include traffic assignment models and network analysis tools.

We also use GIS to calculate the isochrone maps; with this method, the resulting coverage area is not a circle (as it would be using Euclidean distances), but an irregular polygon containing all the sections of streets and public routes located within a network distance threshold.

Results can be obtained within three days when all the data and technical expertise is available for the analysis. This is an estimated time accounting for one day for processing the traffic model using EMM3, one day for bringing the results to the GIS and calculating of the isochrone maps and one more day to elaborate maps and other outputs such as graphics and tables.

This accessibility instrument can be understood by everyone, as access to shopping centres is expressed as travel time, which is a familiar indicator. However some technical knowledge of network analysis using GIS is required.

3.18.4 Relevance for planning practice

Isochrone maps make it possible to assess accessibility to shopping centres by public transport. It can be understood as a measure of accumulated opportunities when considering the amount of population or employment within a certain distance or time threshold from one or several shopping centres. Taking into account the total population within time thresholds, the measure of accumulated opportunities provides an estimation of the potential demand for shopping centres.

The use of isochrone maps of shopping centres has several applications for urban and transportation planning. It allows assessment of the public transport network by identifying populated areas outside the coverage area. Greater attention should be given to areas which are not covered or poorly covered by the public transport system, than to implementing steps to extend the network or to increase the frequency of service provision.

This method can also be used to draw some conclusions about the location of new metro or train stations and bus stops, by comparing time thresholds after the location of new bus stops or stations on the network. It thus helps to determine the most suitable location to boost accessibility to shopping facilities.

It can also be used to propose facilities for soft modes, such as cycling.

This instrument was applied in 2005 in the Autonomous Region of Madrid, in collaboration between the regional Public Transport Authority and the Regional Health Department (Redondo, 2005).

The objective was to study the accessibility by public transport to specialized health centres in the region. The population was calculated (both in absolute and relative terms) within certain distance thresholds from the health facility. Three different scenarios were analysed for the years 2000, 2004 and 2008; each scenario considered changes in population and infrastructure in both transport and health centres. For each year, isochrone maps were calculated individually for each particular health facility (see for example Figure 3.38.

The instrument identified the less accessible health centres and the location of the population with poor accessibility to these types of facilities. The results influenced political decisions in two ways:

1. By reassigning the population with worst accessibility to other health centres, while maximizing their accessibility.
2. Identifying potential locations for new health centres in areas with long travel time to these facilities.

3.18.5 Strengths and limitations

The main strengths of the present accessibility instrument are its low data requirements, and the ease of calculation, transmission and interpretation of results.

The instrument requires relatively few data, which as we have seen, are basically related to the network, and to the locations of the defined economic centres.

Isochrone maps are easy to calculate through simple network analysis performed in a GIS.

Because the output is expressed as travel time thresholds, the results can be easily interpreted by policy makers and transport planners and simply transmitted to everyone.

However, due to the simplicity of the measure, the results of this instrument are not sufficiently realistic, as they use an all-or-nothing function (inside or outside the established distance) rather than a *distance decay* function.

This implies that everyone within the threshold area would have the same probability of access to a shopping centre, without considering the population which lies beyond the selected distance. Isochrone maps do not therefore accurately reflect the behaviour of traffic flows, which tend to decrease progressively as the distance increases.

Another drawback of this instrument is the choice of the distance threshold itself, which is somewhat arbitrary and may cause the results to vary significantly (Tillema, 2007).

Finally, since our case study focuses only on access by public transport the results refer only to this mode. Results computed considering access by private car would be certainly different.

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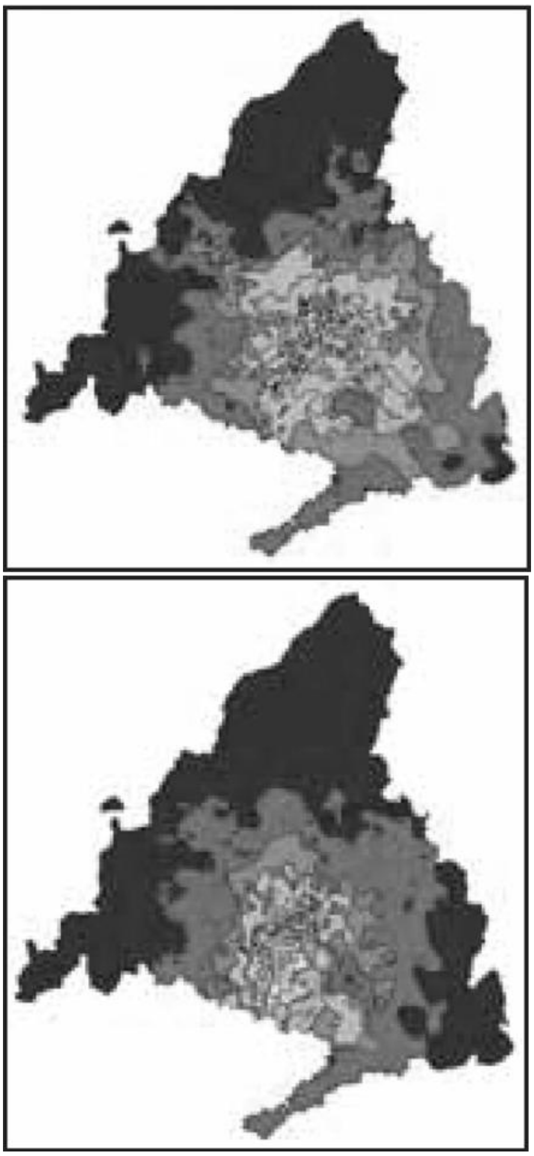

Figure 3.38 Isochrone maps Gregorio Marañon Hospital (left side) and Getafe Hospital (right side)

3.19 Place Syntax Tool (PST)

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3.19.1 Background

Accessibility research of human behaviour has always been limited by the kind of data and analytical tools available. For example “there was no effective means for representing or dealing with the spatial complexity of a realistic urban environment”, neither did past studies “incorporate data about a person's cognitive environment into the analytical framework” (Kwan, 2000). In the past decade many steps have been taken to overcome these limitations, for example, `instead of using the straight-line distance between two locations, the actual travel distance over the transportation network can be used' (Kwan, 2000). Kwan *et al.* (2003) state that still much remains and especially the understanding of our cognitive environment is pointed out to be a crucial issue.

The most important background to the Place Syntax Tool (PST) and the theories of Place syntax is the shortcomings and strengths of space syntax methodology. The strengths consist of a strong empirical theory of cognitive space and cognitive distance, measured in changes of directions, so called axial line steps. However, within space syntax research accessibility is measured only within the network of axial lines with no attractions. This led to the idea to add attractions such as density or transit points to the spatial model to get better predictions of pedestrian flow but also new interesting measures of accessibility. In many planning projects where space syntax was used the issue of attractions came up when describing centrality and proximity. Place syntax has been a natural answer to these questions. Very simply put, Place syntax is adding attractions to Space syntax.

3.19.2 Conceptual framework and theoretical underpinnings

Accessibility is a widely used spatial analytic measure defined as “the relative ‘proximity’ of one place *i* to other places *j*. In generalised terms, the measure can be defined as:

$$A_i = \quad _j f(W_j, d_{ij}) \qquad (3.18)$$

where W_j is some index of the attraction of *j* and d_{ij} is a measure of impedance, typically the distance or travel time of moving from *i* to *j*” (Jiang *et al.,* 1999). From this definition it is easy to see how space syntax does not deal with the full concept of accessibility, in that one rarely deal with W_j or any indexes of place attraction.[11] Another way of putting it is that geographic accessibility deals with ‘places’, where ‘place’ simply means a geographically specific space, a location, or a space with a specific content, while space syntax deals with ‘spaces’, i.e. spaces or locations with no specified content and thereby no measurable attraction. This straightforward distinction, between space and place, can be said to be the basis of what Jiang *et al.* (1999) distinguish as ‘geographic’ and ‘geometric’ accessibility.[12] Hence, if geographic accessibility is the proximity of places, then geometric accessibility is the proximity of spaces, i.e. setting W_j = 1. This can be defined as:

$$A_i = \quad {}_j A_{ij} = \quad {}_j f(d_{ij}) \qquad (3.19)$$

From this we can see exactly why space syntax from the point of view of spatial analysis is a special case of geometric accessibility.

Defining how to measure d_{ij}, the ‘distance’, ‘transport cost’ or ‘energy effort’ to move from *i* to *j*, is then obviously a critical part of a accessibility measure, and in a geometric accessibility measure *the* critical part. The most common distance units used within accessibility research are: topological steps in a network, metric travel distance, travel time, travel cost and monetary charges. But it is exactly concerning such descriptions and measurements of distance one have encountered problems within spatial analysis when moving from the comprehensive level of geography to the detailed level of urban settings: “what is dramatically absent are tools for developing accessibility measures at fine spatial scales which involve the geometry of urban structure in terms of streets and buildings in contrast to the measurement of accessibility at the geographic or thematic level”, (Jiang *et al.*, 1999).

It is here that we propose that the morphological descriptions developed within space syntax can prove useful and can contribute to accessibility research. Hence, the ‘axial map’ developed within space syntax research, an example of topological steps in a network, is a better measure of distance for certain critical issues of accessibility than for example metric travel distance.

3.19.3 Operational aspects

Together with a group of students at the Department of Numerical Analysis and Computer Science at KTH, we have developed the Place Syntax Tool (PST), an application for the desktop software MapInfo. The PST consists of two main components, MapBasic (MB) and Dynamic Link Library (DLL). The MB component is written in MapBasic and implements reading and writing in MapInfo's own databases. The DLL component is written in C/C++ and is compilated as a DLL. It takes care of the graphical user interface (GUI) and does the accessibility calculations. The two

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[11] As discussed in the introduction, this is one of the points with space syntax, trying to develop descriptions whereby the architectural variable can be controlled.

[12] What is called ‘geometric’ here seems to come close to what is also known as ‘pre-geographic’ (e.g. Miller 2000).

communicate through a communication interface integrated within the DLL. The GUI has two main windows. In the first window all tables are selected: input place data (plots or address points) and output place data (where the results will be distributed: plots or address points), axial lines and `unlinks' (points where crossing axial lines do not connect), links (e.g. address points which link plots to closest axial line).

The second window is for selecting the type of analysis and consists of five pages. In the 'Calculation type setting' page you can choose to calculate from all places or just from a single place. In the 'Criteria settings' page the column for desirable place data is selected. Here you can choose multiple columns. Data can also be normalized and given a relative weight. In the `Result settings' page you choose how results are displayed, in a table or on a coloured map in MapInfo. Here there is also a critical section where you decide how data on input place data are distributed to the address points, divided with the amount of address points or the full value to all. Similar to that, the output place data has to be determined, whether they are to collect the mean, max or min of the result values at the address points (that is if you do not choose to display them on the address points). In the `Table Column Keys' page you select the key columns that connect, e.g. address points and plots. The time for running a small city analysis would be typically a couple of seconds.

3.19.4 Relevance for planning practice

We believe that the marriage between spatial analysis and urban morphology that place syntax represents can bring with it certain fruitful theoretical implications. By taking as its point of departure a geometric element, the axial line, that is defined from the point of view of an experiencing subject rather than a more abstract element, (such as street-crossings or bus-stops), the place syntax approach actually turns a lot of things upside down. As earlier argued, many descriptions of accessibility of today are conducted from a pronounced system point of view, partly because it has fit existing descriptive techniques, partly because it has fit existing needs, which primarily has been formulated by large bureaucracies and corporations. Place syntax then introduces the possibility to also conduct descriptions and analyses of accessibility from a life-world point of view in just as systematic and quantitative a way. The effect in our opinion is nothing less than a possible displacement of power.

In many concrete urban planning situations system world descriptions (administrative) and life-world descriptions (user) contradict each other, but since system descriptions usually have more powerful quantitative foundations and life-world descriptions rely more on 'weaker' qualitative descriptions, the former turn out to be the stronger part. In a study by Ståhle (2005) it was shown that the access to parks and green areas perceived by the citizens contradicted the measures by the planning authorities, which measured this as hectare of park and green area per person. When instead the accessibility was measured, using among other parameters axial distance rather than travel distance, perceived access and measured accessibility correlated. The argument was made further critical by the fact that the city districts where the citizens' access to park and green areas was perceived to be low, were rather low status post-war suburbs, that by the planning authorities were understood as 'green', while the city districts where the citizens' access to parks and green areas was perceived to be high, were quite dense high status inner-city districts, that the planning authorities were understood as 'grey'. According to existing measurements there was no need for new or better parks in the post-war suburbs then, while that could be the case in the inner city. The new place syntax measurements could hence show that there existed "more park space in a denser city" and at the same time give quantitative voice to the perceived lack of park and green areas in the conceived 'green' areas. In extension this fundamentally alters both power relations in urban space as well as urban planning and design practice.

3.19.5 Strengths and limitations

With these fundamental findings as a background we believe that the 'place syntax' approach has great potential for the development of new tools for urban planning and design, not only for predicting pedestrian flow or estimating urban accessibilities, not least to redefine the concepts of densities and areas. The aim of the research is to help urban studies and practice to find new and possibly more informative ways or presenting place data in general. These new realms of geographic accessibility analyses with axial lines are however so diverse that only empirical investigation will show their usefulness. Even so we would like to sketch some rough categories of application.

- Between different categories of spaces: This means extending integration analysis to other categories of spaces than those represented by axial lines, such as points (e.g. address points) and districts (e.g. plots). It offers the possibility to for example analyse 'configurative constitution', i.e. the number of entrances within a certain radius, or 'plot configuration', which would be the number or the total size of 'accessible' plots within a certain radius;
- From all places to an attraction: This means calculating the number or the sum of the value of a specific attraction within a specific radius from all places. This implies a 'supply' or LOS (Level of Service). It could for example concern the number of shops, or the amount of green space. These could furthermore be combined into a possible measure of urban attraction;
- Between the same attractions: This means calculating the number or the sum of the value of a specific attraction within a specific radius from the attractions. This could be a measure of 'clustering' of attractions or possible competition/cooperation between businesses,
- Between different places/ attractions: This means calculating the number or the sum of the value of a specific attraction within a specific radius from another attraction. This can be for example used for linking households and jobs, people's accessibility to work etc;
- Place population: This means calculating the number of people within a specific radius from all places. This can, as shown in this article, be used for pedestrian movement prediction. But it could also be a means to analyse for example the size of local economical markets;
- Attraction population: This means calculating the number of people within a specific radius from an attraction. This obviously is an extension to the category above and could be used to analyse for example the number of

potential customers to a particular shop location or the potential amount of visitors to a park.

This said, it is obvious that as with all analyses of accessibility and configuration there are complexes of qualitative factors that are difficult to take into account, as put forth by Kwan *et al.* (2003) among others. Desyllas *et al.* (2003) have tested to integrate street width, adjacent retail and accessibility to underground stations in a pedestrian demand model. Other factors are of course car traffic barriers, safety, noise levels, air quality, identity etc. These factors furthermore affect different users such as children, elderly, disabled etc. to different degrees. Kwan *et al.* (2003) even emphasizes that also the individual level (personal accessibility) has to be taken into account. Still we believe that the rather straight-forward approach of place syntax analysis balances well between rather simple in-data and precision in out-data at the level that is most useful in urban planning and design.

3.19.6 References

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3.19.7 Figures

Figure 3.39 Closest food store within axial lines. Maps are comparable in terms of colour. (Darker is shorter distance)

3.20 Social spatial influences of new transport infrastructure (SoSINeTi)

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3.20.1 Background

Increasing expansion of transport infrastructure is taking place in more and more countries. This trend, strongly encouraged by the globalization process, is reflected in ever-shorter journey times in both national and international travel. During such developments, extensive urban-planning alterations in areas that are being provided with new transport infrastructure tend to be viewed purely in terms of economic and efficiency benefits – and particularly in terms of the time saved when travelling the distance from starting-point to destination. However, there has been little research on the socio-spatial effects of new transport infrastructure systems. There is no awareness or sensibility for such changes, and as a result hardly any methods are available to investigate phenomena of this type. The present study is therefore intended to add a new level to research on the efficacy of new transport facilities – namely, the socio-spatial effects of transport infrastructure. Also the study tries to find methods to investigate and measure social changes because of new transport infrastructure.

3.20.2 Conceptual framework and theoretical underpinnings

Accessibility in this case means not only the time needed and distance to a newly developed transport infrastructure. The instrument looks also on accessibility aspects before and after the new transport infrastructure was established in the same municipality. Also it has a stronger look on regions which are no longer connected, because of the new transport infrastructure, traversing another way.

So accessibility is measured with the number of connections to the next larger city. These numbers of connections are compared over the years, especially before and after the improvement of the new transport infrastructure. In the same way travel times will be collected and compared, in a way of time table analysis.

To this quantitative meaning and measurement of accessibility, there are additional qualitative approaches by observations of human behaviour before and after the new transport infrastructure was built. Theoretical background is within urban sociology, "Raumsoziologie" nd mobility studies, using mobile methods.

This methods and definitions are used to find a new level beside economic and ecological aspects of new build transport infrastructure, this means, to find social influences. So the sociology approach was used to find out, what influences better accessibility has on human behaviour and what social and behavioural changes can be observed in better accessible municipalities.

3.20.3 Operational aspects

The instrument measures different types of accessibility. First travel times between municipalities are measured. Also these travel times are compared over years to have an overall view. But not only travel times are measured, also the number of connections are counted and compared over the years. But accessibility means also changes in social spatial terms. So the development of new apartments for rent is counted and greeting and talking behaviour of people living in the better accessible municipalities are observed. This is all to see differences in social behaviour in fact of the new transport infrastructure. Questionnaires with shop owners are used to show better accessibility. Better Accessibility means therefore: longer shop opening times, renovations in the shops, more international and not only local shops, more articles and what kind of articles (more local or national orientated?). So these Questionnaires help to understand accessibility in a more social way. To start with all these social observations, expert interviews are useful as a pretest for preparing all observations.

All the data is available, but needs investigation and research. Also the list is not completed here. So in other cases maybe other data will be more interesting.

No soft- or hardware is needed. Maybe a statistic programme can be used, like SPSS. But at the end it is more concerned with analysing qualitative data. And there for no good computer programmes are available.

All observations are long term observations within 5 up to 10 years. The first computation is possible after three years. The time needed for computation depends on the available data and the research questions, but needs no longer than one or two weeks. But it has to be repeated every year, maybe more often.

No special requirements in technical aspects are needed. Maybe some interest in social sciences and empirical methods

3.20.4 Relevance for planning practice

Because it is a long-term research and observation, this instrument on social influences of new transport infrastructures can be used for future planning. Accessibility to infrastructure is not only seen on economic and ecological basis, but also on social facts. Specific on this instrument is that it provides information about former projects. With this information it is possible to make future projects for good accessible transport infrastructure more socially acceptable.

The instrument is not been used yet and it is not published at the moment. It will be published in 2012. But practitioners are involved in the project and know about it. So it helps architects and urban designers to create a socially acceptable surrounding for a new transport infrastructure and it is also about, how to design accessible buildings and places for transport facilities.

One mayor problem of the instrument is the long-term operation time of the instrument, before valid data is available. This fits not within a planning context. And also five years after a new transport infrastructure was built, no special interest on social effects is drawn by planners, who are already preparing the next project.

Despite this, the instrument is really easy to apply in other countries. Only new ideas about social research have to been learned, like doing an observation or preparing a questionnaire. The needed and useful data varies from case to case.

3.20.5 Strengths and limitations

In scientific way it is hard to find any methods to measure social accessibility. So the used methods are a kind of testing methods. Because social effects are overall hard to measure and also hard to interpret, all findings sometimes are very subjective. Nevertheless the instrument is easy to use and produce much qualitative data.

The instrument is most useful after implementing a new transport infrastructure, because it is hard to analysis social behaviour before something happened in reality. But it is useful for ideas in urban planning for constructing new accessible buildings and places. So the instrument is more useful for future accessibility tasks than for the case used for the research. This means other projects can learn from the faults, but also from the good things of the observed project.

The advantage by using the instrument is, to create maybe better social contexts for new transport infrastructure. But most important is even to think about social influences of new transport infrastructure and accessibility. One major disadvantage is that the instrument cannot be used every time in the same way and it needs long term observations. But this disadvantage can also been seen as advantage, because every case study is best prepared and the methods used are exactly those ones that are needed.

Future improvements are planned. So the instrument should be improved by going on with the case study longer than 5 years after the new transport infrastructure was opened. This is helpful to observe long term social changes in better accessible municipalities. It will also help to improve the methods to observe social spatial changes because of new transport infrastructure and better accessibility.

3.20.6 Figures

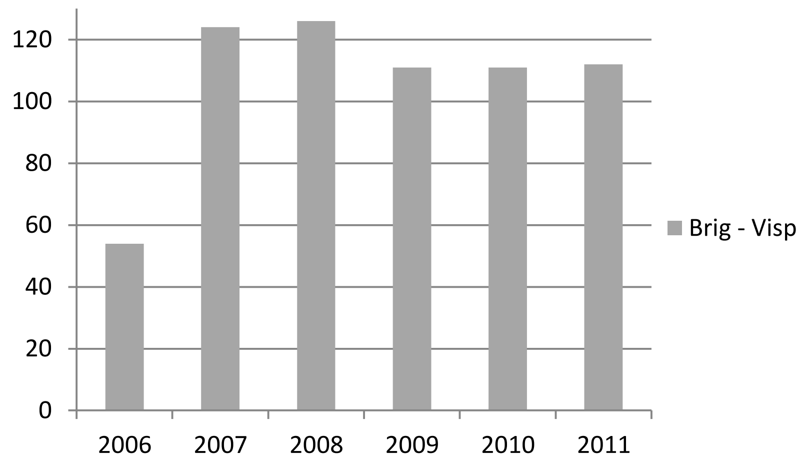

Figure 3.40 Time table analysis: number of trains between better accessible towns because of new improved transport infrastructure

3.21 Spatial Network Analysis of Public Transport Accessibility (SNAPTA)

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3.21.1 Background

SNAPTA has been designed to evaluate the spatial accessibility and the social equity of an urban public transport system. Currently, it has been applied to the Edinburgh transport network to analyse i) the spatial accessibility and equality in the distribution of urban services, and (ii) the impact that planned transport projects in the Local Transport Strategy will have on spatial accessibility by public transport. It, therefore, is used for both *ex post* and *ex ante* evaluation of public transport services.

Good accessibility is seen by the Scottish Government as a driver to economic growth and competitiveness through "providing access to markets and enhancing the attractiveness of cities as focal business locations and tourism" (Scottish Executive, 2004: 18). In the National Transport Plan accessibility is linked to *improving journey times and connections* and to the *quality and affordability of public transport choices* (Scottish Executive, 2006:2). Accessibility is translated into the Edinburgh Local Transport Strategy as "whether or not people can get to services and activities at a reasonable cost, in reasonable time and with reasonable ease". (CEC, 2007:82).

Previous empirical studies of accessibility in the study area have examined the sub-regional context, or wider travel to work context, using an aggregated dataset to make broad-brush statements about accessibility. Halden (2002) examined the accessibility outcomes of different strategies for growth and David Simmonds Consultancy used a computer model to predict the impact of two major new strategic headquarters developments to the west of Edinburgh beyond the city bypass close to the airport (Bramley *et al.*, 2011). More recently, Jan Scheurer has been examining sub-regional accessibility using the SNAMUTS model.

3.21.2 Conceptual framework and theoretical underpinnings

SNAPTA is GIS based accessibility instrument which defines accessibility as "whether or not people can get to services and activities at a reasonable cost, in reasonable time and with reasonable ease". Three measures or indicators of accessibility are used:

Time access to city centre by public transport from each zone during the actual morning peak hour travel to the Central Business District (CBD).

A contour measure which calculates the total number of economic activities or destinations within a maximum travel time by public transport for different trip purposes.

A potential accessibility measure. A gravity-based measure using the morning peak hour travel time between data zones, weighted by the quantity of activity opportunities per zone. Using Hansen's equation [$A_i = \sum_J a_j . f(t_{ij})$], the potential accessibility for the residents of each origin zone A_j is estimated. Where a_j is the attractiveness (quantity or size of activity points) of destination zone J, t_{ij} is travel time, cost or distance from zone i to zone j, and $f(t_{ij})$ is an impedance function. The impedance function adopts a low value for the sensitivity parameter [β] with a value of 0.1 since people using public transport are not very sensitive to a small variation of time (Boucq, 2007; Spiekermann and Wegnener, 2007).

The instrument, therefore, focuses on the land use and transport component of urban interactions and the availability of opportunities during the morning peak hour which can be accessed by public transport. The above-mentioned indicators have been widely used in the literature and they rely on different methodologies to measure accessibility. The fundamental difference between them is that the time access to city centre and contour indicators focus on the separation between locations while the potential indicator focuses on the interaction between locations (Gutiérrez *et al.*, 1996). The selection of accessibility indicators used in SNAPTA depends on the objectives of the instrument user (See Chapter 4 for further discussion).

The theoretical underpinnings of the potential accessibility measure are that the interactions between an origin and destination will decline with increasing distance and time but that interactions are positively associated with the amount of activity at each location (Hansen, 1959). The instrument focuses on groups of people, and assumes that they have a set of social and economic activity needs to be met at different destinations, and that travel demand will be determined by the attractiveness of these locations and the quality of the transport infrastructure linking these places.

3.21.3 Operational aspects

SNAPTA uses the UK Census Data Zones, which have a population of 500-1000 residents, so that contextual data on the population and socio-economic criteria can be used. Land-use and socio-demographic data (at Data Zone level) including the total number of jobs, total gross floor area of retail services and recreation facilities, and number of patients in health care centres and hospitals, can be obtained under licence from government organisations. The data on the number of students in secondary schools and universities, and number of leisure and recreation facilities can be obtained from these organisations' websites.

The digital multimodal transport network of bus services, tramways and railways can be modelled in GIS (ARC/INFO). The network covers the whole of the studied area and consists of links and nodes. The nodes are chosen on the network to correspond to boarding points which provide a regular coverage across the study area. The analysis involves the closest node on each public transport route (within the zone) to the zone's centroid. The centroids of larger, lower density zones of the periphery of the urban area are re-calculated on the basis of population origins.

For each transport link in the GIS data base, tabular attributes of its type, length and the time needed to pass that link have been built. SNAPTA takes into account walk access time, waiting time, in-vehicle time and interchange time. In-vehicle travel time through each link belonging to the currently running transport services can be calculated based on the timetables associated with the bus and tram stops or railway stations during the morning peak times.

Accessibility is calculated for the time access to city centre based on the shortest journey time (or the fastest possible route) by public transport from the nearest node (boarding point) in the network to the centroid of each zone to the nearest node to the centroid of the CBD. The shortest possible journey time might be achieved by using one or more services whether those services are provided by the same type of transport mode or not. The calculation of the potential accessibility indicator is more complicated. It also involves the shortest possible journey times on the network using public transport from the nearest node to the centroid of each zone as an origin to those nodes nearest to the centroids of the other zones as destinations. Once the travel time is computed for each relationship, the accessibility value of each origin zone will be obtained by relating the travel times with the land use attractiveness values (opportunities size) in the destination zones by applying Hansen's equation. A contour indicator has also been measured for each zone by calculating the size of desired opportunity (land use attractiveness) that can be reached by using public transport from that node in the network nearest to the zone centroid within the determined maximum time. A maximum travel time of 15 minutes applies to trips for shopping purposes, while a length of 30 minutes is used for other services, since having a choice of retail services such as a supermarket is not as significant as the choice within recreational and educational services. In a GIS environment, the outputs of SNAPTA can be mapped and demonstrated in 3D using Interpolation and 3D Analyst techniques to show the spatial distribution of accessibility across the modelled area.

Data collection and input into GIS database is a quite time-consuming process while, by comparison, running the SNAPTA instrument in GIS does not take a long time. However, data input and performing the calculation require a good knowledge of GIS software including ArcCatalog and ArcMap especially the functions of ArcGIS Network Analyst (i.e. Cost Matrix, Closest Facility, Service Areas and the Best Route) that are used to run the accessibility calculation. With regard to the degree of expertise required to interpret a SNAPTA output, it depends on the choice of accessibility measure. The results of the potential indicator are not easy to interpret by non-modellers as they are expressed in units while those of the contour indicator and time access to the CBD represent the number of reached opportunities and the needed travel time respectively, which are easy to interpret.

3.21.4 Relevance for planning practice

This instrument has only just been designed so it has not yet been used by public or private sector decision makers. Both the City of Edinburgh transport department and the Lothian Region Health Board were involved in early stages of the design of the instrument. The intention is to work with these institutions to refine the instrument to their specific needs. The instrument will be useful to service providers in several ways;

SNAPTA compares the zonal accessibility by public transport and can estimate the accessibility impacts brought about by proposed transport infrastructure changes. In the case of Edinburgh, it can evaluate the zonal impact of route choices for new infrastructure such as the tram.

At a strategic level, it provides an overview of the attractiveness of zones accessed by public transport to identify the “hotspots” of activity during the morning peak hour. This locates areas of potential congestion which may require specific management approaches.

At a strategic level, it can identify at a disaggregated level those zones that are relatively poorly served by public transport. This can be correlated with income and car ownership data to identify where the public transport system needs strengthening.

At a service operational level, when disaggregated by activity, the instrument shows the length of public transport commute for residents using the isochrones feature.

At a service operational level, the instrument can show the likely zonal impact of service closure and relocation (e.g., Hospital).

Accessibility is one of the UK government’s *ex ante* evaluation criteria for transport project proposals in that the impact on accessibility is one of the key criteria for (i) the assessment of major development proposals in the UK and (ii) the assessment of major transport infrastructure projects by the Department of Transport and Transport for Scotland. Current appraisal methodologies are limited to assessing the impacts of development or transport infrastructure on the surrounding neighbourhood roads. SNAPTA, therefore, introduces a focus on the spatial equity by public transport.

3.21.5 Strengths and limitations

One of SNAPTA’s drawbacks is that zonal centroids are used, and so SNAPTA assumes that all individuals are gathered at the centroid and enjoy the same level of accessibility, although they have different travel demands and may perceive the set of alternatives quite differently. In addition, since Data Zones are groups of 2001 Census output areas have populations of between 500 and 1,000 residents, however, the areas of some zones are very large compared with the rest due to their low population density. Therefore, generating the same accessibility value for the whole area of a large zone is questionable. Another drawback is that the opportunities which are located just outside the modelled area even by only few seconds are neglected. Assuming a walk time between origin or destination and boarding point of 10 or 15 minutes (based on the zone size) rather than calculating the actual walk time through the pedestrian network can be considered as a weakness. Also, the input of the required transport data into a GIS environment is a quite time consuming process.

On the other hand, the key strength of SNAPTA is the ability to apply a package of accessibility indicators using small geographical divisions, and with different ranges of land-use and socio-demographic data. Therefore, the instrument takes into account both transport and land-use systems for accessibility analysis. Since three different types of accessibility indicators are applied in SNAPTA, the results can be used for different applications in transport and land-use planning. Another benefit of including different accessibility indicators is the ability to tackle a limitation of one of the applied indicators by using another indicator in the package. For example, no distance decay is considered in the contour indicator (i.e. all the opportunities located within the selected maximum travel time area are equally counted and not weighted by the distance) while the potential accessibility indicator applies a gradual decay in the distance. The potential indicator considers all the relationships between all origins and destinations while the considered area is limited by using the contour indicator. Also, the results of potential indicator are not easy to interpret by non-modellers as they are expressed in units while the contour indicator output represents the number of reached opportunities which is easy to interpret.

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3.21.7 Figures

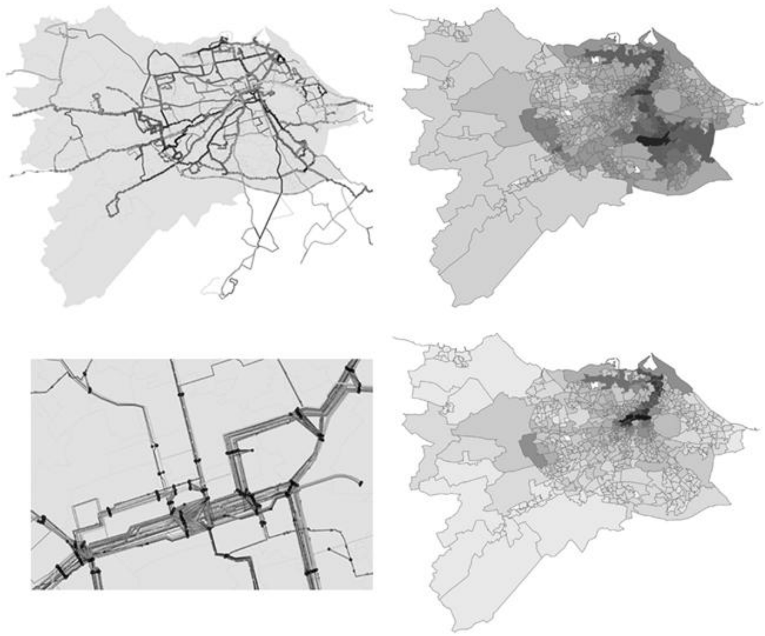

Figure 3.41 Left- Modelling of public transport routes. Right- Mapping of potential accessibility indicator result

3.22 Database suite for calculation of UK accessibility statistics (ACCALC)

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3.22.1 Background

In 1992 when planning an integrated land use and transport strategy for east central Scotland it was identified that modelling tools for accessibility were very limited. Consultants MVA had done some land use transport policy interaction modelling work under JATES (Joint Authorities Transport and Environmental Studies) but it was clear that further work was needed to identify how accessibility analysis could be made more practical to land use and transport planners.

The conceptual foundations of ACCALC were developed to solve this problem. DHC founder Derek Halden (whilst working for the UK Transport Research Laboratory) undertook a review of accessibility modelling techniques to identify how better information could be made available to land use and transport planners to help them plan changes. Out of this review came various papers which showed that accessibility change was perhaps the most important parameter to focus on when planning land use and transport e.g. “managing uncertainty in transport policy development” (Halden, 1996) and “transport and economic development around Inverness” (TRL, 2003).

By 1996 the opposition Labour party had picked up on the accessibility theme as the paradigm shift they wanted to make in transport policy and when they were elected in 1997 the accessibility goal was included in transport and land use policy. DHC was appointed to design the first the Scottish approach to implementing this approach in 1998 and subsequently DHC was also appointed to lead the development of accessibility planning policy in England in 2002 (DHC et al, 2004).

In 1999 version 1 of the ACCALC model was issued on CD to all local authorities in Scotland with Planning Advice note 57 – Planning and Transport. In 2005 this model was substantially upgraded when DHC was appointed to calculate the core accessibility indicators for England and Wales. Since 2005 ACCALC has been used annually to update the CAI which are neighbourhood level indicators (approximately 1000 houses) and cover mainland UK.

3.22.2 Conceptual framework and theoretical underpinnings

The basic concepts in ACCALC are that it is a relational database helping planners to manage large and complex data sets and to output meaningful accessibility indicators (DfT 2011). Version 1 allowed users to upload spatially referenced data on land uses, spatially referenced data on locations from which trips are generated and tables showing the deterrents affecting travel between each origin and destination location. Functions are provided to automate the calculation of a variety of common accessibility indicators formulations.

By far the most widespread application of the model is using travel time data between origins and destination. These are calculated from the digital road and public transport network using a hierarchy of related sparse matrices to represent the journey times between any two points. The matrices are populated using observed travel speeds/costs on each road/footpath link and scheduled journey times/costs from public transport timetables. On some links other barriers are added. For example certain public transport services are not available to people due to physical barriers to using services such as no lifts at rail stations for people who cannot use stairs. Some links have time penalties added due to known difficulties using them such as reliability or quality factors.

By aggregating the travel times or costs between nodes for each mobility groups within the database, the journey times/costs between any two points can be output. The model algorithms search for better journey times or costs until convergence is achieved relevant for the user group being considered and the range of barriers (time, cost, quality, information, etc being considered).

A key part of the model is to guide users when formulating useful indicators: “which population group are you considering, what type of land use are they trying to reach, what barriers to access are being considered?”

Default parameters are included to represent the deterrent effect of travel allowing trip opportunities to be combined in Hansen, Logsum, and other opportunity and value measures. These are based on observed behaviour but can be overwritten by a user who wishes to use their own parameters based on local survey data (e.g. the deterrent effect of safety factors is greater in Middlesborough than Inverness so understanding locally relevant factors like not being willing to travel on a bus after 6pm if over 60 is important) (UoW, 2004).

3.22.3 Operational aspects

ACCALC version 1 in 1999 was based on Microsoft Access 97 but became obsolete when this software was not commonly available on people’s computers after about 2002. Active users maintained a separate copy of Access 1997 (including at the UK universities which used it for training students).

A revised version has never been publicly issued and instead government uses a MS SQL server version of ACCALC to calculate and publish 468 different accessibility indicators annually in Excel spreadsheets. This means that local authorities generally do not need to do their own analysis. If they are looking at a land use plan or transport change they can read off and compare indicators or commission additional analysis.

Building the matrices takes many hours of computation even on high specification servers. However once built, ACCALC uses these matrices as look up tables for any policy question to be analysed so that questions can be answered in real time e.g. when working on a project or policy. A high level of technical expertise is needed to run the analysis but it is hoped to provide a web based user front end so that anyone can use the tools free of charge. To create a user interface suitable for non-technical people will require significant investment so each year DfT defer it till the next year.

In general users concentrate on travel time analysis since the data is more readily available. However analysis of travel costs is also common. Users have not commonly used the model for other factors.

Travel times and costs vary throughout the day and the journey times and costs used in any analysis need to be weighted to match the probability of users wanting to make a trip at each time of day. For example there might be regular bus services on a route between 9am and 5pm but these would be of little use for people wanting to make a journey to a night club. Analysis typically measures 23 journey times across a 24 hour period and two cost periods – peak and off peak.

Data has become much more freely available over the last two years with the opendata government initiative. However data on commercial facilities like shops and theatres can still be quite expensive to purchase.

3.22.4 Relevance for planning practice

National planning policy guidance suggests that as a minimum in a planning application comparisons should be made between the car available and non car available trip times. If the ratio of non car available to car available time exceeds 2.5 then the location would only be suitable for certain types of development and if it exceeds 10 then the location is considered to be car dependent. Although planning guidance requires these checks it is still common practice in the UK not to present the accessibility information with planning applications. Common practice is to make vague statements about accessibility issues not being a problem.

Part of the reason for this is that government puts out far too much guidance and much of it is rarely read. DfT considered a major training and information programme about accessibility planning in 2004 but did not go ahead, instead undertaking some small scale information sessions “within-reach”.

In transport planning the Scottish Government require four different types of accessibility measure to be reported for all transport appraisals: stated, expressed, social and comparative (STAG 2003). The social measures can use the core national indicators and deterrence parameters are published in Scottish Transport Appraisal Guidance to let people use look up tables to calculate simple indicators. DfT are considering similar approaches for UK appraisal but the NATA refresh is taking many years.

3.22.5 Strengths and limitations

The main limitation of the model is that it does not yet incorporate user data as standard but plans are being put in place to address this using data from http://www.fixmytransport.com/, http://www.fixmystreet.com/ and the Loop (www.theloopuk.co.uk). This means that there is little calibration of indicators to show that this is actually how people view the opportunities that have to reach services and facilities.

At a practical level accessibility indicators need to become as integrated and easy to use as other key information affecting decision making like cost. The Auditor General in Scotland recently concluded in a recent review of local government that if there was only one type of indicator local authorities could monitor it should be accessibility, since accessibility was the most useful way to demonstrate the opportunities available to citizens for health, education, work, leisure, etc.

The barriers to making these changes happen are not technical but relate to changing culture and attitudes of professionals who work in narrow areas and are not focused enough at the needs of the people they serve. Uses of the indicators has therefore been common by campaign groups showing how and why people's needs are not being met and it may take many years to support service providers to become more citizen/consumer focused.

See http://www.dft.gov.uk/statistics/releases/accessibility-2010 for further details.

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3.22.7 Figures

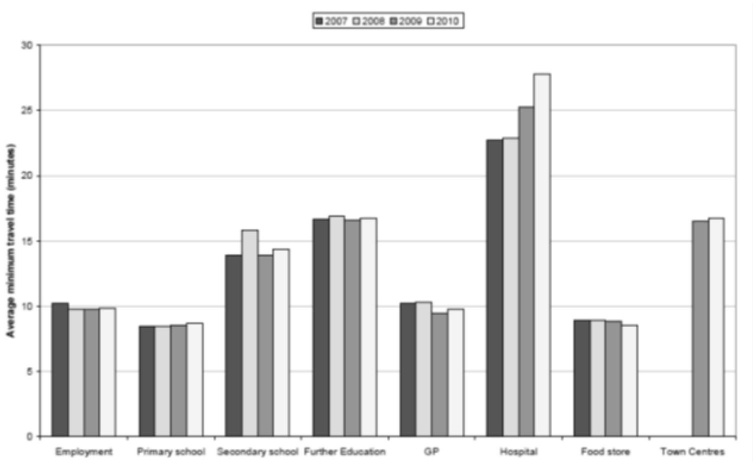


Figure 3.42 Average minimum travel time to reach the nearest key service by public transport/waking, England, 2007 to 2010

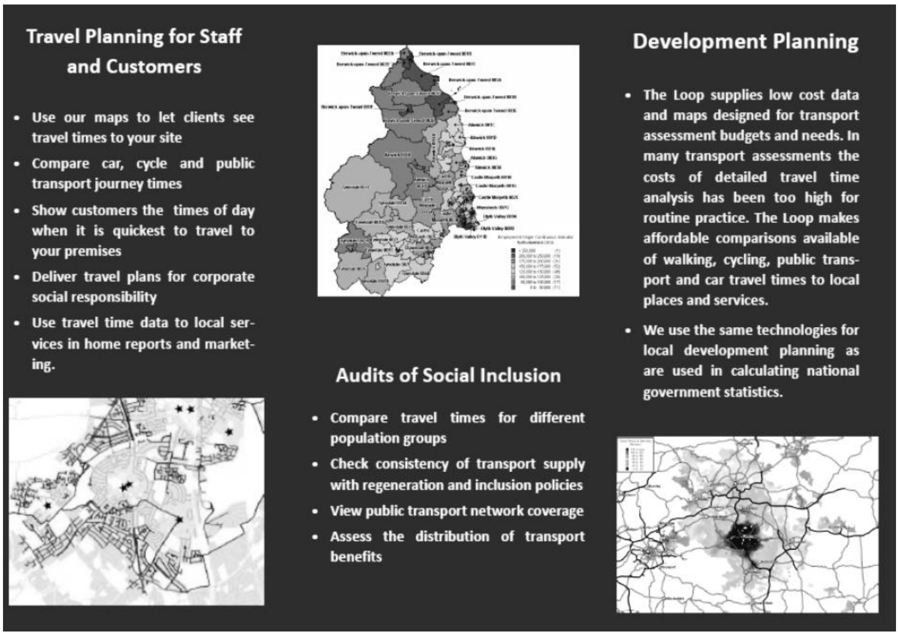


Figure 3.43 Uses of ACCALC

3.23 Cross-analysis of the accessibility instruments presented in Chapter 3

Luca Bertolini, Derek Halden, Sanna Iltanen, Stefano Pensa and Bruno Filipe Santos

In this concluding section, we look at how the different accessibility instruments presented in this chapter compare on the different aspects: background, conceptual framework and theoretical underpinnings, operational aspects, relevance for planning practice, strengths and limitations, and visualization. We identify, per item, significant similarities and differences and reflect on potential implications for the following steps of the Action.

3.23.1 Background

The main motivation to develop an accessibility instrument can be roughly divided in three categories: policy and planning support, scientific enquiry, or a combination of the two. The borders between these categories are not always clear cut. However, based on the motivation expressed by the authors and for the sake of orientation, 10 of the 22 instruments reviewed in Chapter 3 can be placed in the first category, 4 in the second, and 8 in the third.

Within the instruments primarily motivated by a policy support aim, two groups can be identified. A first group is primarily directed at supporting policy *development and delivery* in a multi-disciplinary (both transport and land use) and multi-stakeholder (including different levels of expertise) context. Examples are SNAMUTS (0), EMM (3.7), InViTo (3.10), and JAD (3.12). A second group rather aims to develop tools for the *assessment* of land use and/or transport development proposals and/or service provision. Examples are TRACE (3.2), RIN (3.8), MaReSi SC (3.13), IMaFa (3.18), SNAPTA (3.21), and ACCALC (3.22).

On the other extreme of the spectrum are instruments that are primarily motivated by scientific enquiry, even though the potential relevance for planning is also envisaged, as it might be expected from participants in this COST action. In this category fall HIMMELI (3.5), GDATI (3.14), UrbCA (3.16), and SoSINeTi (3.20).

A middle category is rather above all motivated by the wish to innovatively apply in planning practice insights already fairly consolidated in the scientific domain. The Space Synthax inspired instruments described in sections 3.3, 3.9, and 3.19 fall in this category. Other examples are ABICA (3.4), Contactability (3.6), GraBAM (3.11), SAL (3.15), and ATI (3.17).

This variety of motivations is both a challenge and an asset for the COST Action. It is a challenge because it demands establishing a common language and sense of direction between researchers coming from different backgrounds and having different primary motivations. It is an asset because it gives the Action a rich variety of expertise spanning the scientific and policy domains. Such variety seems essential for our aim of establishing a bridge between scientific enquiry and policy practice.

3.23.2 Conceptual framework and theoretical underpinnings

The ease or difficulty in reaching different activities dominates among the instruments as a conceptual definition of accessibility. The kind of activities or services that are included in measurements varies more or is not reported in a very detailed way. Some of the instruments focus on certain services like retail and shopping (e.g. TRACE, MaReSi SC), some approach public transportation or technical infrastructure as service (to be accessed) (e.g. InViTo, ATI) while others approach transportation and infrastructure as a system which enables the access to activities or services. Several different activities are taken into account for example in instruments like 'SAL' and 'GraBAM'.

One clear group of instruments concentrate only on the physical and configurational aspects of space and define accessibility in terms of the topological network properties of urban space using transportation network or other networks based on visual perception. ASAMeD and 'MoSC' are examples of instruments that are based strongly on space syntax approach. Some of the instruments settle between these two like 'PST' has a more individual approach to the accessibility concept.

The theoretical underpinnings vary from geography to architecture. Most of the activity related instruments utilise gravity based accessibility measures and are thus related to the modelling tradition of urban geography. Instruments that emphasise the spatial and structural properties of urban environments mostly refer to the 'space syntax school' which has its origins in architecture and urban morphology. Instruments that are part of larger model structures, like 'HIMMELI' and 'UrbCA' are related to different traditions of modelling theories like systems theory, complexity theory and the theory of cellular automata. Some instruments like 'ABICA' refer to time geography or information visualisation. A significant part of the instruments are not reported having any theoretical underpinnings, but they are merely developed for normative planning purposes.

The motivation for choosing and developing the instruments is generally an aim to support strategic planning decisions – especially the focus is on the integration of transport and land use planning. Some of the reports emphasise more economic issues and assessment of investments while others emphasise more social aspects e.g. social equity. Differences can be seen also between normative tools that are developed to set certain (unambiguous) standard solutions for planning (e.g. maximum travel times to services or minimum customer potential within given distance) and more analytical tools that don't include straightforward instructions for planning but rather increase understanding of the interdependencies between urban elements.

3.23.3 Operational aspects

The authors were asked to give an answer to the following questions:

- Which types of accessibility does the instrument measure?
- How does your instrument calculate accessibility?
- Which data is required? Is the data publicly and freely available? If not at which conditions can it be obtained?

- How is the data processed? What are the hardware and software requirements? Is the software publicly and freely available? If not, at which conditions can it be used?
- How much time does the calculation require?
- Which degree of technical expertise is required to perform the calculation?
- Which degree of technical expertise is required to interpret the results?

A comparative overview of the responses to these questions is reported in Appendix 3.

Significant similarities and differences are:

- Most instruments deal with aggregated measures of accessibility, by either considering a network distance (despite the mode) or the different modes together;
- The techniques for computing accessibility, when mentioned, vary from spatial syntax (3) and gravity models (5), to activity based (2), social based approaches (2) and clustering (1);
- Part of the instruments (6 of 22) deal with the impact of land-use changes, some instruments deal with accessibility to stores, while few deal with the accessibility to facilities;
- In general, data needed is transportation info (maps, OD matrices, times/costs) and population data. Most of the authors mention that the info they need is available on the web (10 of 22) or is provided by planning/local authorities (7 of 22). Only 5 authors mention that data must be purchased;
- No clear idea of computation time is always provided – the time for applying the instruments depend on the type of tool used and the size of the case study, but most of the authors mention the duration of hours or days;
- 14 of the instruments are based on GIS software, 2 use data management software, and only 6 authors mention that they use (or developed) open source tools;
- The level of expertise need to use the instruments also vary between instruments – 6 authors mention that no specific expertise is needed to use the instrument and 10 mention the same for interpretation of the results; 3 authors mention that a high level of expertise is needed for preparing data, 7 to use the instrument, and 4 to read the results.

Potential implications for the following steps of the Action are:

- The summary shows that different accessibility techniques are being used and different transport modes are focused upon by the authors. The compatibility of these different perspectives can be a major challenge for the Action but it also proves the wide coverage of this Action;
- In the same way, some authors focus on urban-level accessibility, while others focus on neighboorhood-level accessibility (e.g., walking or cycling distance) and others on interregional-level accessibility (e.g., long distance trips by rail or air). The merger of both scales, by using more than one instrument in the future can be a potential goal for accessibility research - .

- Most authors present instruments that deal with accessibility in a static fashion, i.e. they try to get the picture for a given scenario (in the past, present or future), but 3 authors mention that their instruments focus on measuring the impacts on time of land use changes and impacts of infrastructure investments. The Action may explore these different approaches, trying to understand how they can differently be used by planners and, if they provide different answers, for which uses which approaches can be better.

3.23.4 Relevance for planning practice

Each of the reports attempted to address the following questions:

- What information does your instrument produce that can be useful for planning practitioners?
- Has the instrument been used before in a real planning context?

If yes:

- Where and when?
- Which planning problem, or problems, did the instrument address?
- How did the instrument help in decision-making?
- What difference did it make in the planning outcome and/or in the decision-making process?

If no:

- Why not?
- Has the possibility of using the instrument to address a planning problem and support a decision-making process been otherwise explored? If yes, provide a brief description of the planning problem and how the instrument can provide support to decision makers.

A comparative overview of the responses to these questions is reported in Appendix 4.

Significant similarities and differences among the reviewed instruments with respect to planning practice are:

- Some are tools to aid calculation;
- Some are expert systems to help define and answer problems;
- Some are repeatable analytical methods using existing and widely available tools like GIS systems.

Potential implications for the following steps of the Action are:

- Where there are clear policies defined for accessibility, then tools have an application since they can be optimized to implement the policy and make calculation easier.

- Where accessibility analysis contributes to another policy goal like transport or land use planning then repeatable analytical methods can be most useful.
- Accessibility can be a difficult concept so both of the above can use expert systems to guide people through the process of data collection, analysis, policy formulation and planning.

3.23.5 Strengths and limitations

The variety of motivations for developing the accessibility instruments and the even greater variety in their content focus mean that it is difficult if not impossible to synthesize their strengths and limitations. The discussion here would therefore have to be at a high level of abstraction and be limited to the most salient issues. For more concreteness and detail we refer to the individual chapters.

A key strength cited by most if not all is the ability of the instrument to link (1) some information on transportation networks, land uses and the urban fabric, to (2) their impact on location and mobility behaviour and therefore (3) implications for the achievement of policy goals ranging from economic development, to social equity and environmental preservation. From the point of view of instrument developers, accessibility is, in its various forms, a (if not *the*) key indicator of the performance of the built environment. Most authors would subscribe the view of the Auditor General in Scotland reported in section 3.22 that, if there was only one type of indicator local authorities could monitor it should be accessibility, since accessibility is the most useful way to demonstrate the opportunities available to citizens for health, education, work, leisure, etc.

A second key strength cited by many is the straightforwardness, ease of interpretation and communicative power of the indicators, often in map form. These last claims, however, are not always supported by actual applications in planning practice, or by applications going beyond a pilot study, as documented in the previous section. Accordingly, several authors also cite the need to embark in practice applications and to learn through them how usable the instruments actually are, and how to improve usability. This provides, of course, a clear focus for the next steps of this Action.

Requirements in terms of data availability, calculation time and technical expertise are also often cited as limitations and areas of improvement. Other areas of improvement mentioned concern, perhaps somewhat contradictorily with the previous ones, the need to extend the range of inputs (e.g. more transportation modes, more qualitative urban morphology features) and outputs (e.g. more impacts), or to increase the realism of the underlying behavioural assumptions (e.g. by including distance decay and competitions effects, or transport-land use feedback mechanisms). Some of the authors, however, point out the fact that models are by definition limited in their realism, and that the aim should rather be to ensure that the accessibility instrument is transparent in its assumptions and logic, and easy to use. They further contend that complexity should rather be added by also using other instruments, or through the discussion with other experts and stakeholders. The rigor-relevance dilemma cited in section 3.15 sums up this conundrum and seems to point to a key area of discussion and exploration for the following phases of the Action.

3.23.6 Visualization of outputs

The accessibility instruments described here show a variety of visualization forms. Sometimes the output of accessibility tools can be numerical and listed in tables, matrix or datasheets, without offering any kind of visual outcome (e.g. tools in sections 3.2, 3.13, 3.14, 3.17, and 3.20). But this kind of outcome can be needed for some users to make sense of accessibility which can otherwise be treated as a 'slippery' concept and not trusted by decision makers. Nevertheless, the most of accessibility tools generates a visual product, generally represented by bi-dimensional maps.

In order to analyse these different approaches to visualization, an overview will be shown, including only the instruments which generate a visual output. Furthermore, since many case studies have very similar output, their analysis will be conducted aggregating the tools on the basis of the technique of visualization. Main categories are:

- 2D areal aggregation: data are grouped in macro-zones and classified on the basis of a colour scale;
- 2D axis-based maps: data are defined by the road network (e.g. Space Syntax based instruments) or by lines connecting points. The colour of shapes define the intensity of values;
- 2D point-based maps: data are represented by points on 2D maps. Size and colour of shapes define the intensity of values;
- 3D images: maps with a third, z-axis;
- no visual output: tools with no visual output described.

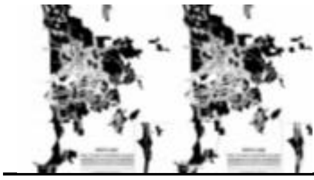
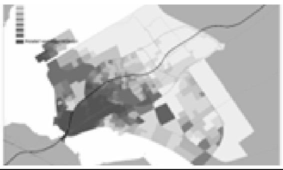
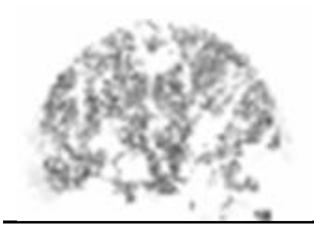
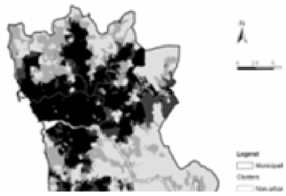
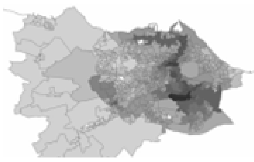
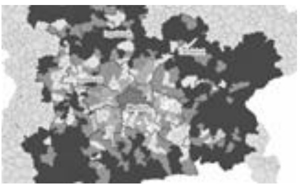
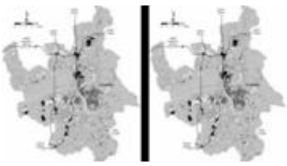
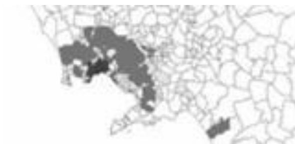
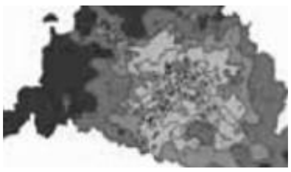
The accessibility instruments have been ordered as shown in the Table 3.5.

Only 5 of 23 tools do not report a visual output, highlighting the importance of visual communication for the most of the studies. Nevertheless, communication is mostly intended to provide knowledge rather than simply present data. In fact, except in one case (ABICA, section 3.4), all the accessibility instruments which have a visual output make use of bi-dimensional maps, preferring traditional methods of communication which are commonly used in spatial studies. This can be due to several factors. Firstly, 2D maps are generally perceived as more easy to understand for a wider range of people with different levels of expertise. Secondly, accessibility studies involve the use of spatial indicators which perfectly fit geo-referenced representations. Thirdly, input data are bi-dimensional. Finally, the different approaches to the study of accessibility do not cover the z-dimension, projecting all the connections to the ground level.

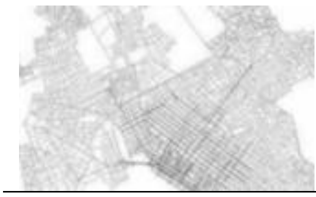
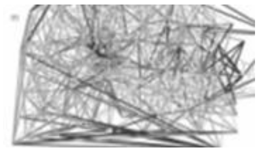
Half of the tools represent data by the use of area aggregation, generally based on the administrative boundaries of studied areas. This technique provides results highly dependent on the scale of aggregation, which is generally a balance between the dimension of the area and the amount of data to consider.

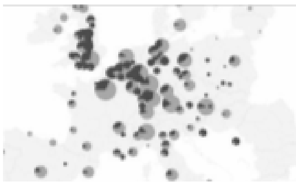
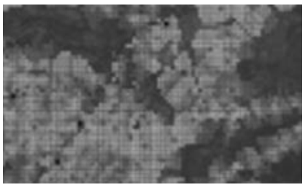
Table 3.5 Tools aggregation according to their type of output visualization

2D areal aggregation

SNAMUTS (3.1)	JAD (3.12)	PST (3.19)
		
HIMMELI (3.5)	SAL (3.15)	SNAPTA (3.21)
		
EMM (3.8)	UrbCA (3.16)	ACCALC (3.22)
		
GraBAM (3.11)	IMaFa (3.18)	
		

2D axis-based maps

ASAMeD (3.3)	MoSC (3.9)	RIN (3.8)
		

2D point-based maps		3D images
Contactability (3.6)	InViTo (3.10)	ABICA (3.4)
		

No visual output
TRACE (3.2)
MaReSi SC (3.13)
GDATI (3.14)
ATI (3.17)
SoSINeTi (3.20)

Space syntax based tools (ASAMeD and MoSC) use the road network to visualize the value associated to their indicators. This allows them to define the behaviour of each axis in relation to the whole area, creating a well performing visualization for describing the relations among the parts. Nevertheless, they seem more suitable in testing alternative project options rather than generate useful information for project design. Also the RIN shows its output by the use of coloured axes, however the overlapping reduced the clarity of the information provided.

Point-based maps are used by just two tools and in a similar way but at different scales. The Contactibility uses elements of info-graphic to implement the readability of a very large scale map, generating a picture which highlights well the size and location of value clusters. On the other side InViTo proposes a point output at urban scale where points vary in colour and size according to indicator values.

The overview on tool shows that the techniques of visualization are not affected by the scale of representation, but rather by the type of data aggregation. In determining the required visualization approach it seems necessary to first understand the intended audience and what the planner hoped they will do when they see the visualization. Among the accessibility tools presented in this report, the purposes of visualizations mostly focus on data explanation to high and medium experts, with map-based knowledge. All the visual outputs, both concerning policy support and scientific enquiry, provide representations which distil complex concepts into relatively simple maps and graphs helping planners to understand spatial dimensions of key accessibility statistics. Some visualizations use more artful techniques, which can be helpful in facilitating engagement, but still remain knowledge-focused.

Most of the tools need calculation times within the range of hours to days. Only one tool (InViTo), allows data exploration, generally considered as the highest form of data knowledge, by the use of interactive dynamic maps which work in real-time.

The majority of tools show their outcomes with colours that refer to three common techniques: the first is the traditional green-yellow-red scale, the second resorts to the different gradients of the same colour while the third uses the opposition between red and blue to highlight the contrasts. These traditional approaches to the use of colour shows once again the purpose of these tools to provide results that can be understood by the most of people and, in particular, to inform spatial planners on the capabilities of an area to access another one or to be accessed.

Chapter 4. ACCESSIBILITY INSTRUMENTS SURVEY

Angela Hull, Enrica Papa, Cecilia Silva, Anssi Joutsiniemi

4.1 Introduction

This chapter presents the main results of the Accessibility Instrument Survey (AIS), collecting basic information on each of the accessibility instruments reviewed in this report (for more detail on these Instruments see Chapter 3). The aim of the survey was to enable quick, objective and comparable overviews of each of the reviewed accessibility instruments. The information collected will enable the categorization of accessibility instruments present in this research, aiming to be a reference for future categorization of accessibility instruments for planning practice. These categories will support the analysis of the coverage of accessibility instruments in this research, i.e., identify how representative this research is across different accessibility instrument types. In addition, these will be used to analyse the characteristics and concerns which most frequently underlie the development of accessibility instruments. Finally, the survey also collects developer's perceptions on the usefulness of their accessibility instruments in planning practice, enabling the first insight into the main research question of this COST Action, although limited to the developer's point of view.

In summary, the results of the survey will be used for four purposes:

- Development of an accessibility instrument sheet for each accessibility instrument summarizing its main characteristics (Appendix A);
- Identify the coverage of accessibility instrument types present in this research (Section 4.3.1) discussing the representativeness of this Action;
- Provide a glimpse on the characteristics and concerns which most frequently underlie the development of accessibility instruments (Section 4.3.2);
- Provide a first insight into the perceived usefulness of accessibility instruments in planning practice from the point of view of the developer (Section 4.3.2 and Section 4.3.3).

The next section provides an overview of the Survey describing the information collected. This section also describes the development process of this survey including data collection, dates and means. The results of the survey are analysed in the third section starting with a discussion on the coverage of accessibility instruments reviewed by this research (Section 4.3.1), identifying accessibility measure types which are represented and which are absent. This discussion is accompanied by the presentation of the main categories of accessibility instruments from the perspective of the end user. These categories try to summarize the main concerns planning practitioners are expected to have when searching for an accessibility instrument and is built upon some of the information collected by the survey. Following, the third section also presents a general analysis of the results (Section 4.3.2), focussing on the dominant characteristics of the accessibility instruments reviewed and on the developer's perception of the usefulness their instrument will have for end users. The section ends with a brief cross analysis of results (Section 4.3.3) trying to identify relationships between accessibility instrument characteristics and perceptions of usefulness by developers. The fourth and last section presents the main conclusions of this study.

4.2 The Accessibility Instrument Survey

The Accessibility Instrument Survey was conducted on the Action's website (http://www.accessibilityplanning.eu) with developers of accessibility instruments participating in this research being invited by e-mail with a direct link to the survey (which was not accessible otherwise or searchable on the web).

The development of the survey started in the beginning of 2011 with a general discussion meeting involving all research groups of this COST Action. The main issues of the survey were discussed in a general assembly, which was later subdivided into smaller groups to work on the particular questions in each group. This process enabled the development of an inclusive survey considering different perspectives and the backgrounds of accessibility instrument developers. The draft version of the survey was then further developed by a smaller team. The survey was available to be filled in by all participating accessibility instrument developers from mid-August to mid-September 2011.

A preliminary analysis of the results of the survey and of the comments left by the accessibility instrument developers revealed some minor corrections required for the survey. These corrections were developed following a general discussion meeting in Edinburgh in the fall of the same year with corrected questions sent out for a second round by the end of the year, concluding the data collection phase of the survey.

The final version of the survey (see Appendix B) holds 4 main groups of questions preceded by a preliminary group of questions providing general information on the developer of the accessibility instrument (such as, name, e-mail and institution) as well as the name of the accessibility instrument. The remaining questions are divided into four groups:

1. Planning Context.
2. Planning Goals.
3. Characteristics of the Instrument.
4. End-users and how they use the tool.

The first group of questions aimed to identify a number of baseline issues for the development of the accessibility instrument, namely, if there are political requirements for accessibility planning in the country/region of origin/activity of the developer, as well as, information on the geographical scale, the status of development of the instrument and the type of planning process for which the instrument is intended.

The second group of questions aimed to identify the main planning goals considered in the development of the instrument, or in other words, the planning goals the instruments are able to consider or provide an answer to. Within this group of questions, planning goals were divided into public stakeholder goals, private investor goals and personal/individual goals.

The third group of questions aimed to summarize the main operational characteristics of the accessibility instruments surveyed, including accessibility measures type (identifying if the measure follows traditional contour measures, gravity measures, utility measures, etc.) and the components considered (from the 4 main components of Transport, Land use, Temporal and Individual components), the level of disaggregation with regard to spatial, socio-economic and temporal data and analysis, and the transport modes and opportunities considered. This group also includes questions evaluating the developer's perception on the ability of the instrument to replicate reality and on the speed of the tool.

Finally, the last group of questions aimed to evaluate the developer's perception on the usefulness of the accessibility instrument in planning practice and to understand the relationship with the potential end users. With regard to the developer's perception of usefulness, respondents are asked to rate how easy it is to use the instrument, the knowledge and skills required to use the instrument, the ability to provide understanding on the quality and experience of travel and the success of the instrument in its intended role in urban planning. Additional questions include issues on potential users, the role in connecting service users and accessibility providers and the role in urban planning. This group ends with questions on the main issues blocking implementation of the accessibility instrument.

With the exclusion of the rating questions, most questions allowed multiple responses. The large majority of questions allowed an answer of "Not applicable" or "Don't know yet" (in this case only for instruments marked as "in development" in question 1.3 identifying the status of development of the instrument).

4.3 Accessibility Instruments in TU1002

4.3.1. Coverage of Accessibility Instruments

The aim of this section is to present an overview of accessibility instruments and to show the coverage of the tools reviewed by this research, identifying which types and which application are represented or are absent and to provide a tool for urban and transport planning practitioners for choosing what they may need. In other words, this paragraph illustrates a "coverage analysis", showing how many instruments of each type have been proposed in the COST Action, through a clear and quick synopsis of the main characteristics of the different instruments.

The coverage analysis of accessibility tools has been developed starting from the point of view of the potential user and the instruments have been categorized starting from five basic questions planning practitioners may have when they have to choose the instrument that best fits their requirements: For each planning question a category and several classes have been defined as summarized in the following table.

Table 4.1 Categories of how the Accessibility Instruments inform planning goals

Practitioners' planning question	Category	Class
What is the geographical scale? (question 1.1 of the survey)	Geographical scale	Supra-national
		National
		Supra-municipal
		Municipal
		Neighbourhood
		Street
What is the planning goal? (question 2.1 of the survey)	Planning goal	How to decide on the loc ation of residences /activities / services?
		How to manage, encoura ge or reduce the use of a particular transport mode(s)?
		How to stimulate economic development?
		How to ensure economic equity?
		How to ensure social equity and/or cohesion?
		How to ensure reductions of emission/energy use?
What kind of support are you looking for? (question 3.1 of the survey)	Decision support task	Passive decision support tool
		Active decision support tool
		Cooperative decision sup port tool
		Used in the ex-post evalu ation of the decision impact
What will you need support on? (question 4.7 of the survey)	Role in urban planning	to create new insights
		to justify decisions/ positi ons already taken
		to support strategy/ optio n generation
		to support strategy/ optio

Practitioners' planning question	Category	Class
		n selection
What are the transport modes you want to consider? (question 3.8 of the survey)	Transport mode	Any mode
		Walking
		Bicycle
		Public Transport
		Car
		Truck
What are the trip purposes you want to consider? (question 3.9 of the survey)	Trip purpose	No purpose / not applica ble
		All purposes (aggregate measure)
		Work
		Leisure
		Healthcare
		Shopping

In order to show the coverage of the accessibility instrument, the following tables (from Table 4.2 to Table 4.7) demonstrate how the tools presented in this research can be used and in which circumstances, according to the different services provided by the instruments. From the coverage analysis some clusters of accessibility instruments were defined according to the categories used.

The accessibility instruments presented in this research cover all the geographic scales from the supra-national scale to the street level, but only *IMaFa* and *RIN* can be used at the supranational scale; *IMaFa*, *GDATI*, *TRACE* and *RIN* can be applied at the national scale. Only *IMaFa*, *PlaSynt*, *ASAMeD* and *MoSC* consider the street level. Almost all of the instruments have been developed for the use at the supra-municipal scale and around 3/4 for the municipal scale. On the other hand, the instruments for applications at the macro or micro scale are less numerous. Most of the instruments, as showed in Table 4.2, can be used also for applications at two or more geographic scales.

Table 4.2 Coverage of each Accessibility Instrument according to the geographical scale

Accessibility instrument		Geographic scale						
Acronym	**Country**	supra_national	national	supra-municipal	municipal	neighbourhood	street	
IMafA	ES	X	X	X	X	X	X	multi scale
RIN	DE	X	X	X	X			multi scale
TRACE	BE		X	X	X	X		multi scale
PlaSynt	SE			X	X	X	X	multi scale
MoSC	USA			X	X	X	X	multi scale
GDATI	PL		X	X	X			multi scale
SAL	PT			X	X	X		multi scale
InViTo	IT			X	X	X		multi scale
EMM	DE			X	X			municipal and/ or supramunicipal
SNAMUTS	AU			X	X			municipal and/ or supramunicipal
SOTO	NO			X	X			municipal and/ or supramunicipal
ABICA	DK			X	X			municipal and/ or supramunicipal
UrbCA	PT			X	X			municipal and/ or supramunicipal
HIMMELI	FI			X				municipal and/ or supramunicipal
GraBAM	IT			X				municipal and/ or supramunicipal
JAD	NL			X				municipal and/ or supramunicipal
SNAPTA	UK				X			municipal and/ or supramunicipal
ATI	SL				X			municipal and/ or supramunicipal
SoSINeTi	SW				X			municipal and/ or supramunicipal
ASAMeD	UK				X	X	X	under municipal
PST	SE				X	X		under municipal
MaReSi SC	NO				X	X		under municipal

Table 4.3 Coverage of the Accessibility Instruments according to the planning goals

Accessibility Instruments		Public Sector Planning goal						
Acronym	**Country**	How to decide on the location of residences /activities / services?	How to manage, encourage or reduce the use of a particular transport mode(s)?	How to ensure economic equity?	How to ensure social equity and/or cohesion?	How to stimulate economic development?	How to ensure reductions of emission/energy use?	Other
SNAMUTS	AU	■	■	■	■			■
ATI	SL	■		■	■			
ABICA	DK	■	■					
EMM	DE	■				■		
PST	SW		■					■
PlaSynt	SW		■					■
IMaFa	ES							■
SoSINeTi	SW							■
ASAMeD	GR	■						■
SNAPTA	UK	■						
HIMMELI	FI	■						
TRACE	BE	■						
SOTO	NO	■						
INVITO	IT	■						
MSC	USA	■						
UrbCA	PT, ES	■						
GDATI	PL		■					
MaReSi SC	NO		■					
GraBAM	IT		■					
SAL	PT		■					

multi objective (SNAMUTS – SoSINeTi)

urban planning oriented (ASAMeD – UrbCA, first goal column)

trasport planning oriented (GDATI – SAL, second goal column)

According to the planning goals (see Table 4.3), nine accessibility tools proposed in this research have a multi objective structure. The other tools are mainly aimed at deciding on the location of residences /activities / services (urban planning oriented) or at managing, encouraging or reducing the use of a particular transport mode (transport planning oriented). One instrument (*EMM*) has the objective of stimulating economic development. The economic and social equity goals are covered by two instruments (*SNAMUTS* and *ATI*). None of the accessibility tools has any particular relevant aim to reduce emissions/energy use. Several instruments have also identified other specific objectives besides of the once available, which nevertheless could be settled within the existing list of general objectives and concerns (focussing on particular transport, land use, social or economic objectives).

The tools that are “transport planning oriented”, aiming to manage, encourage or reduce the use of a particular transport mode, can be divided into different categories according to the particular transport mode they are oriented towards. Two instruments (*SAL* and *ABICA*) have the goal of managing all the transport modes. *GraBAM* has the aim of reducing car use and encouraging public transport, while *PST* has the objective of managing car, bicycle and walking modes. *PlaSynt* and *MaReSi SC* focus on car use and *SNAMUTS* and *GDATI* have the aim of managing public transport modes (see Table 4.4).

Table 4.4 Coverage of the Accessibility Instruments according to the planning goals – transport modes

Accessibility Instruments		**Public Planning goal – transport modes** (How to manage, encourage or reduce the use of a particular transport mode(s)?)			
Acronym	**Country**	**Car**	**Public Transport**	**Bicycle**	**Walking**
SAL	PT	■	■	■	■
ABICA	DK	■	■	■	■
GraBAM	IT	■	■		
PlaSynt	SW	■		■	■
PST	SW	■			
MaReSi SC	NO	■			
SNAMUTS	AU		■		
GDATI	PO		■		

As regards the decision support task, the accessibility tools can be categorized according to their mission in the planning process: a passive decision support tool (aids the process of decision making, but cannot bring out explicit decision suggestions or solutions), an active decision support tool (can bring out such decision suggestions or solutions), a cooperative decision support tool (allows the decision maker or advisor to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation) or a tool used in the ex-post evaluation of the decision impact.

The accessibility instruments cover all the different decision support tasks, with a significant (nearly half of the instruments) prevalence of strategic planning support tools (see Table 4.5). We can find two passive decision support tools; three active decision support tools; four cooperative decision support tools; three can be used in the ex-post evaluation of the decision impact. Finally, one instrument is used in many different parts of the planning, appraisal and project delivery process.

Table 4.5 Coverage of the Accessibility Instruments according to the decision support task

Accessibility Instruments		Decision support task					
Acronym	**Country**	Passive decision support tool	Active decision support tool	Cooperative decision support tool	Used in the ex-post evaluation of the decision impact	Strategic planning support tool	Other
PST	SW	■	**PDSS**				
SAL	PT	■					
MaReSi SC	NO		■				
GraBAM	IT		■	**ADSS**			
RIN	DE		■				
GDATI	PO			■	**CDSS**		
TRACE	BE			■			
MSC	USA			■			
UrbCA	PT, ES			■			
SNAPTA	UK				■		
ASAMeD	UK;NL;SE;BRA;CH;SA;JA				■	**Ex post evaluation**	
SoSINeTi	SW				■		
PlaSynt	SE					■	
EMM	DE					■	
HIMMELI	FI					■	**Strategic planning DSS**
SNAMUTS	AU					■	
SOTO	NO					■	
IMaFa	ES					■	
ATI	SL					■	
JAD	NL					■	
INVITO	IT					■	
ABICA	DK					■	
ACCALC	UK;EC;Global						■

Table 4.6 Coverage of the Accessibility Instruments according to the instrument's role in urban planning

Accessibility Instruments		Role in urban planning					
Acronym	Country	To create new insights	To justify decisions/ positions already taken	To support strategy/ option generation	To support strategy/ option selection	To support integration of urban planning perspectives	Other
PST	SW	■	■	■	■	■	
CAM	PT, ES	■	■	■	■	■	
PlaSynt	SW	■		■	■	■	
EMM	DE	■		■	■	■	
SNAMUTS	AU	■		■	■	■	
ASAMeD	UK;NL;SE;BRA;CHI;SA;JA	■	multi role	■	■	■	
SAL	PT	■		■	■	■	
INVITO	IT	■		■	■	■	
IMaFa	ES		■	■	■		
TRACE	BE		■	■		■	
RIN	DE		■		■	■	
–SOTO	NO	■		■			
JAD	NL	■		■			
ABICA	DN	■		■			
HIMMELI	FI	■				■	
GDATI	PL		■				
GraBAM	IT			■	■		
SNAPTA	UK			■	specific role		
ATI	SL				■	■	
MaReSi SC	NO					■	■
GDATI	PO		■				
MoSC	USA					■	
SoSINeTI	SW						■
ACCALC	UK /EC/ Global						■

The accessibility instruments have different (intended) roles in the urban planning process: they can be used to create new insights, to justify decisions/ positions already taken, to support strategy/ option generation, to support strategy/ option selection, to support integration of urban planning perspectives. According to this categorization, two tools (*PST* and *UrbCA)* have all the above mentioned functions.

PlaSynt, EMM, SNAMUTS, ASAMeD, SAL and *InViTo* can be used to create new insights, strategy/ option generation, strategy/ option selection and integration of urban planning perspectives. *SOTO*, *JAD* and *ABICA* have the function of creating new insights and of supporting strategy / option generation.

In general, it is fair to say that around half of the accessibility instruments have a multi-role in urban planning, focussing most of the different urban planning roles for which planning support systems generally developed. The other half has more specific roles, concentrating on one of two of these roles at a time. Within these instruments, the roles of creating new insight, supporting strategy/ option generation and to supporting integration of urban planning perspectives are most frequently found.

Table 4.7 Coverage of the Accessibility Instruments according to the transport modes used in the instrument

Accessibility Instruments		Transport modes used in the instruments							
Acronym	Country	Any mode	Car	Public Transport	Walking	Bicycle	Other	Not applicable	
PST	SW	■					■		Multi modal
MaReSi SC	NO	■					■		Multi modal
ACCALC	UK /EC/ Global	■							Multi modal
EMM	DE		■	■	■	■			Multi modal
SAL	PT		■	■	■	■			Multi modal
RIN	DE		■	■	■	■			Multi modal
JAD	NL		■	■		■			Multi modal
ABICA	DK		■	■		■			Multi modal
HIMMELI	FI		■						Car
UrbCA	PT, ES		■						Car
INVITO	IT		■		■				Car + sm
GraBAM	IT		■	■					Car + sm
IMaFa	ES			■	■				Sustainable mobility
SNAPTA	UK			■					Sustainable mobility
SNAMUTS	AU			■					Sustainable mobility
GDATI	PO			■					Sustainable mobility
SOTO	NO			■					Sustainable mobility
SoSINeTi	SW			■					Sustainable mobility
PlaSynt	SW				■	■			Sustainable mobility
ASAMeD	UK;NL;SE;BRA;CHI;SA;JA				■	■			Sustainable mobility
MoSC	USA				■				Sustainable mobility
TRACE	BE							■	

Accessibility instruments use different transport modes and in most cases combinations of them. All main transport modes are covered by the accessibility instruments researched in this Action, although analysis on accessibility by public transport, have more instruments to choose from. Instruments, such as, *PST*, *MaReSi SC* and *ACCALC* can use any mode, while *EMM*, *SAL* and *RIN* consider accessibility by the major transport mode groups (car, public transport, bicycle and walking). Most instruments consider more than one transport mode. Instruments dedicated exclusively to one particular transport mode can be found for car accessibility (HIMMELI and UrbCA) and for public transport (SNPTA, SNAMUTS, GDATI, SOTO and SoSINeTi).

According to the trip purposes/ opportunities used in the instruments, the majority of the instruments make use of all purposes (work, leisure, healthcare, shopping, education). Some of these use aggregate measure and thus are unable to specify the accessibility to particular activities while others may consider accessibility to any particular activity type. From the remaining instruments some focus on work and shopping activities can be inferred.

Table 4.8 Coverage of the Accessibility Instruments according to the trip purpose

Accessibility Instruments		Trip purposes / opportunities used in the instrument						
Acronym	Country	Any purpose (disaggregate) or All purposes (aggregate measure)	Work	Leisure	Healthcare	Shopping	Education	Other
SNAPTA	UK	■						
PST	SW	■						
PlaSynt	SW	■						
SNAMUTS	AU	■						
SOTO	NO	■						
SAL	PT	■						
MoSC	USA	■						
RIN	DE	■						
UrbCA	PT, ES	■						
EMM	DE	■						
IMaFa	ES		■	■	■	■		
ABICA	DK		■	■		■		
GraBAM	IT		■				■	
HIMMELI	FI					■		
TRACE	BE					■		
MaReSi SC	NO					■		
JAD	NL							■
ACCALC	UK /EC/ Global							■

Groupings marked in the table: Multi purpose (SNAPTA to IMaFa); Systematic trips (GraBAM, with ABICA); Shopping (HIMMELI, TRACE, MaReSi SC).

All the characteristics of each instrument have been summarized in Appendix 2 in order to clearly show the characteristics and coverage of each instrument presented in the research and their specific differences.

4.3.2. Planning Context and Usability of Accessibility Instruments

This section covers what the survey has told us about the planning context in which the accessibility instruments are designed to be used, the planning goals the instruments can address, the characteristics of the instruments, and developers' perceptions of how useful their instruments are for end users.

Planning Context

In three of the countries sampled (UK, Norway and Germany) there is a policy requirement to assess accessibility in urban planning and/ or transport planning (See Figure 4.1). Whilst in Sweden, Belgium, Spain, Greece and Denmark it is advised to use an accessibility instrument in either urban planning or transportation planning. Undertaking an accessibility assessment does not appear to be a requirement, at least in the context of Finland, Australia, Poland, Italy, Portugal, Slovenia, and the Netherlands.

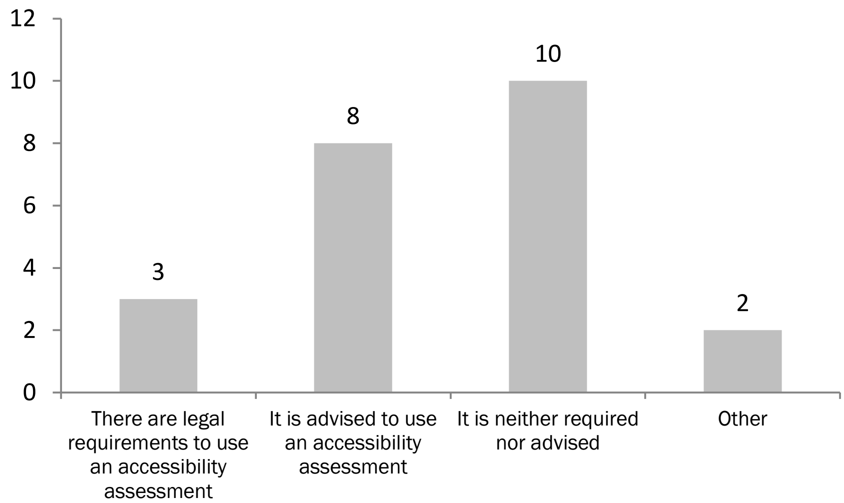


Figure 4.1 Policy requirements to undertake an accessibility analysis

Twelve of the instruments have been already used in either urban/ transport or health service planning. Five of these tools are also used in research by the tool developer. The remaining instruments are research tools which have either been developed or are in the process of development.

All the instruments are designed to be used by spatial or urban planners. In four cases these users were the only ones perceived to be potential users. Eighteen (78%) are also relevant for transport planners. Just over half (52%) of tool initiators also feel that their instruments would be appropriate for other tool initiators/ developers or researchers to use too.

Twelve tool initiators thought a range of other users would be interested in their instrument besides urban and transport planners. Of the 3 retail location instruments, two mention retailers and two mention politicians. Politicians are mentioned by 6 other tool initiators in combination with citizens/ citizens and retailers/ and health, education, and retailers. 3 other tool initiators anticipate that either health and education, or health, education, retailers and citizens could be potential users.

Planning Goals

Thirteen of the instruments only address one of the public stakeholder planning goals as shown in

Table 4.3 above. 7 instruments address multiple goals (See Table 4.9), and in 4 cases no answer was given.

Table 4.9 Instruments that address multiple public stakeholder goals

Instrument	Public Stakeholder Goals Addressed
PST	How to manage, encourage or reduce the use of a particular transport mode(s)
	Traffic and urban planning in municipalities
PlaSynt	How to manage, encourage or reduce the use of a particular transport mode(s)
	The impact of planning/ development proposals on travel habits such as route choice and mode choice, the retail potential and the potential for public space to be used
EMM	How to decide on the location of residences/ activities/ services
	How to stimulate economic development
	How to ensure reductions of emissions/ energy use
SNAMUTS	How to decide on the location of residences/ activities/ services
	How to manage, encourage or reduce the use of a particular transport mode(s)
	How to ensure social equity and/ or cohesion
	How to ensure economic equity
	How to secure speed/ cost efficiency/ potential of a particular transport mode. How to manage urban growth/ transformation/ revitalization. How to enhance stakeholders' understanding of the link between land use and transport planning, and best practice in public transport network and service design.
ASAMeD	How to decide on the location of residences/ activities/ services
	How to improve cycling and pedestrian access; how to revitalize central areas; how to achieve social sustainability or cohesive communities; how to ensure access to basic services (health, education, welfare, food, shopping); how to increase the quality and experience of travel; how to create a low energy built environment.
ATI	How to decide on the location of residences/ activities/ services;
	How to ensure economic equity;
	How to ensure social equity and/ or cohesion.
ABICA	How to decide on the location of residences/ activities/ services
	How to manage, encourage or reduce the use of a particular transport mode(s)

PST, PlaSynt and *SNAMUTS* are research tools that are already used by urban or transport planners; *EMM* and *ASAMeD* are accessibility instruments used by researchers; and *ATI* and *ABICA* are instruments "in development".

Figure 4.2 Private investor concerns addressed by the instruments

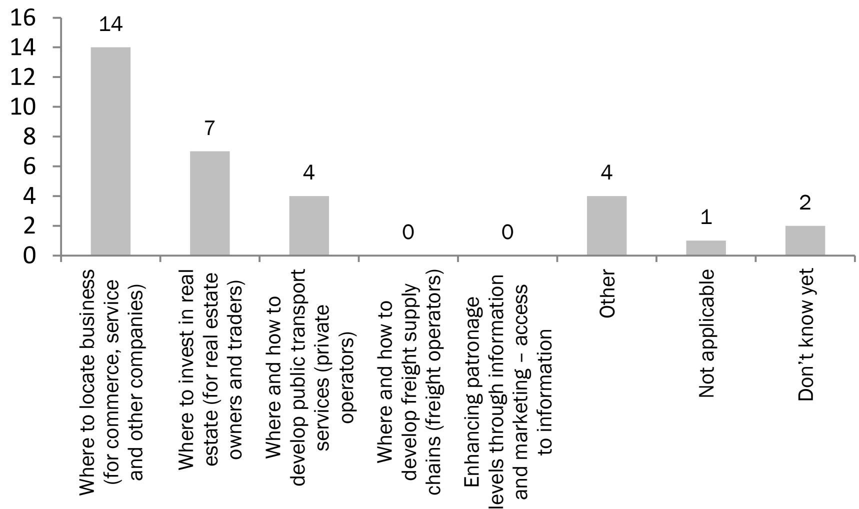


Figure 4.2 shows that nearly two-thirds (61%) of the instruments address private investors' concerns of where to locate their business. Thirteen of the instruments focus only on this and/or the issue of where to invest in real estate. *JAD* specifically addresses the private investors' goal of how to create places with high land values through transport investment.

PST and *ASAMeD* also address the public stakeholder concern of developing efficient transport services.

EMM, SNAMUTS, GDATI, and *InVio* provide information to private transport operators on where and how to develop public transport services. Except for *GDATI*, these instruments also address the issues of where to locate a business and/ or invest in real estate.

PlaSynt and *MaReSi SC* specifically focus on private sector retailers and public sector goals of managing transport. *PlaSynt* aims to identify the local market catchment area for retail and *MaReSi SC* answers the question of how large a shopping centre do we need in this location?

Figure 4.3 shows that 43% of instruments address the key issue for individuals of choosing where to live. Eight of the 10 instruments focus on this individual goal only; *EMM* also aims to support decisions on where to find the nearest activity, and *MaReSi SC* also supports decisions on where to find the nearest activity and choosing the best route to that activity.

SNAMUTS and *ASAMeD* address both how to choose the best route to a particular activity and how to choose the nearest activity. The latter specifically has the aim of "Choosing a neighbourhood/ housing area with a good choice of services available (health, education, etc), the quickest route to work, and how to get to the nearest opportunity". *TRACE* assesses how to choose the nearest retail activity.

Four instruments are able to help in the choice of the best route to a particular activity. *SNAMUTS* focuses on only district centres within the metropolitan area where there are spatial concentrations of two or more activities (employment, education, leisure, retail or health facilities). *SNAPTA* focuses on how to choose the best route to a destination by public transport and covers the activities of employment, education, leisure and health facilities. The two other instruments that enable choosing the best route to a particular activity are *MaReSi SC* and *ASAMeD.*

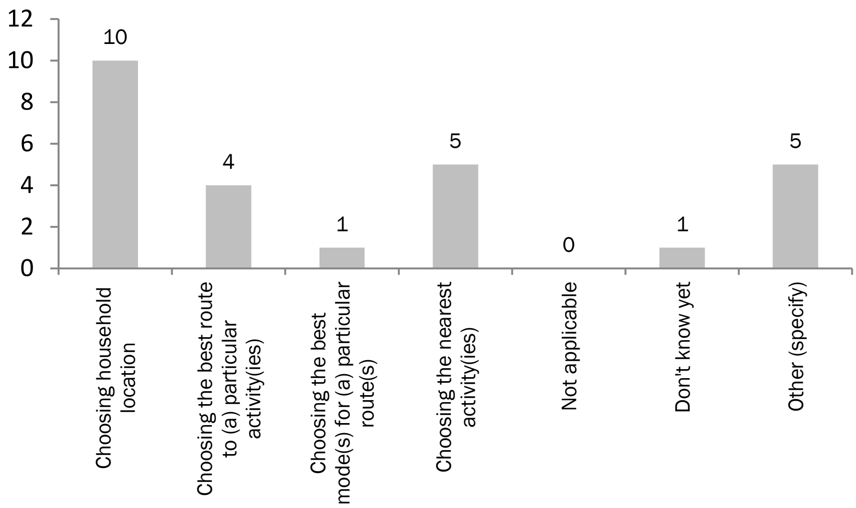


Figure 4.3 Individual goals addressed by the instruments

Accessibility Instrument Characteristics

Several questions sought information on the specific characteristics or the components of accessibility which the instruments focussed on. The transport modes and the trip purposes analysed have already been addressed in tables Table 4.7 and Table 4.8 above. This section focuses on the accessibility components, the accessibility measure traditions the instrument is attached to, how well instrument developers perceive their instrument represents reality, and what the perceived user experience is.

Only 3 instruments (13%) take into account all the accessibility components of land use, transport, temporal and individual characteristics as shown in Figure 4.4. These are *PlaSynt, ATI*, and *RIN*. The remaining instruments (87%) take into account some of the components.

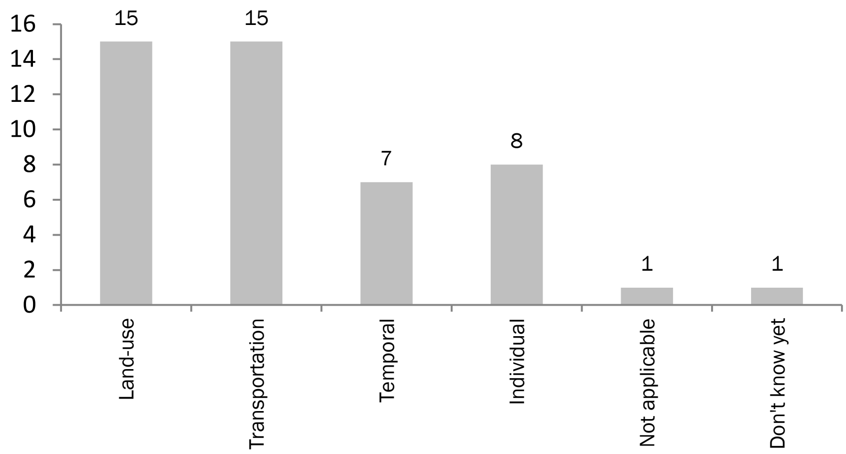


Figure 4.4 Accessibility components addressed by the instruments

There are four main accessibility measures that the instruments rely on. These are gravity-based measures, network measures, spatial separation measures and contour measures (See Figure 4.5). Ten instruments are attached to only one of these traditions; the other instruments use combinations of accessibility measures in their analysis. Table 4.9 shows a grouping of the instruments around the accessibility measure traditions.

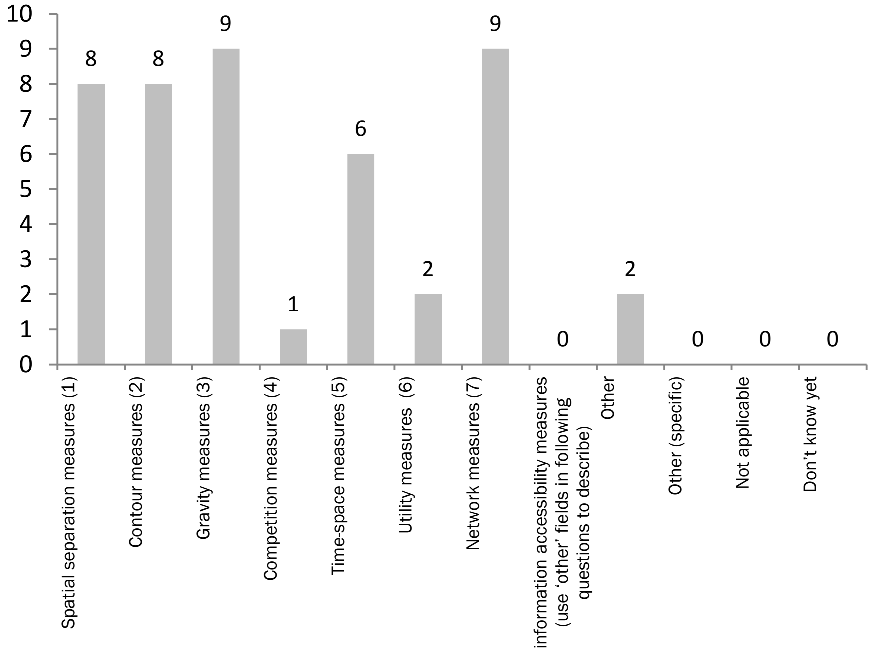


Figure 4.5 Accessibility measures used in the instruments

Table 4.10 Accessibility measures used in the instruments

Accessibility Instruments		**Accessibility measure traditions**								
Acronym	**Country**	**Spatial separation**	**Contour**	**Gravity**	**Network**	**Time-space**	**Information**	**Utility**	**Competition**	**Other**
SNAPTA	UK	X	X	X				X		
SNAMUTS	AU	X	X	X	X					
TRACE	BE	X	X			X				
IMaFa	ES	X	X		X					
ASAMeD	UK;NL;SE;BRA;CHI;SA;JA	X	X		X					
ATI	SL	X						X		
SOTO	NO	X	X							
SAL	PT	X	X							
MSC	USA	X			X		X			
GDATI	PO	X			X					
PST	SW				X					
PlaSynt	SW				X					
RIN	DE				X					
MRSC	NO			X		X			X	
EMM	DE		X	X						
HIMMELI	FI			X	X					
JAD	NL		X	X						
ABICA	DK			X		X				
GraBAM	IT			X						
UrbCA	PT, ES			X						
INVITO	IT					X				
SoSINeTi	SW					X				
ACCALC	UK /EC/ Global									X

Spatial separation/ contour measures (SNAPTA–SOTO)

Network measures (MSC–PlaSynt)

Gravity-based measures (MRSC–ACCALC)

Few of the instruments have been designed to evaluate the quality and experience of travel. Tool developers were asked to rate their instruments on this attribute on a scale of 1-7, with 7 being the highest rating The mean and median scores in Table 4.11 show that the sample accessibility instruments are relatively weak in their ability to demonstrate understanding of the quality and experience of travel.

Table 4.11 Developer's perception on a number of issues influencing usability of Accessibility Instruments

Theme	Question	Min.	Max	Mean	Median
Usability of tool in understanding the quality and experience of travel	Social evaluation	1	7	4	4.5
	Environmental evaluation	1	7	3.9	4
	Safety and security evaluation	1	7	2.5	2
	Physical skills evaluation	1	6	2.4	1
Quality, accuracy and speed of the instrument	Quality of data	3	7	5.6	6
	Quality of calculations	3	7	5.6	5
	Accuracy of the model	3	7	5.2	5
	Speed of the tool	1	7	3.9	4
Knowledge and Skill levels required by practitioners	Modelling and computational skills	1	7	4.5	4
	Spatial awareness skills	2	7	4.6	5
	Understanding policy context	1	6	3.7	4
Tool Initiators Evaluation of the Ease of Using Accessibility Instruments	Ease of collecting data	2	7	4.2	4
	Ease to play	1	7	3.8	3
	Transparency	3	7	5.4	5
	Flexibility	3	7	5.4	6
	Understandable output	4	7	5.3	5
	Visual representation	2	7	5.5	6

A number of questions explored how ‘easy to use’ the instruments would be for practitioners, Table 4.11 above shows the four categories of questions with each question rated by tool developers on a scale of 1-7, with 7 being the highest rating.. The first category focused on the quality and experience of travel. The table shows that the mean and median scores are the lowest ratings given overall for this suite of questions, with tool developers being more confident that their instrument would be able to provide evaluation of the social aspects of accessibility.

Tool developers were asked to rate the quality of the data and the calculations as well as the accuracy of the model and the speed of the instrument’s calculations. Tool developers gave slightly higher ratings for the quality of data and the quality of calculations than the accuracy and the speed of the instrument. The best performing instruments on these representations of reality were both gravity-based accessibility measures.

Tool developers rated the prior knowledge and skills required from practitioners to be able to use their instrument. Modelling and computational, and spatial awareness, skills were seen as more necessary than knowledge and understanding of the policy context

The visual representation of accessibility instruments for end users and the flexibility of the instrument in terms of the ease of changing parameters and variables are both highly rated in this sample. In both cases the median score shows that the distribution is influenced by a few low scoring instruments. Tool initiators also consider their instruments have a high level of transparency in terms of the main causal assumptions and that the output is understandable. Problems arise more from the ease of playing with the instrument and the ease of collecting the necessary data, both of which have lower ratings.

Two of the instruments described as ‘in use’ by practitioners received higher scores on the usability of instruments, as did many of the instruments classified as ‘in development’. This suggests that engagement with practitioners does lead to positive refinement of the instruments and also that the more recent tool developers are starting to address the usability of their instruments.

Institutional barriers to using Accessibility Instruments

This last section looks at some of the known barriers to using accessibility instruments. Tool developers identified a number of institutional issues that block the effective use of accessibility instruments in their country. Data availability is the most problematic issue identified, followed by separate institutions for urban and transport planning and formal government processes. The different objectives of organisations and the political commitment to implement accessibility instruments are also seen as problematic.

Table 4.12 Barriers to the use of Accessibility Instruments

Barrier	No. of responses	% of sample
Separate urban and transport planning institutions	9	39%
Formal processes	7	30%
Financial arrangements	2	9%
Data availability	11	48%
Different planning objectives and/ or assumptions	6	26%
Staff technical skills	4	17%
Political commitment	6	26%
Other	5	22%

Four respondents were not aware of any institutional issues that might create a barrier to the use of accessibility instruments. Two respondents mentioned only barriers which were not included in the question. Seven respondents identified three or more barriers. Several respondents identified additional barriers.

Table 4.13 Institutional and other issues that might block the effective use of accessibility instruments

Instrument	Barriers
SNAPTA	Resources including time available to planning agencies to engage in such deliberation; Sometimes - timely and consistent data availability
TRACE	Data availability, tool in development
SAL	The instrument considers several activities (any you want but this does not mean it does so in an aggregate manner)
MaReSi SC	Black-boxing and competing analyses (non-transparent, non-understandable, incomprehensible assumption etc) from the initiators' consultants
ACCALC	Most money in transport planning is linked to the delivery of a project not to the analysis of problems for users so there will always be relatively more analysis to make the case for than to understand the accessibility needs of people
IMaFa	Not easy to elaborate and high cost instrument
SoSiNeTi	Long term data, post evaluation data

4.3.3. Cross-analysis

In this cross-analysis questions from three survey sections – *Planning Context* (Q 1.1-1.4), *Planning Goals* (Q 2.1-2.3), and *Characteristics of the Instrument* (Q 3.1-3.12) – were tested against evaluative answers of *End-users and how they use the tool* (Q 4.1-4.9).

It was clear from the very beginning, that the survey composed as the first stage of the Action will contain inconsistencies in terminology and it became clear in the analysis of the survey that the respondents from different backgrounds bring natural uncertainties, fluctuation and mismatch to their answers. Therefore at this stage it is not feasible to try a comprehensive cross analysis, but instead to seek to find some preliminary main characteristics of the instruments.

A systematic check was made for clusters of answers in each question according to the most obviously recognised components and mapped against Qs 4.2, 4.4 and 4.5. For each class the mean values of the answers have been calculated and histogram have been defined, in order to understand if any relation exists between the Accessibility Instruments and the usage potential of the tool. For most of the analyses no significant relations have been found.

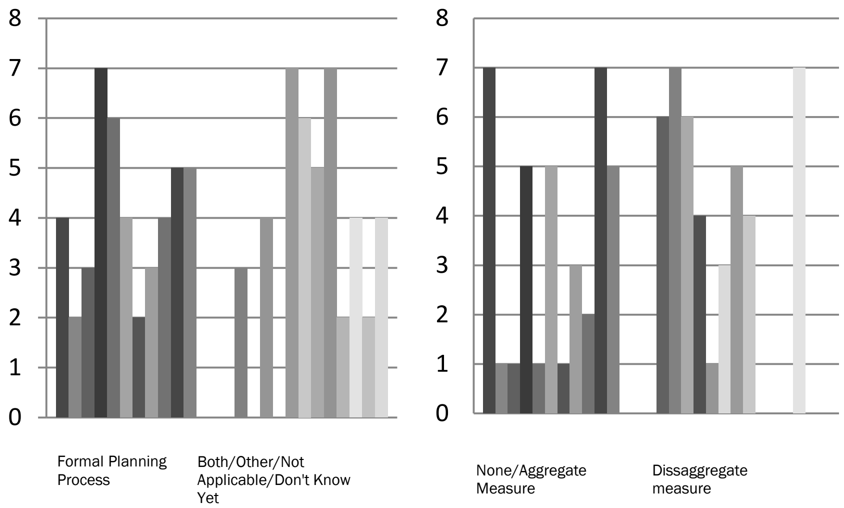


Figure 4.6 Cross-analysis of selected questions

Typical histograms of cross analyses in Figure 4.6 above show the variation in answers that make further explanation using cluster analysis difficult. So far the best candidate for providing a common explanatory factor for the end-use characteristics was found from the group of questions concerning the aggregation/disaggregation level of data (Q3.4-3.6).

Some tentative results can be seen through a single analysis. Questions in section 3.4 required respondents to identify the level(s) of spatial aggregation in their instrument. Detailed sub questions were divided in four and included aggregation by area units (administrative unit level), local level spatial enclaves (plot level), networks (street segment level) and social grouping (individual group level). Of these the last three contain a description of disaggregated spatial entities in models, which might give a hint of the complexity of the operation procedure. This was used as a clustering principle that is easily recognized. Five instruments [13] are based solely on aggregated data and four instruments [14] use only a single type of disaggregated data. The remaining twelve instruments [15] were ones containing multiple disaggregate data sources.

[13] SoSINeTi, ABICA, GraBAM, SOTO, SNAMUTS

[14] MoSC, ATI, IMaFa, SNAPTA

[15] UrbCA, RIN, IN.VI.TO, JAD, SAL, ASAMeD, MaReSi SC, TRACE, GDATI, HIMMELI, PST; PlaSynt

Table 4.14 Grouping by spatial aggregation and the difference between three instrument groups

3.4 Identify the level(s) of spatial aggregation of data used in the instrument.	. Ease of collecting data	ease to play with instrument	transparency of main causal assumptions	flexibility of instrument (ease of changing parameters and variables)	understandable output	visually representation	Please rate the knowledge and skills required to use the tool in terms of: modellingcomputational skills	spatial awareness skills	understanding policy context	usability in environmental evaluation	usability in safety and security evaluation	usability for physical skills evaluation
	Q 4.2						Q 4.4			Q 4.5		
	A	B	C	D	E	F	A	B	C	B	C	D
Only aggregate data (N=6); MEAN	2,333	2,333	3,667	3,833	3,667	2,833	3,000	2,667	1,500	1,500	0,833	1,000
One disaggregate source (N=4); MEAN	4,750	2,750	5,500	5,500	5,750	6,500	5,250	4,000	2,000	4,000	3,500	2,750
Multiple disaggregate data source (N=12); MEAN	4,308	4,154	5,308	5,308	5,154	5,538	4,231	4,923	4,308	4,077	2,154	2,154
Difference: row1 | row2	-2,417	-0,417	-1,833	-1,667	-2,083	-3,667	-2,250	-1,333	-0,500	-2,500	-2,667	-1,750
Difference: row1 | row3	-1,974	-1,821	-1,641	-1,474	-1,487	-2,705	-1,231	-2,256	-2,808	-2,577	-1,321	-1,154
Difference: row2 | row3	0,442	-1,404	0,192	0,192	0,596	0,962	1,019	-0,923	-2,308	-0,077	1,346	0,596

Although it is obvious that the visual representation benefits from detailed data collection in the same way as the applicability of the instrument for social-economic evaluation is correlated with the level of the socioeconomic disaggregation of the data, it appears that it also has the effect of wider usage and operation of the instrument. Even though the sample sizes are small and the objectivity of respondents can be further debated, it is probably not too much to say that the level of aggregation/disaggregation divides instruments into two major categories that also have very different usage potentials.

Figure 4.7 Images showing two extreme principles of accessibility instruments: zonal aggregation vs. detailed morphology

4.4 Conclusions

This conclusion summarises the main findings of the questionnaire survey and draws out some salient points that will be reflected on in Section 5 of this report.

We have heterogeneity evident in the accessibility instruments in this COST Action. This may reflect the diversity of the urban planning contexts across Europe and the different institutional contexts for urban planning such as the legal underpinnings, responsibilities and the spatial levels at which urban planning governance takes place. The instruments in this Action focus essentially on the needs of spatial/ urban planners (27%) and transport planners (24%) for data on accessibility.

In particular, the instruments are intended to support the following urban planning tasks:

1. The integration of urban planning perspectives (27%).
2. Strategy/ option generation (25%).
3. Strategy/ option selection (23%).
4. Create new insights (16%).
5. Justify decisions/ positions already taken (10%).

Few instruments are able to understand the quality and experience of travel.

An accessibility analysis is required in 3 EU member states for some aspects of urban and transport planning. The survey confirms that the instruments developed in these countries tend to have a higher level of transparency of the main causal assumptions, since they have been used by practitioner and other stakeholders. The visual representation of the findings is also more developed in these instruments. Where there is a legal requirement, the instruments focus more on aspects of a liveable, sustainable community/ settlement, than the other instruments.

The survey suggests that in another four member states it is advised to undertake accessibility assessments and in the remaining countries in this Action, it does not yet appear to be supported. Respondents drew attention to a number of barriers to using accessibility instruments in their country. These included data availability (mentioned by 48% of respondents), separate urban and transport planning institutions (39%), formal processes (30%), different planning objectives/ assumptions (26%), and political commitment (26%). Five respondents mentioned other barriers too.

Despite the diversity of instruments and their purposes, the Tables in this section have started to cluster and categorize the instruments based on the questionnaire responses. Clustering has been analyzed for the issues of geographic scale (Table 4.2), public sector planning goals (

Table 4.3), decision support task (Table 4.5), role in urban planning (Table 4.6), transport modes used in the instruments (Table 4.7), trip purposes (Table 4.8), and accessibility measure traditions (Table 4.10).

Tool developers were asked to rate how user-friendly their instruments were on a number of dimensions. Generally higher ratings were given for the quality of the data used, the quality of the instrument calculations, the visual representation of outputs and the flexibility of the instrument in terms of changing parameters. Lower ratings were generally given for the speed and accuracy of the instrument, the ease of playing with the instrument and the ease of collecting data by end –users. However, some instruments “in development” were given higher ratings on these aspects by their tool developers.

Chapter 5. CONCLUSIONS

Angela Hull, Luca Bertolini, Cecilia Silva

5.1 Introduction

This Action seeks to find out why Accessibility Instruments are not more often used in urban planning practice and how to improve this. Accessibility Instruments have been around since the 1960s but practitioners do not appear to have found them useful or usable enough for addressing the tasks of sustainable urban management.

This Action has brought together the developers of 24 Accessibility Instruments to work with land use and transport planning practitioners to explore how these instruments can play a more supportive role in enhancing accessibility in European cities and beyond.

This report has sought to understand in detail the characteristics and specific purposes of these instruments. Chapter 1 and Chapter 2 of this report summarize the types of Accessibility Instruments discussed in the literature and provides an overview of how these are used in practice. Chapter 3 presents 22 [16] of the instruments brought together for this Action in some detail covering the purpose or planning issues addressed, the definition and measurement of accessibility, the perceived relevance for urban planning, and the instrument's strengths and weaknesses.

Chapter 4 provides a cross-analysis of 23 of the instruments using the findings of a questionnaire survey completed by their developers. This sought to attempt a systematic categorization of the instruments in terms of the planning purpose or goal they address, the measurement of accessibility, the spatial aggregation of the data, the perceived representation of reality and the ease of use by practitioners/end users.

This final chapter 5 draws on the concluding comments of the chapter authors to highlight the many different ways in which accessibility is considered in transportation research and urban planning practice, the salient features of the specific collection of accessibility instruments discussed here, and the implications for the next stages of this Action. The chapter first summarizes the traditions of accessibility instruments in the urban geography and transportation literatures and then moves on to examine the research on the practical value of these instruments in urban planning practice. It then focuses on the potential for use in planning practice of the instruments in this Action and highlights some of the issues which will have to be addressed by the instrument developers to ensure their usability in the complex transport planning, land use planning and private development decision making environment.

5.2 Traditions in planning and transport evaluation

The literature review on accessibility demonstrated that authors defined accessibility in terms of both the components and the indicators of accessibility. These definitions tend to encompass some of the following:

- People's preferences and choice sets, including the timing of travel;

[16] Two of the instruments brought together for this COST Action only participated in the survey detailed in Chapter 4.

- Land use in terms of existing opportunities (location of housing, jobs, and other activities); and
- Transport provision, including the degree and intensity, by mode between origins and destinations.

The review found that some accessibility instruments focus on people or origins, some on opportunities, and some on the connection. The review suggests that instrument developers and users have taken quite a pragmatic approach to defining the measurement of accessibility including balancing the importance of detailed representation of reality against the speed and ease of using the instrument. Various proxy and aggregate measures have been used to represent people's preferences, the representation of origins and destinations or the spatial separation between land uses, and for assessing the benefits of increasing the degree and intensity of transport provision.

The population has often been regarded as homogenous with similar preferences according to the location of their residence, possibly with some distinction in terms of workers/ non-workers. Rarely has the characteristics of the population been disaggregated to gender, age, physical condition, family responsibilities, and type of job. This blindness to heterogeneity in people's preferences and choice sets also extends to the selective representation of the attractiveness of land uses/ facilities and the representation of the transport system.

This selectivity in representing reality has been influenced by the instrument developers' interests in scientific research, government policy requirements, and the available computer power and datasets. The criteria, in many countries, for gaining access to public sector funds for major infrastructure projects has also skewed the focus of the instruments developed. In particular, a requirement to demonstrate time savings benefits, as a proxy for welfare benefits, of new transport infrastructure has encouraged the development of instruments that focus on calculating/predicting the time required to reach desired destinations. Speed and mobility have been considered the cornerstones of economic competitiveness and personal freedom and, therefore, perceived as the appropriate indicators for assessing welfare benefits in the cost benefit models used in evaluating the relative value of transport projects.

The initial focus on car travel has expanded to analysing travel times by public transport modes often in comparison with private motorized vehicles. The rapid increase in computing power and the availability of a wide range of electronic data sets allowed the much more flexible use of GIS software packages to replace the complex land use transportation models. In addition to estimating travel time savings from new infrastructure, these packages lend themselves to road and/or public transport journey planning .

Retail and other service planners have been using accessibility instruments to plan service provision for their customers or residents to enable/improve access to facilities based on an analysis of the potential customers in the local population surrounding their proposed/actual facilities and the existing transportation system. This function of accessibility usually incorporates some normative benchmark setting of how long the journey should be to reach the type of facility and is displayed using contour or catchment indicators. Some instruments focus on the public transport accessibility to facilities and more recently instruments have been developed to analyse the walk times to public transport services and to local facilities. These instruments have proved useful both to the providers of public services (schools, hospitals, etc.) and commercial facilities (retail, etc.).

The focus of these early instruments has, thus, been mainly on the accessibility characteristics of transport networks in terms of travel speeds to certain destinations – a narrow transport planning focus. Transport planning has provided for accessibility through improved mobility using economic assessments of the overall costs and benefits of public sector infrastructure investment.

This focus on mobility may help to explain the limited use of accessibility instruments by land use practitioners since these measures and indicators are too simple and say little about proximity to be of use in analysing the more complex interactions between land use change, transport provision, and individual preferences.

0 concluded by identifying the gaps in the focus of accessibility instruments referred to in the literature:

- Walking and cycling modes were under-represented in the instruments as was the representation of the different walk access speeds by the type of area and the physical condition of population groups. This would introduce deeper analysis of different walk/cycling access thresholds (time or distance) to destinations taking into account the physical obstructions along the journey;
- Public transport accessibility analysis should consider mode choice by including all public transport networks (i.e. bus, tram, rail, underground, ferry, air, etc.) in the modelled area rather than the bus network only. The interchange options between these public transport services should be considered based on minimum accepted times/ number of interchanges required and the best route (fastest, cheapest, shortest);
- The temporal component of accessibility should be improved by including real time updates due to traffic congestion, roadwork or delay and the analysis should be widened beyond the morning rush hour peak times;
- People's preferences should be analysed more carefully to understand the accessibility needs of different population groups (physically impaired, passengers with luggage/ wheelchair/ pushchair). Passengers' perceptions of safety and security on different modes and different routes should also be included;
- Accessibility analysis should consider the quality and environment of the journey including opportunities for shelter from weather and for rest points; comfort of waiting areas and vehicles; attractiveness and aesthetics of walking routes; support services when travelling (e.g. catering); and assistance and helpfulness of public transport staff;
- Accessibility analysis should give an indication of the environmental impact of the route choice, for example emissions resulting from the journey;

- Accessibility instruments need to be developed so that they are able to identify feedback mechanisms or changes in demand and in land-use patterns that might result from an improvement – or deterioration – in accessibility in an area.

5.3 The Use of Accessibility Instruments in Urban Planning Practice

0 aimed to present evidence of the usability of accessibility instruments for urban planning tasks. In particular, it set out to find out how Accessibility Instruments have been used to identify how to make places more liveable and identify the opportunities available to people when planning new facilities or destinations.

The literature review in Chapter 2 focussing on the usability of Accessibility Instruments found that simple measures of accessibility have been used in urban planning practice to audit, monitor or set standards for planning policies, such as parking policy standards based on accessibility criteria or public transport service delivery requirements based on people's accessibility needs. However, these accessibility measures were unable to understand and quantify the complex nature of people's preferences and choice sets and the real barriers to individuals' accessibility.

It is also unclear whether Accessibility Instruments currently available can support the planning task of assessing the appropriateness of locations for residential or commercial development through identifying whether a proposed location will result in, on average, increasing or decreasing travel distances and times, compared to alternative locations. Alternatively, land use planners may require Accessibility Instruments that support policy decisions on compactness and proximity already agreed by their political masters by demonstrating that development on the urban fringe will result in poorer accessibility to facilities, and more time/ energy/ greenhouse gas emissions spent in traveling to relevant destinations than one in the inner city.

Chapter 2 concludes that little research has been carried out on the practical value and usefulness of Accessibility Instruments. Curl *et al.*'s (2011) research in the UK found that accessibility measures are too complex, abstract and hard to comprehend and interpret for non-modellers, including planners. Research with transport planning practitioners on the usability of transport models in the UK (Hull, 2010) and in the Netherlands (te Brömmelstroet, 2010) confirm these weaknesses and identified several other weaknesses with existing tools. These include inadequately supporting the generation and testing of new strategies and projects, and not providing insights into land use and transport dynamics.

Chapter 2concludes by setting a research agenda on how to arrive at useful accessibility measures and indicators that will cover the relevant dimensions of planning problems. The measures need to represent urban dynamics accurately enough whilst being understandable and interpretable for all involved stakeholders (urban, transport, and environmental planners, commercial developers, politicians). Providing this common language requires:

- More transparency in the data aggregation methods;
- Collaboration with practitioners/ end users to ensure that accessibility measures provide enough input and stimulation;
- Ensure the instruments are not skewed by the priorities of individual interests but serve existing and emerging public welfare needs e.g. the reduction of greenhouse gases from the transport sector;
- Understanding the different planning contexts and the interaction between the different spatial levels of planning from the household, neighbourhood level, metropolitan area, region to the national level in order to understand the relationship between accessibility and associated outcomes, and therefore target interventions appropriately.

5.4 State of practice on the design of accessibility-based planning instruments

The Accessibility Instruments collected by this COST Action represent a new tranche of instruments which will be tested with urban planning practitioners to assess and improve their usability. Chapter 3 of this Report presented details about each of the instruments covering their purpose and/or the planning issues addressed, the definition and measurement of accessibility, the perceived relevance for urban planning, and the instrument's strengths and weaknesses.

An extensive comparative assessment of the instruments along the different dimensions of the individual reports is reported at the end of Chapter 3. The main findings are summarized below.

The main motivation to develop an accessibility instrument can be roughly divided in three categories: policy and planning support, scientific enquiry, or a combination of the two. Within the instruments primarily motivated by a policy and planning support aim, two further groups can be identified. A first group is primarily directed at supporting policy development and delivery in a multi-disciplinary (both transport and land use) and multi-stakeholder (including different levels of expertise) context. A second group rather aims to develop tools for the assessment of land use and/or transport development proposals and/or service provision. On the other extreme of the spectrum are instruments that are primarily motivated by scientific enquiry, even though the potential relevance for planning is also envisaged, as it might be expected from participants in this COST action. A middle category is rather motivated by the wish to innovatively apply in planning practice insights already fairly consolidated in the scientific domain.

The ease or difficulty in reaching different activities dominates among the instruments as a conceptual definition of accessibility. What kind of activities or services are included in measurements however, varies. The theoretical underpinnings vary from geography to architecture. Most of the activity related instruments utilise gravity based accessibility measures and are thus related to the modelling tradition of urban geography. Instruments that emphasise the spatial and structural properties of urban environments mostly refer to the ‘space syntax school’ which has its origins in architecture and urban morphology. Instruments that are part of larger model structures are related to different traditions of modelling theories like systems theory, complexity theory and the theory of cellular automata. Some instruments like refer to space-time geography or information visualisation.

With respect to operational aspects, most instruments deal with aggregated measures of accessibility, by either considering a network distance (despite the mode) or the different modes together. The techniques for computing accessibility, when mentioned, vary from spatial syntax and gravity models, to activity based, social based approaches and clustering. Part of the instruments deal with the impact of land-use changes, some instruments deal with accessibility to shops, while few deal with the accessibility to other facilities. In general, data needed is transportation info (maps, origin-destination matrices, times/costs) and population data. Most of the authors mention that the info they need is available on the web or is provided by planning/local authorities. Only a few authors mention that data must be purchased. The time for applying the instruments depend on the type of tool used and the size of the case study, but most of the authors mention the duration of hours or days. Several instruments are based on GIS software, some use data management software, and only a few authors mention that they used (or developed) open source tools. The level of expertise need to use the instruments also vary between instruments – most authors mention that no specific expertise is needed for interpretation of the results, but they are divided as to whether this is the case for use of the instrument. A high level of expertise seems needed in all cases for preparing the data. .

There are also similarities and differences in the ways the reviewed instruments see their role with respect to supporting planning practice: some are intended as tools to aid calculation, some are rather repeatable analytical methods using existing and widely available tools like GIS systems, and yet others are expert systems to help define and answer problems.

Finally, the accessibility instruments show a variety of visualization forms. Sometimes the output of accessibility tools can be numerical and listed in tables, matrix or datasheets, without offering any kind of visual outcome. But the latter can be needed for some users to make sense of accessibility which can otherwise be treated as a ‘slippery’ concept and not trusted by decision makers. Most of accessibility tools generates a visual product, generally represented by bi-dimensional maps. Main categories include: 2D areal aggregation(data are grouped in macro-zones and classified on the basis of a colour scale); 2D axis-based maps (data are defined by the road network or by lines connecting points); 2D point-based maps (data are represented by points on 2D maps); 3D images (maps with a third, z-axis). In determining the required visualization approach it seems necessary to first understand the intended audience and what the planner hoped they will do when they see the visualization. Among the accessibility tools presented in this report, the purposes of visualizations mostly focus on data explanation to high and medium-level experts, with map-based knowledge. All the visual outputs, both concerning policy support and scientific enquiry, provide representations which distil complex concepts into relatively simple maps and graphs helping planners to understand spatial dimensions of key accessibility statistics.

5.5 Accessibility Instrument Survey

Chapter 4 presented the main results of the Accessibility Instrument Survey (AIS), collecting basic information on 23 [17] of the accessibility instruments reviewed in this work. The aim of the survey was to enable quick, objective and comparable overviews of each of the reviewed accessibility instruments for systematic comparison purposes. The summary sheets produced for each instrument are presented in Appendix B.

Chapter 4 discusses the survey findings in three broad areas:

- The operationalization or treatment of the different components of accessibility and the data requirements;
- The planning problem or policy goal addressed, and the context within which the instrument is being deployed, and;
- The interpretability and communicability of the findings.

The 23 Accessibility Instruments are quite diverse in terms of focus on the components of accessibility, the aggregation/ disaggregation of data, the policy goal addressed, the transparency of the calculations, and the visual representation of findings. They focus essentially on the needs of spatial/ urban planners (27%) and transport planners (24%) and aim to support the following urban planning tasks:

1. The integration of urban planning perspectives (27%).
2. Strategy/ option generation (25%).
3. Strategy/ option selection (23%).
4. Create new insights (16%).
5. Justify decisions/ positions already taken (10%).

Few instruments are able to understand the quality and experience of travel.

Since this Action concerns the usefulness of Accessibility Instruments in planning practice tool developers were asked to rate how user-friendly their instruments were on a number of dimensions. Generally higher ratings were given for the quality of the data used, the quality of the instrument calculations, the visual representation of outputs and the flexibility of the instrument in terms of changing parameters. Lower ratings were generally given for the speed and accuracy of the instrument, the ease of interactively playing with the instrument and the ease of collecting data by end –users. However, some instruments “in development” were given higher ratings on these aspects by their developers.

Several barriers to using accessibility instruments were identified by survey respondents in their country. These included data availability (mentioned by 48% of respondents), separate urban and transport planning institutions (39%), formal processes (30%), different planning objectives/ assumptions (26%), and political commitment (26%).

[17] One of the accessibility instruments brought together by this action did not participate in the survey conducted for Chapter 4.

5.6 Concluding Remarks and next steps in this COST Action

This report started off with the promise of a new approach to measuring accessibility, moving from the widely shared expectation that the concept of accessibility could play an integrative force to bring land use and transport planners working collaboratively in managing urban change in a sustainable way.

The report has shown that there are new approaches in accessibility which include, for instance, applications in the following areas:

- Public transport planning;
- Network design for non-motorized modes (walking, cycling);
- Land-use planning / location choice;
- Social inclusion and basic service provision;
- Information planning;
- GIS: increasing detail/ visualization;
- Distributional justice/ extent of spatial (in) equity;
- Travel data collection: Smartphones, etc.

The review of the state of practice of accessibility instruments and of their use in planning practice produced by this report (Chapter 1 and Chapter 2), together with the accessibility instruments here presented and compared (Chapter 3 and Chapter 4), provides the baseline for the future European-wide assessment of the usability of accessibility instruments in planning practice to be developed in the next steps of the COST Action, also including an Australian assessment case. This assessment will bring together local planning practitioners, the accessibility instruments reviewed here and their developer's, across different planning or decision making contexts aiming to further contribute to a new approach to measuring accessibility and to bridging the implementation gap of accessibility instruments in planning practice. It will shed further light on the debate reviewed by Chapter 1 and Chapter 2 (as summarised in section 5.2 and 5.3) which shows somehow contradicting concerns in research focussed on the development of accessibility instrument and in the research focussed on the implementation of accessibility-based design support systems in planning practice. While the gaps identified in the first research stream point towards increasing complexity and thoroughness of accessibility instruments, the second research stream highlights the importance of simple, usable and understandable instruments for planning practice. This 'rigour-relevance dilemma' (Bertolini *et al.* 2005) will be further discussed throughout the upcoming local workshops across several European and Australian cities.

Taking a closer look at the accessibility instruments participating in this research, diversity of background, contexts, concerns and purposes comes out as both a challenge and an advantage.

The variety of motivations for developing the instruments seems both a challenge and an asset for the COST Action. It is a challenge because it demands establishing a common language and sense of direction between researchers coming from different backgrounds and having different primary motivations. It is an asset because it gives the Action a rich variety of expertise spanning the scientific and policy domains.

On the conceptual, theoretical and operational side, the compatibility of different perspectives can also be a major challenge for the Action but it also provides unique opportunities. For instance, different transport modes and opportunities are focused upon by the authors. Furthermore, some authors focus on urban-level accessibility, while others focus on neighboorhood-level accessibility or interregional-level accessibility. Ways of merging modes, opportunities and scales, for instance by jointly using more than one instrument can be explored as part of the Action.

Most authors present instruments that deal with accessibility in a static fashion, i.e. they try to get the picture for a given scenario (in the past, present or future), but a few authors mention that their instruments focus on measuring the impacts on time of land use changes and impacts of infrastructure investments. The Action may explore these different approaches, trying to understand how they can differently be used by planners and, if they provide different answers, for which uses and which approaches can be better.

Also differences in views of how to support planning practice can be the basis of a 'contingency approach' to using accessibility instruments. Where there are clear policies defined for accessibility, then 'calculation aid' tools have an application since they can be optimized to implement the policy and make calculation easier. Where accessibility analysis contributes to another policy goal like transport or land use planning then repeatable analytical methods can be most useful. Accessibility can be a difficult concept so both of the above can use expert systems to guide people through the process of data collection, analysis, policy formulation and planning.

A key strength seems the ability of the instrument to link (1) some information on transportation networks, land uses and the urban fabric, to (2) their impact on location and mobility behaviour and therefore (3) implications for the achievement of policy goals ranging from economic development, to social equity and environmental preservation. In the view of the instrument developers, accessibility, in its various forms, is a key indicator of the performance of the built environment. This notion should be also central in communication with intended users.

A second key strength cited by many is the straightforwardness, ease of interpretation and communicative power of the indicators, often in map form. These last claims, however, are not always supported by actual applications in planning practice, or by applications going beyond a pilot study. Accordingly, several authors also cite the need to embark in practice applications and to learn through them how usable the instruments actually are, and how to improve usability. This provides, of course, a clear focus for the next steps of this Action.

Requirements in terms of data availability, calculation time and technical expertise are also often cited as limitations and areas of improvement. These limitations will now be tested in practice producing comparable assessments and enabling a better view of what characteristics make an accessibility instrument more or less data consuming, time consuming or demanding on technical expertise, and this from the point of view of planning practitioners.

Other areas of improvement mentioned concern, perhaps somewhat contradictorily with the previous one, the need to extend the range of inputs (e.g. more transportation modes, more qualitative urban morphology features) and outputs (e.g. more impacts), or to increase the realism of the underlying behavioural assumptions (e.g. by including distance decay and competitions effects, or transport-land use feedback mechanisms). Other authors, however, point to the fact that models are by definition limited in their realism, and that the aim should rather be to ensure that the accessibility instrument is transparent in its assumptions and logic, and easy to use. The rigor-relevance dilemma referred here sums up this conundrum and points to a key area of discussion and exploration for the following phases of the Action.

The work developed so far and compiled in this report has set the scene for the upcoming local workshops were local practitioners will now have the main role in assessing usability of accessibility instruments in planning practice. These workshops will be developed in different European and Australian cities to solve different planning problems resorting to different accessibility instruments. Comparability of results is thus a baseline issue for these workshops, and has been tackled through a common workshop methodology developed in the COST Action (in Working Group 3). This asset will allow comparability throughout all the variability making challenges into added value. Transferability of workshop methodology to all local contexts and accessibility instruments will be guaranteed through testing and joint improvement of the methodology in two Pilot workshops. Once consolidated, the methodology will be applied to discuss the main questions arising from the review presented here and to raise new questions and awareness on usability of accessibility instruments in planning practice.

The following questions provide a summary outlook into the main questions pursued in the upcoming workshop assessment with local planning practitioners:

- Do the instruments reflect planning needs in terms of their understanding of political goals and planning issues?
- Do the instruments represent transport behaviour and activity choices made within the context of the distribution, and attractiveness, of opportunities in specific cities?
- Have the instruments balanced the need for data requirements versus the need for comprehensiveness so that they are easy to use by end-users?
- Have the instruments configured the interface with end-users so that instrument parameters can be altered and the visualization of findings is easy to understand?

Results produced by the local workshops are expected to provide important contributions to the debate on the general usefulness and usability of accessibility instruments in planning practice. One of the main outcomes of this research will be the development of recommendations for the development of the practice of accessibility instruments (intended for planning practice) incorporating concerns of potential users (planning practitioners). This will require balancing the rigour-relevance dilemma identified before. At the strategic level this Action aims to achieve increased implementation of accessibility-based planning support tools in practice.

Glossary

Enrica Papa, Gennaro Angiello

The Glossary of the Action "Accessibility Instrument for Planning Practice" was born in order to create a common platform where to share a common language/understanding between all the participants of the Cost Action. All members were involved in the choice of the terms to define and their meanings in a collaborating way. A first version of the glossary was proposed in the first stage of the work of the Action, in order to better explain the accessibility survey and it was published in the action website during the first year of work. The published glossary received several comments by the action members suggesting to add, to eliminate or to modify some terms, as detailed in the appendix. The work here presented is a result of this first phase of work and do not consist into a final product, but into a first step of a continuous process.

Accessibility

is a concept expressing the relationship between the activity system located in a region and the transportation system serving it (Cascetta, 2012).

Accessibility evolution definition

"the opportunity which an individual or type of person at given location possesses to take part in a particular activity or set of activities" Hansen (1959)

"the accessibility of a point in a system is a function of its location in space with respect to all other points in the system" and "implies relative nearness either in the sense of a direct linkage or a minimum expenditure of travel cost or time" Hack (1976) and de Lannoy (1978)

"the average opportunity which the residents of the area possess to take part in a particular activity or set of activities" Wachs and Kumagai (1972)

"the consumer surplus, or net benefit, that people achieve from using the transport and land-use system" Leonardi (1978)

"the ease and convenience of access to spatially distributed opportunities with a choice of travel" U.S. Department of Environment (1996)

Accessibility instrument

A tool that aims to provide explicit knowledge on accessibility to actors in the planning domain, a tool of measure, interpretation and modelling of accessibility developed to support planning practice (analysis, design support, evaluation, monitoring etc.). Mostly, they consist of computer model(s) that transfers data/information about urban systems into meaningful knowledge, by providing visualization tools such as maps or numerical indicators.

"Accessibility Instruments can be:

1. Measuring attributes of places or people – e.g. planning tools to identify how to make places more liveable or ways of identifying the opportunities available to people when planning new facilities or destinations;
2. Analytical methods to apply accessibility principles within planning – e.g., parking policy standards based on accessibility criteria or public transport service delivery requirements based on people's accessibility needs;

3. Models to understand dynamic effects and connectedness in transport networks, in particular the dynamics between spatial plans and transport investments;
4. Indicator calculation methods where indicators are used to audit, monitor or set standards for planning policies (e.g. travel time indicators)".

Accessibility Measure

are used to translate the concept of accessibility in quantitative indicators that take into account both the socio-economical and the transportation systems. Each accessibility measure has a general conception and a general formulation of its accessibility indicator (distance measures, contour measures, potential measures, gravity measure. inverse balancing factors, utility-based measures, etc.)

Table A classification on accessibility measure (proposed by Cascetta, 2012)

		Approach	
		Non Behavioral approach:	**Behavioral approach**
Type of measure	Utility-based measures	Random Utility models (Trip-based measure or Activity-based measure)	Gravity models
	Opportunity-based	Isochrones	Perceived opportunity models

Component of accessibility

Opportunity component (of accessibility) – dealing with the (qualities of the) desired goods, services, activities and destinations (together called opportunities) as objects to the study of accessibility.

Perceptional component (of accessibility) – dealing with the perception (by an individual/people) of other components of accessibility; concerning individual subjective measures of availability and attraction of opportunities.

Individual component (of accessibility) – The needs, abilities (depending on people's physical condition, availability of travel modes, etc.) and opportunities (depending on people's income, travel budget, educational level, etc.) of individuals.

Land use component (of accessibility) – The land-use system, consisting of the amount, quality and spatial distribution of identifiable opportunities.

Temporal component (of accessibility) – The availability of opportunities at different times of the day, and the time available for individuals to participate in certain activities.

Transportation component (of accessibility) – The transport system, expressed as the disutility for an individual to cover the distance between an origin and a destination using a transport mode.

Contour measures

Defines catchment areas by drawing one or more travel time contours around a node, and measures the number of opportunities within each contour (jobs, employees, customers, etc) (C. Curtis, J. Scheurer 2010).

Decision Support System (DSS)

A computer-based information system that supports decision-making activities. DSS serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance.

Network measures

A group of measure based on graph theory and network analysis that correlate accessibility with topological measures of the transportation network. In some case this measures can include also opportunity components.

Planning

Planning, as a general activity is the making of an orderly sequence of action that will lead to the achievement of a stated goal or goals" (Peter Hall, Urban and Regional Planning, 4th edition)

"The specification of a proposed future coupled with systematic intervention and/or regulations in order to achieve that future [...] a control parameter – something which can have a profound influence on the future which comes to pass". Byrne (2003:174)

Planning Support Systems (PSS)

PSS is a subset of geoinformation-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, etc) that collectively support all of, or some part of, a unique planning task (Geertman and Stillwell; 2003).

Potential measures

Are based on the concept of attraction and impedence. These measures assumes that accessibility of a region is proportional to the attractiveness of destinations surrounding(e.g. , the distribution of population, employment, income, etc) and inversely proportional to the spatial impedance of travel required to reach those destinations (e.g. travel time, distance, generalised cost etc.).

Spatial separation measures

Measures travel impediment or resistance between origin and destination, or between nodes. Travel impediment measures can include: Physical (Euclidean) distance Network distance (by mode) Travel time (by mode) Travel time (by network status—congestion, free-flow, etc.) Travel cost (variable user cost or total social cost) Service quality (e.g. public transport frequency) (C. Curtis, J. Scheurer, 2010).

Statutory planning

The part of the planning process that is concerned with the regulation and management of changes to land use and development. (Source: Wikipedia)

Time-space measures

Measures travel opportunities within pre-defined time constraints. (C. Curtis, J. Scheurer 2010)

Urban Simulation

Use of a wide range of modeling concepts to capture and reproduce any type of physical or socioeconomic phenomena observed in urban systems, allowing the forecast of potential evolutions under controlled conditions to assist planning or decision-making processes in general.

Usability (of an instrument)

A qualitative indicator of the extent to which an accessibility instrument is accepted and applied in planning or decision making process by its end-users.

Utility measures

Measures individual or societal benefits of accessibility. This can occur in monetarised form as a measure of economic utility, or as an indicator for social equity (or for other sustainability objectives). It can also be applied as a behavioural indicator, measuring the value individuals afford to the accessibility of particular activities (C. Curtis, J. Scheurer 2010).

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APPENDIX A

General Information

On which mail address can we reach you?

For which university/institute are you working?

What is the name of your accessibility instrument?

In which country is the accessibility instrument used/developed?

For which university/institute are you working?

1. Planning Context

1.1 What geographic scale does the instrument cover?

☐ Supra-National

☐ National

☐ Supra-Municipal

☐ Municipal

☐ Neighbourhood

☐ Street

1.2 Are there policy requirements to assess accessibility?

☐ There are legal requirements to use an accessibility assessment

☐ It is advised to use an accessibility assessment

☐ It is neither required nor advised

☐ Other:

1.3 What is the status of the instrument?

☐ Implemented as part of the urban/ transport planning process

☐ Functioning as a research tool

☐ In development/ prototype

☐ Other:

1.4 Is the planning process in which the instrument is (intended to be) used:

☐ Formal planning process (top-down)

☐ Informal planning process (bottom-up)

☐ A combination of both

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

2. Planning Goals

2.1 What are the main public stakeholder goals to be achieved with the instrument?

☐ How to decide on the location of residences /activities / services (What is the influence of accessibility in the location of residences /activities / services)

☐ How to manage, encourage or reduce the use of a particular transport mode(s) (Understanding how to measure and how to develop efficient transport services by a particular mode or combination of modes)

☐ How to stimulate economic development

☐ How to ensure economic equity

☐ How to ensure social equity and/or cohesion

☐ How to ensure reductions of emission/energy use

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question

1.3)

☐ Other:

Additional Explanation If you checked “manage, encourage or reduce the use of a particular transport mode(s), please specify which mode here. Please separate your answers with a semicolon.

2.2 What are the main private investors’ concerns that can be tackled with the instrument?

☐ Where to locate business (for commerce, service and other companies)

☐ Where to invest in real estate (for real estate owners and traders)

☐ Where and how to develop public transport services (private operators)

☐ Where and how to develop freight supply chains (freight operators)

☐ Enhancing patronage levels through information and marketing – access to information

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

2.3 What are the main individual goals that can be achieved with the instrument?

☐ Choosing household location

☐ Choosing the best route to (a) particular activity (ies)

☐ Choosing the best mode(s) for (a) particular route(s)

☐ Choosing the nearest activity (ies)□

□ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

Additional Explanation If you checked “choosing the best route to (a) particular activity (ies) please specify which activity (ies).

3. Characteristics of the Instrument

3.1 Classify the instrument with regard to the decision support task.

☐ Passive decision support tool (aids the process of decision making, but cannot bring out explicit decision suggestions or solutions)

☐ Active decision support tool (can bring out such decision suggestions or solutions)

☐ Cooperative decision support tool (allows the decision maker or advisor to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation)

☐ Used in the ex-post evaluation of the decision impact

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other :

3.2 Identify the accessibility measure tradition(s) the instrument is attached to.

☐ Spatial separation measures [1]

☐ Contour measures [2]

☐ Gravity measures [3]

☐ Competition measures [4]

☐ Time-space measures [5]

☐ Utility measures [6]

☐ Network measures [7]

☐ Information accessibility measures (use 'other' fields in following questions to describe)

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

3.3 Identify the components used in the instrument.

☐ The instrument takes into consideration all accessibility components (Land-use, transportation, temporal and individual)

☐ The instrument takes into consideration some accessibility components.

Additional Explanation If you checked "The instrument takes into consideration some accessibility components", please specify which:

☐ Land-use

☐ Transportation

☐ Temporal

☐ Individual

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

3.4 Identify the level(s) of spatial disaggregation of data used in the instrument.

a. Administrative units.

☐ NUTS 1 level (e.g. Country based)

☐ NUTS 2 level (e.g. Regional)

☐ NUTS 3 level (e.g. Supra-municipal)

☐ NUTS 4/LAU 1 level (e.g. Municipal)

☐ NUTS 5/LAU 2 level (e.g. Parish)

☐ Census tract

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

b. Plot level data.

☐ Plots

☐ Buildings

☐ Transportation terminal/ hubs

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

c. Street segment level data.

☐ Axial lines

☐ Road centre lines

☐ Intersections

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

d. Individual level data.

☐ Households

☐ Individuals

☐ Other:

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

3.5 Identify the level of socio-economic disaggregation used in the instrument.

☐ None/ aggregate measure

☐ Gender

☐ Age

☐ Physical ability

☐ Work/ non-Work

☐ Income

☐ Education

☐ Car ownership

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

3.6 Identify the level of temporal disaggregation used in the instrument.

☐ None/ aggregate measure

☐ Year

☐ Month

☐ Week

☐ Day

☐ Peak/ off-peak

☐ Hour

☐ Dynamic (real-time)

☐ Not applicable

☐ Don’t know yet (only for instruments marked as “in development” in question 1.3)

☐ Other:

3.7 Identify how ‘travel cost’ is assessed in the instrument.

☐ Actual travel expense (cost)

☐ Imputed from travel distance

☐ Imputed from travel time

☐ Imputed from observation area structure

☐ Generalised cost

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

Additional Explanation If you checked "Generalised cost", please provide a more detailed description of the generalised costs.

3.8 Identify the transport modes that are used in the instrument.

☐ Any mode

☐ Walking

☐ Bicycle

☐ Public Transport (specify below)

☐ Taxi

☐ Car

☐ Plane

☐ Truck

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

Additional Explanation When you checked Public Transport, please specify which specific transport modes are includes (i.e. bus, train, tram, metro)

☐ Bus

☐ Train

☐ Tram

☐ Metro

☐ Other

3.9 Which trip purposes/ opportunities are used in the instrument?

☐ No purpose / not applicable

☐ All purposes (aggregate measure)

☐ Work

☐ Leisure

☐ Healthcare

☐ Shopping

☐ Education

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

3.10 How well does the instrument replicate reality?

a. Please rate the quality of data.

Bad quality ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Good quality

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

b. Please rate the quality of calculations.

Bad quality ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Good quality

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

c. Please rate the accuracy of the model.

Bad accuracy ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Good accuracy

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

3.11 Please rate the speed of the tool.

Fast – interactive ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Slow –static report

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4. End-Users and How They Use the Tool

4.1 Who are the potential users?

☐ Spatial/ Urban Planners

☐ Transport Planners

☐ Health service planners

☐ Education service planners

☐ Politicians

☐ Retailers

☐ Citizens

☐ Tool initiators

☐ Developers/Researchers

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

4.2 Please rate how easy it is for practitioners to use the instrument.

a. Please rate the ease of collecting data.

Difficult ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Easy

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

b. Please rate the ease to play with instrument.

Difficult ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Easy

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

c. Please rate the transparency of main causal assumptions.

Not transparent ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very transparent

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

d. Please rate the flexibility of instrument (ease of changing parameters and variables).

Not transparent ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very transparent

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

e. To what extent are the accessibility measures (output) understandable for the end user.

Difficult to understand ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Easy to understand

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

f. To what extent the accessibility measures visually represented.

Not very well ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very well

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.3 Does the accessibility instrument make use of interpretable units?

☐ Define

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.4 Please rate the knowledge and skills required to use the tool in terms of:

a. Modelling/computational skills.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

b. Spatial awareness skills.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

c. understanding policy context

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.5 How is the instrument used to understand the quality and experience of travel?

a. Please rate the usability in social evaluations.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

b. Please rate the usability in environmental evaluations.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

c. Please rate the usability in safety and security evaluations.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

d. Please rate the usability for physical skills evaluations.

Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very high

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.6 How is the instrument intended to be used to connect service users (e.g. citizens, companies) and providers (e.g. governments)?

☐ A marketing tool to inform people what providers offer (top-down)

☐ A networking tool for users to inform providers (bottom-up)

☐ A tool to monitor consistency of perceptions/ expectations between providers, users, suppliers (matching top-down to bottom-up)

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

☐ Other:

4.7 What is the (intended) role of the instrument in urban planning?

☐ To create new insights

☐ To justify decisions/ positions already taken

☐ To support strategy/ option generation

☐ To support strategy/ option selection

☐ To support integration of urban planning perspectives

☐ Other (specify):

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

Additional Explanation When you checked "to support integration..." please specify which perspectives are aimed at.

a. How successful is the instrument in that role?

Not successful ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very successful

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.8 Are there any institutional issues that block the effective use of the instrument?

☐ Separate urban and transport planning institutions

☐ Formal processes

☐ Financial arrangements

☐ Data availability

☐ Different planning objectives/ and assumptions

☐ Staff technical skills

☐ Political commitment

☐ Not applicable

☐ Don't know yet (only for instruments marked as "in development" in question 1.3)

4.9 Do you see any other issues that block the effective use of the instrument (if so, please specify which)?

APPENDIX B

SNAMUTS - Spatial Network Analysis for Multimodal Urban Transport Systems

Carey Curtis & Jan Scheurer, Curtin University, Australia (c.curtis@curtin.edu.au; jan.sheurer@rmit.edu.au)

1. Planning Context

Geographical Scale:	Supra-Municipal Municipal
Status:	Implemented as part of the planning process Research tool
Planning Process:	Formal and informal planning processes

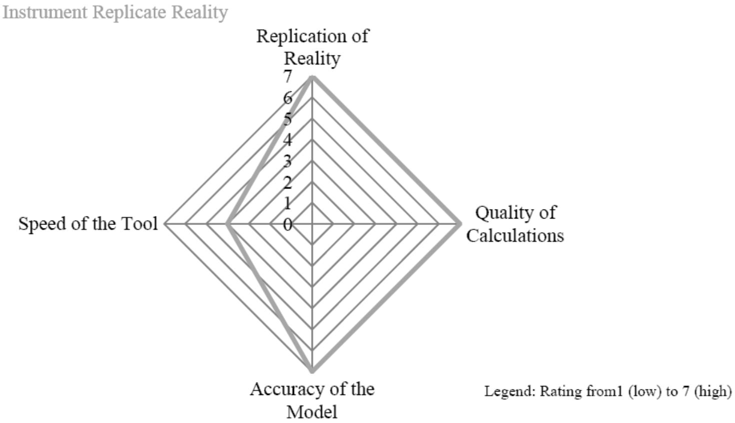
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location of residences/activities How to manage the use and operation of transport modes How to ensure social and economic equity
Private Investors Concerns:	Where to locate business Where to invest in real estate
Main Individual Goals:	Choosing household activities Choosing the nearest activities

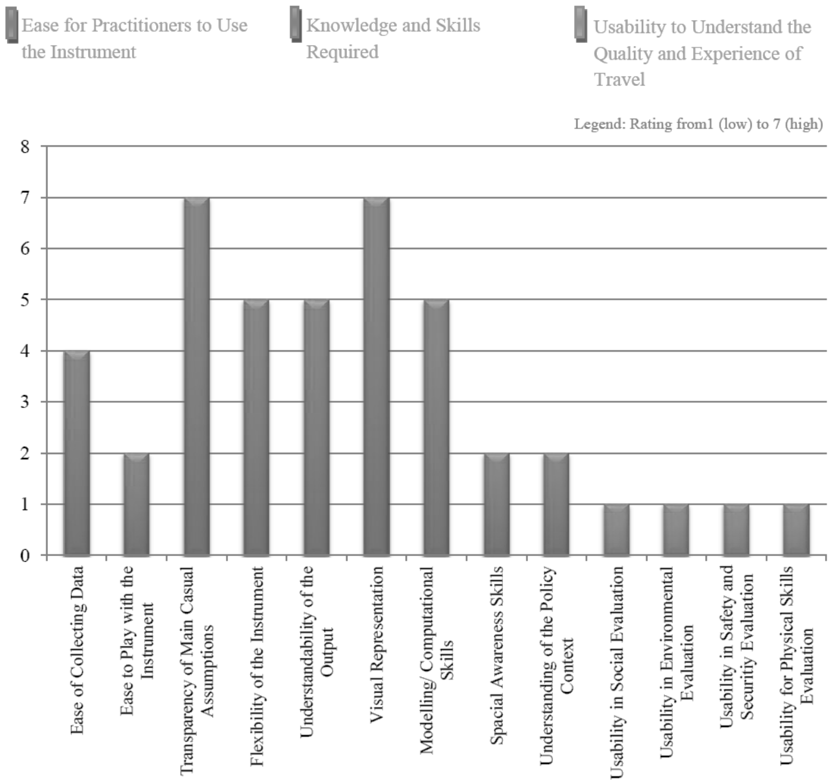
3. Characteristics of the Instrument

Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Spatial separation measures Contour measures Gravity measures Network measures
Components:	Some accessibility measures: Land-use and transport
Level of Spatial Disaggregation:	Census tract Activity center catchments
Level of Socio-economic Disaggregation:	None/aggregate measure
Level of Temporal Disaggregation:	None/aggregate measure
Transport Modes:	Public Transportation (bus, trains, tram, metro)
Purposes/ Opportunities:	All purposes (aggregate measure)

How the Instrument Replicate Reality



4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Politicians Citizens Developers/ Researchers
Interpretable Units Used:	Scaling and average of indices
Intended Use to Connect Service Users and Providers:	Tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of Urban Planning Perspectives
Institutional Issues Blocking Effectiveness :	Resources including time available to planning agencies to engage in such deliberation

TRACE - Retail Cluster Accessibility

Ann Verhetsel University of Antwerp, Belgium (ann.verhetsel@ua.ac.be)

1. Planning Context

Geographical Scale	National Supra-Municipal Municipal Neighbourhood
Status:	Research tool In development
Planning Process:	Formal planning process

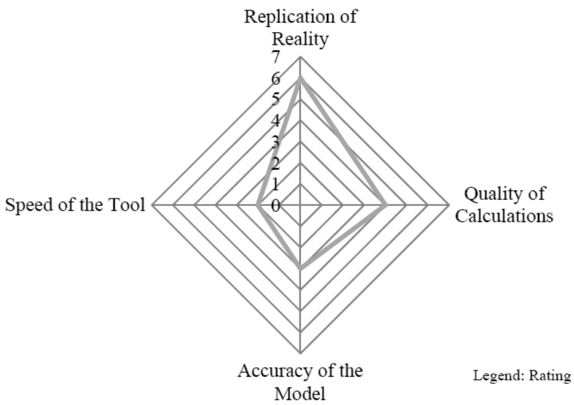
2. Planning Goals

Public Stakeholder Goals:	To decide on the location of residences/activities/ services
Private Investors Concerns:	Where to locate business
Main Individual Goals:	Choosing the nearest activities

3. Characteristics of the Instrument

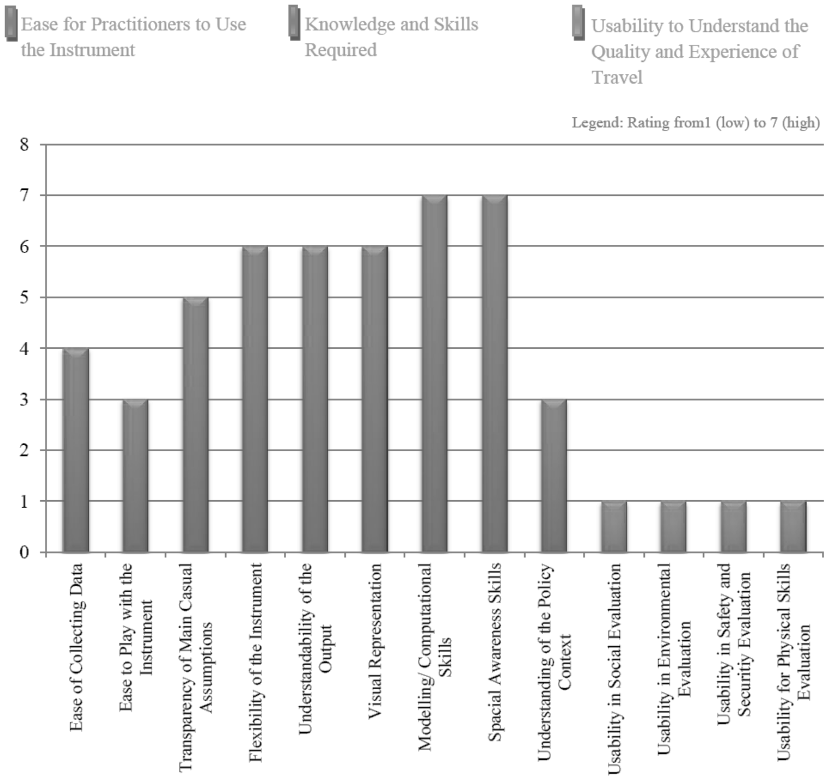
Decision Support Task:	Cooperative decision support tool
Accessibility Measure Tradition:	Spatial separation measures Contour measures Time-space measures
Components:	Some accessibility components: land-use; transportation; individual
Level of Spatial Aggregation:	Post addresses Buildings Axial lines Shops
Level of Socio-economic Disaggregation:	Characteristics of shops
Level of Temporal Disaggregation:	None/ aggregate measure
Transport Modes:	None
Purposes/ Opportunities:	Shopping

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Politicians Retailers Developers/ Researchers
Interpretable Units Used:	Do not understand the question
Intended Use to Connect Service Users and Providers:	Tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To justify decision/ positions already taken To support strategy/ option generation To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Data availability Tool in development

ASAMeD - Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance

Magda Mavridou, University of Thessaly, Greece (magdamavridou@teemail.gr)

1. Planning Context

Geographical Scale	Municipal Neighbourhood Street
Status:	Implemented as part of the planning process Research tool
Planning Process:	Formal planning process

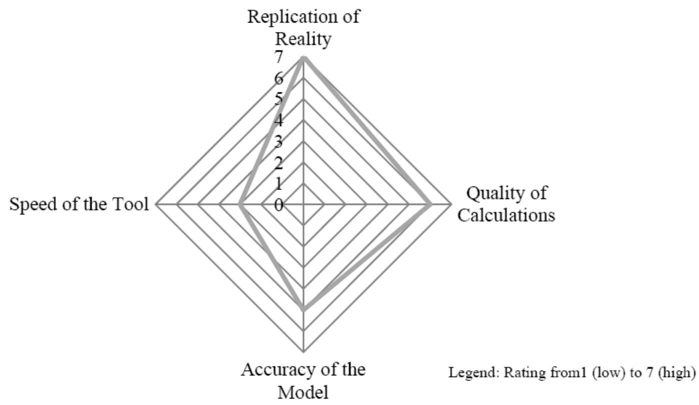
2. Planning Goals

Public Stakeholder Goals:	To decide on the location of residences/ activities To ensure social cohesion To revitalize city center To increase the quality the quality/experience of travel To improve cycling/ pedestrian access
Private Investors Concerns:	Where to locate business Where to invest in real state
Main Individual Goals:	Choosing housing area with a good choice of service available The quickest route to work

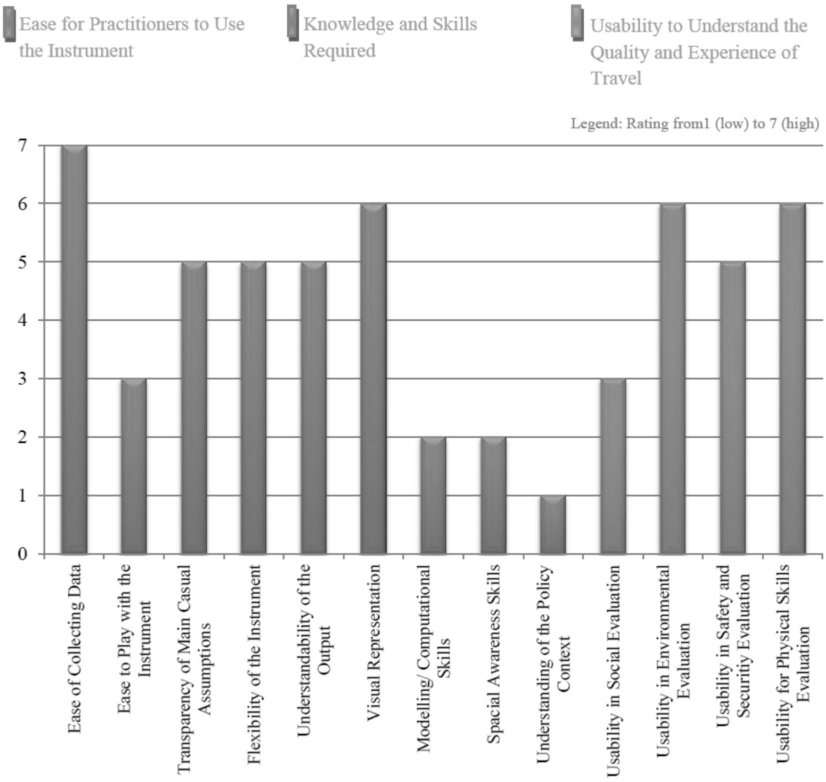
3. Characteristics of the Instrument

Decision Support Task:	Used in the ex-port evaluation of the decision impact
Accessibility Measure Tradition:	Spatial separation measure Time-space measures Network measures
Components:	Some accessibility components (spatial connectivity)
Level of Spatial Aggregation:	NUTS 4/ LAU 1; NUTS 5/ LAU 2 Buildings Axial lines; Road center lines; Intersections; Individuals
Level of Socio-economic Disaggregation:	Gender; Work – non-work
Level of Temporal Disaggregation:	Hour; Peak/ off-peak
Transport Modes:	Walking; Bicycle
Purposes/ Opportunities:	No purpose/ Not applicable

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Health Service Planners Education Service Planners Tool Initiators Developers/ Researchers
Interpretable Units Used:	No accessibility units
Intended Use to Connect Service Users and Providers:	Marketing tool to inform people what providers offer (top-down)
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Formal processes

ABICA - Activity Based Indicators of Connections and Access Needs

Petter Nass, Aalborg University, Denmark (petter@plan.aau.dk)

1. Planning Context

Geographical Scale	Supra-Municipal Municipal
Status:	In development
Planning Process:	Not relevant yet

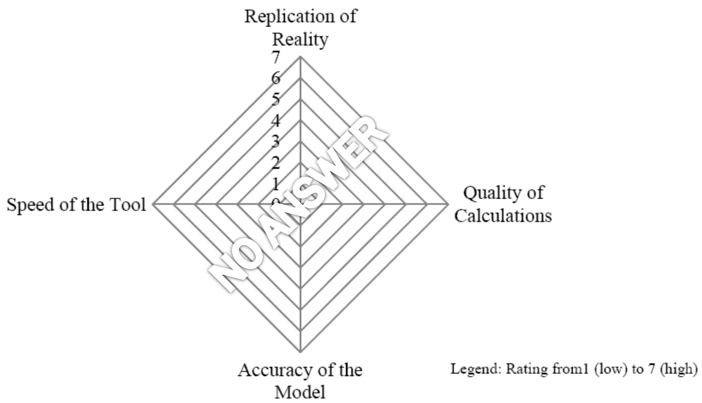
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location of houses/ activities How to manage the use of transport modes
Private Investors Concerns:	Don't know yet
Main Individual Goals:	Choosing household location

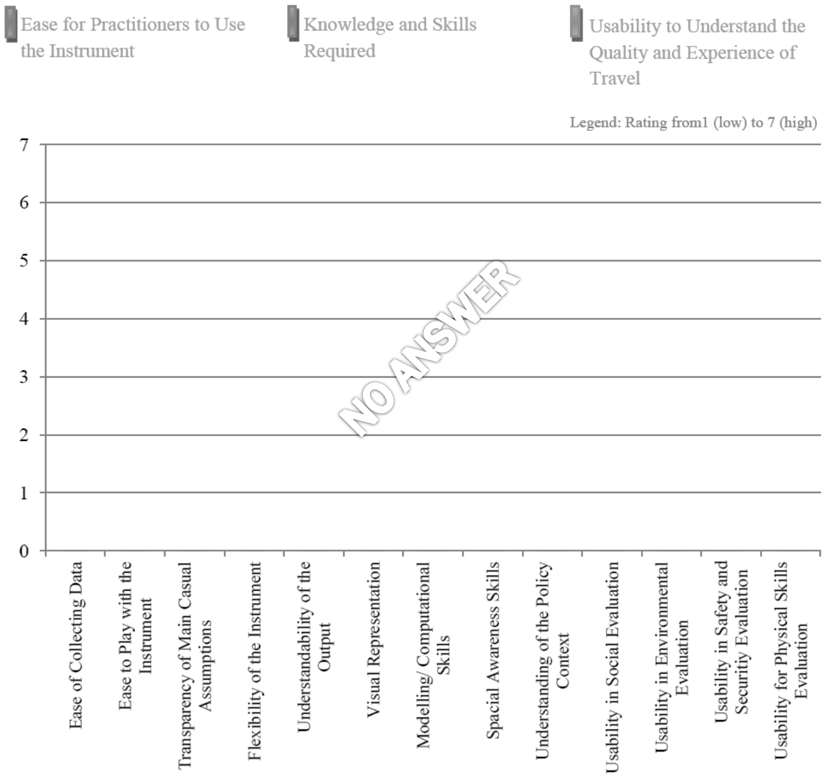
3. Characteristics of the Instrument

Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Gravity measures Time-space measures
Components:	Some accessibility components (Accessibility to jobs, to non-local service and to local service)
Level of Spatial Aggregation:	
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None / aggregate measure
Transport Modes:	Bicycle; Public Transport; Car
Purposes/ Opportunities:	Work: Leisure; Shopping

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Don't know yet
Interpretable Units Used:	Don't know yet
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation
Institutional Issues Blocking Effectiveness :	None

HIMMELI - Heuristic three-level Instrument combining urban Morphology, Mobility, service Environments and Locational Information

Sanna Iltanen, Tampere University of Technology, Finland (sanna.iltanen@tut.fi)

1. PLANNING CONTEXT

Geographical Scale:	Supra-Municipal
Status:	In development
Planning Process:	Formal and informal planning processes

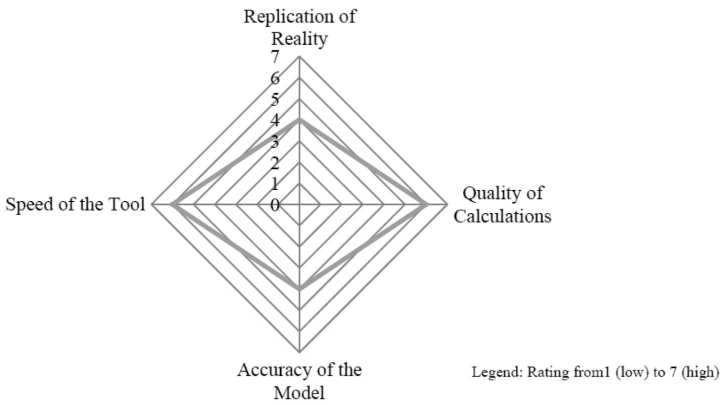
2. PLANNING GOALS

Public Stakeholder Goals:	How to decide on the location of residences/activities/services
Private Investors Concerns:	Creating value through information and marketing Access to information
Main Individual Goals:	Selecting housing area with a good choice of services

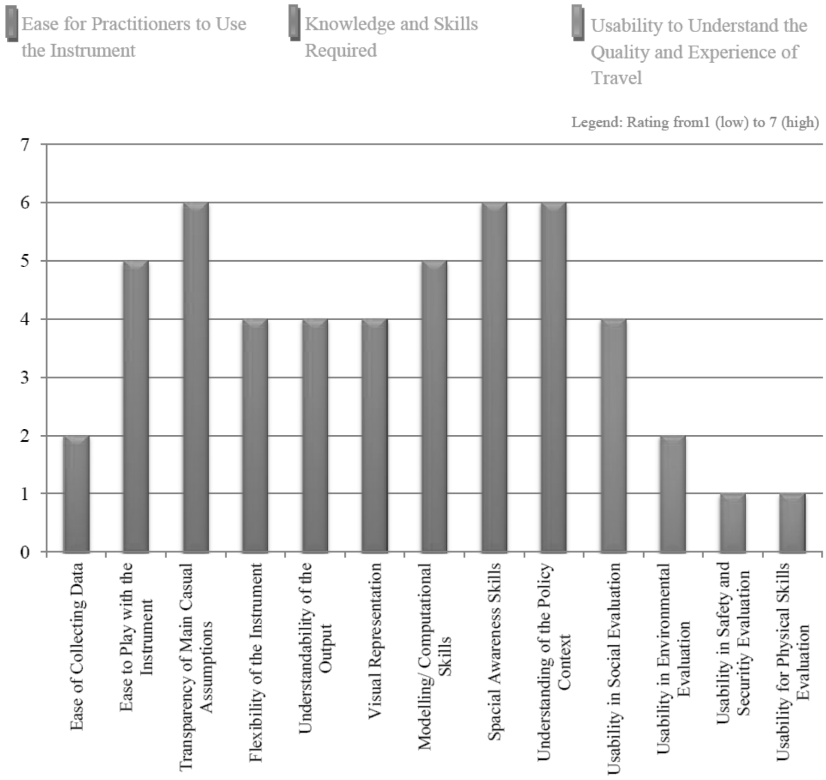
3. CHARACTERISTICS OF THE INSTRUMENT

Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Gravity Measures Network Measures
Components:	Some accessibility measures: Land-use; Transport; Household type
Level of Spatial Disaggregation:	NUTS 3 Retail service locations Road center lines Households
Level of Socio-economic Disaggregation:	Income
Level of Temporal Disaggregation:	Year Month
Transport Modes:	Car
Purposes/ Opportunities:	Shopping

How the Instrument Replicate Reality



4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Retailers
Interpretable Units Used:	Travel cost Centrality measures
Intended Use to Connect Service Users and Providers:	To monitor consistency of perceptions/expectations between providers, users and suppliers
Intended Role in Urban Planning:	To create new insights To support integration of Urban Planning Perspectives (future land use development options; future transport network options)
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions

EMM - Erreichbarkeitsatlas der Europäischen Metropolregion Muenchen

Johannes Keller, TU Muenchen, Germany (johannes.keller@tum.de)

1. Planning Context

Geographical Scale:	Supra-Municipal Municipal
Status:	Research tool In development
Planning Process:	Formal and informal planning processes

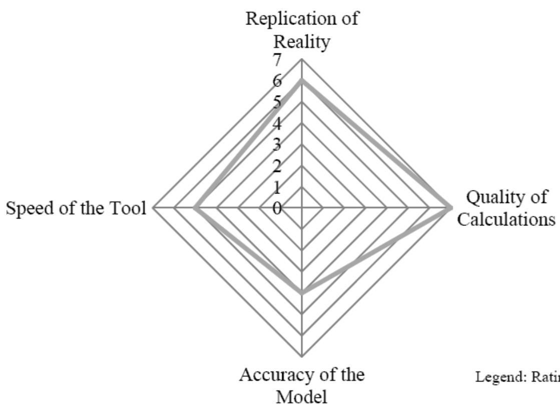
2. Planning Goals

Public Stakeholder Goals:	To ensure the quality of the transport modes and housing/ built environment
Private Investors Concerns:	Creating value through information and marketing Access to information
Main Individual Goals:	Selecting housing area with a good choice of services

3. Characteristics of the Instrument

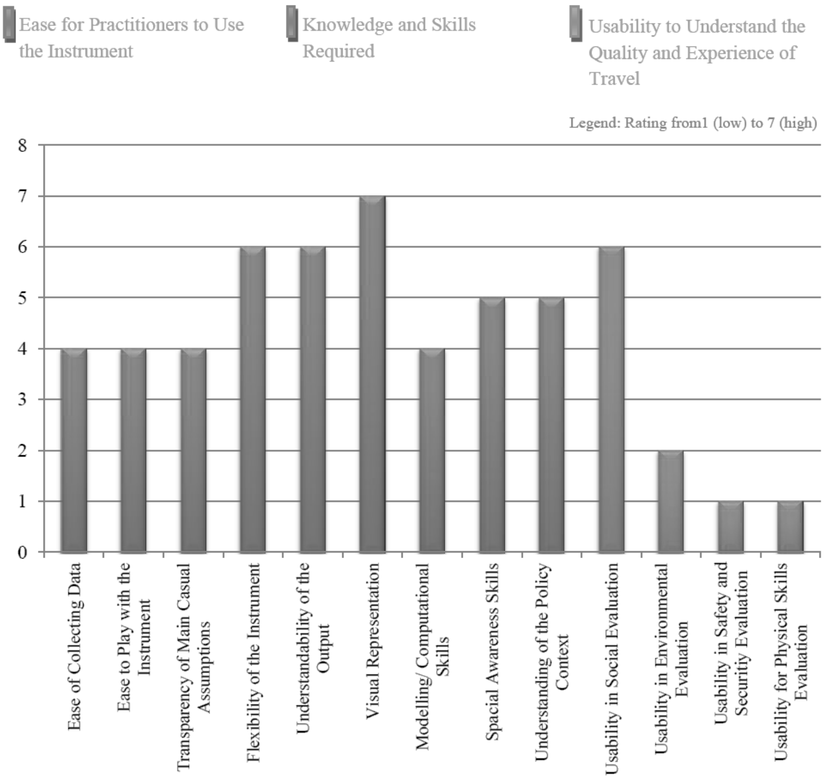
Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Contour measures Gravity Measures
Components:	Some accessibility measures: Land-use and transport; temporal
Level of Spatial Disaggregation:	NUTS 4/ LAU 1; Census tract Road center lines
Level of Socio-economic Disaggregation:	Age; Work/ non-work; Income; Car ownership
Level of Temporal Disaggregation:	Peak/ off-peak
Transport Modes:	Walking, bicycle; Public Transportation (bus, trains, tram, metro); Car
Purposes/ Opportunities:	Any purpose

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Politicians Citizens Tool initiators
Interpretable Units Used:	Number of jobs/ population Within catchment area
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of Urban Planning Perspectives
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Formal processes Financial arrangements Data availability Different planning objectives/assumptions

RIN - German Guidelines for Integrated Network Design-Binding Accessibility Standards

Juergen Gerlach, Wuppertal, Germany (jgerlach@uni-wupertal.de)

1. Planning Context

Geographical Scale	Supra-National National Supra-Municipal Municipal
Status:	Implemented as part of the planning process
Planning Process:	Formal planning process

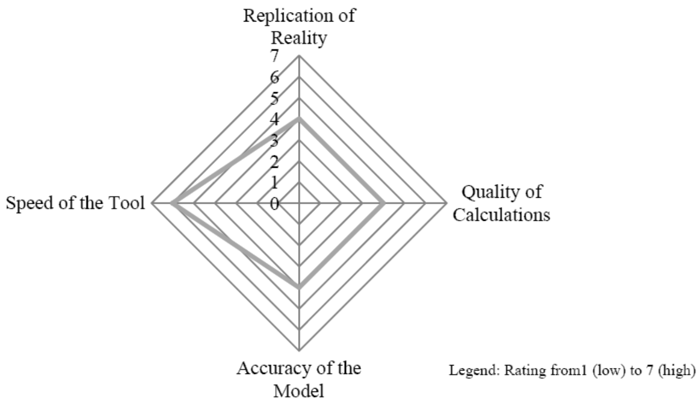
2. Planning Goals

Public Stakeholder Goals:	How to ensure secure speed, to facilitate support and to ensure a good connectivites for transport modes (public transport, cycling) How on decide on the location of new houses How to activate a satellite or remote region How to ensure access to basic services
Private Investors Concerns:	Where to locate business
Main Individual Goals:	Choosing the best route to particular activities Choosing the best transport mode and connections

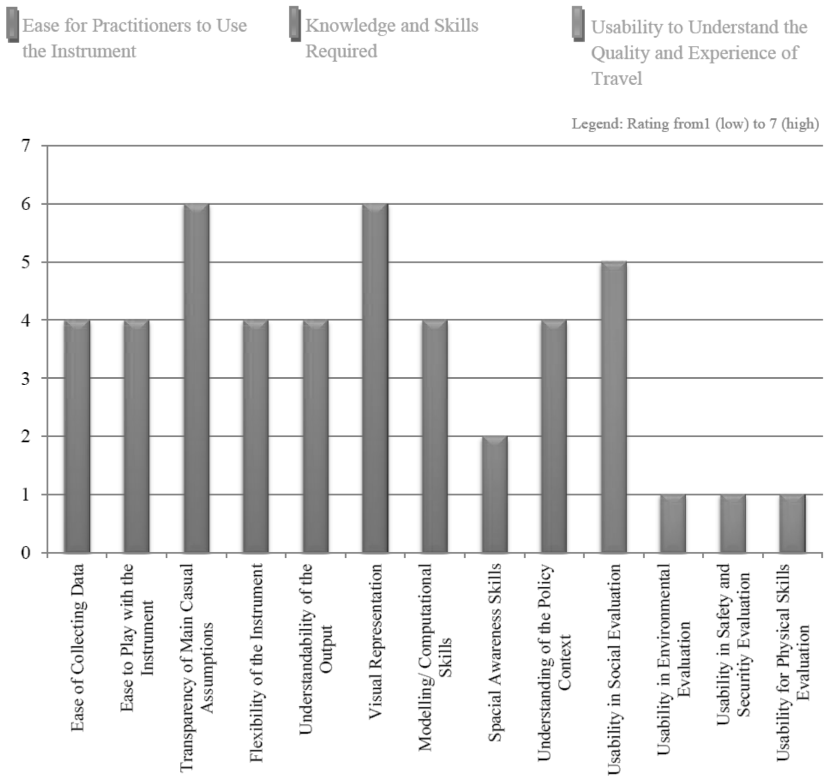
3. Characteristics of the Instrument

Decision Support Task:	Active decision support tool
Accessibility Measure Tradition:	Network measures
Components:	All accessibility components (Land-use; Transportation; Temporal; Individual)
Level of Spatial Aggregation:	NUTS 1; NUTS 2; NUTS 3 Plots Axial lines
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None / aggregate measure
Transport Modes:	Waling; Bicycle; Public Transport (Bus; Train; Tram; Metro); Car
Purposes/ Opportunities:	All purposes (aggregate measure)

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners
Interpretable Units Used:	Time
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To justify decisions/ positions already taken To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Data availability

MoSC - Measures of Street Connectivity: Spatialist Lines

Vasileia Trova, University of Thessaly, Greece (Vatrova@uth.gr)

1. Planning Context

Geographical Scale	Supra-Municipal Municipal Neighbourhood Street
Status:	Implemented as part of the planning process Research tool
Planning Process:	Formal planning process

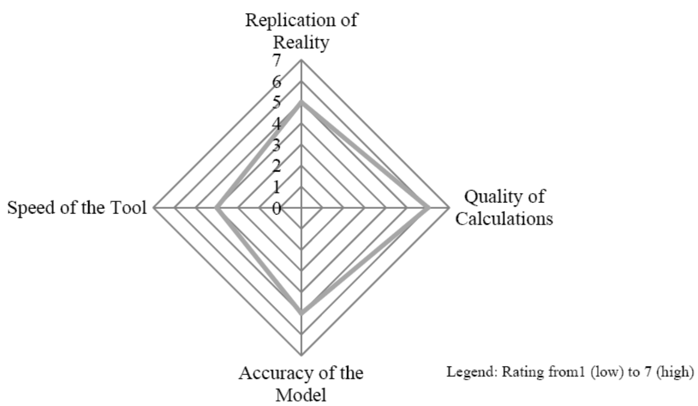
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location od residences/ activities/ services
Private Investors Concerns:	Where to locate business
Main Individual Goals:	Choosing the best route to particular activities Choosing the nearest activities

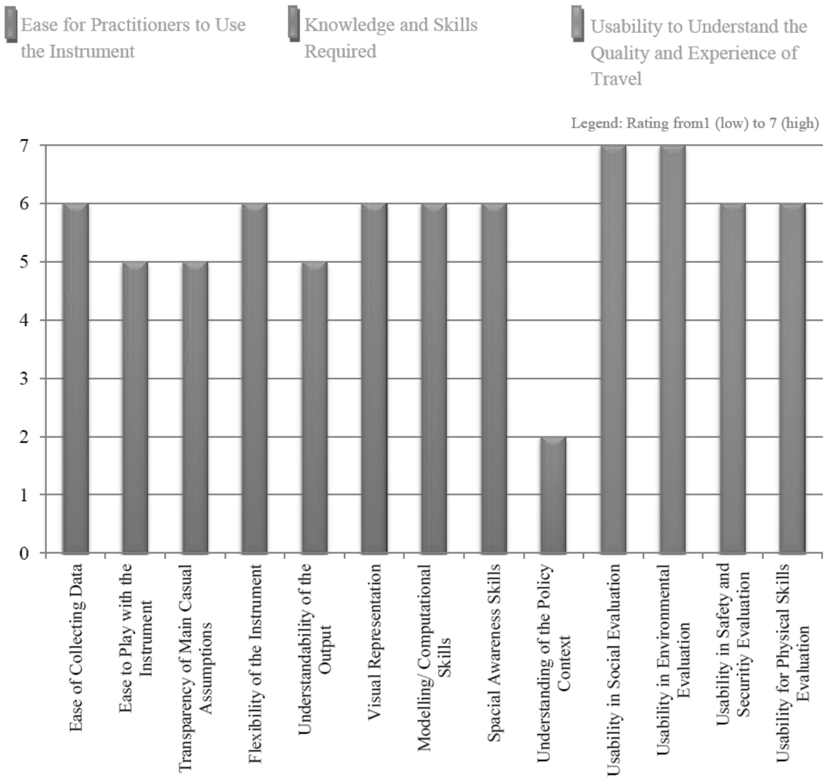
3. Characteristics of the Instrument

Decision Support Task:	Cooperative decision support tool
Accessibility Measure Tradition:	Spatial separation measures Network measures Information accessibility measures
Components:	Some accessibility components (Individual)
Level of Spatial Aggregation:	NUTS 3; NUTS 4/ LAU 1; NUTS 5/ LAU 2 Road centre lines
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None / aggregate measure
Transport Modes:	Waling
Purposes/ Opportunities:	All purposes (aggregate measure)

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners
Interpretable Units Used:	Define
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Data availability

InViTo – Interactive Visualization Tool

Matteo Tabasso, SiTI Higher Institute on Territorial Systems For innovation, Italy (matteo.tabasso@siti.polito.it)

1. Planning Context

Geographical Scale	Supra-Municipal Municipal Neighbourhood
Status:	In development
Planning Process:	Formal and informal planning processses

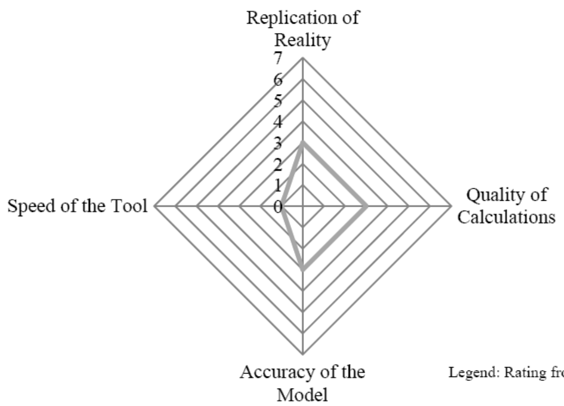
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location od residences/ activities/ services
Private Investors Concerns:	Where to locate business Where o invest in real estate Where and how to develop public transport services
Main Individual Goals:	Choosing household location

3. Characteristics of the Instrument

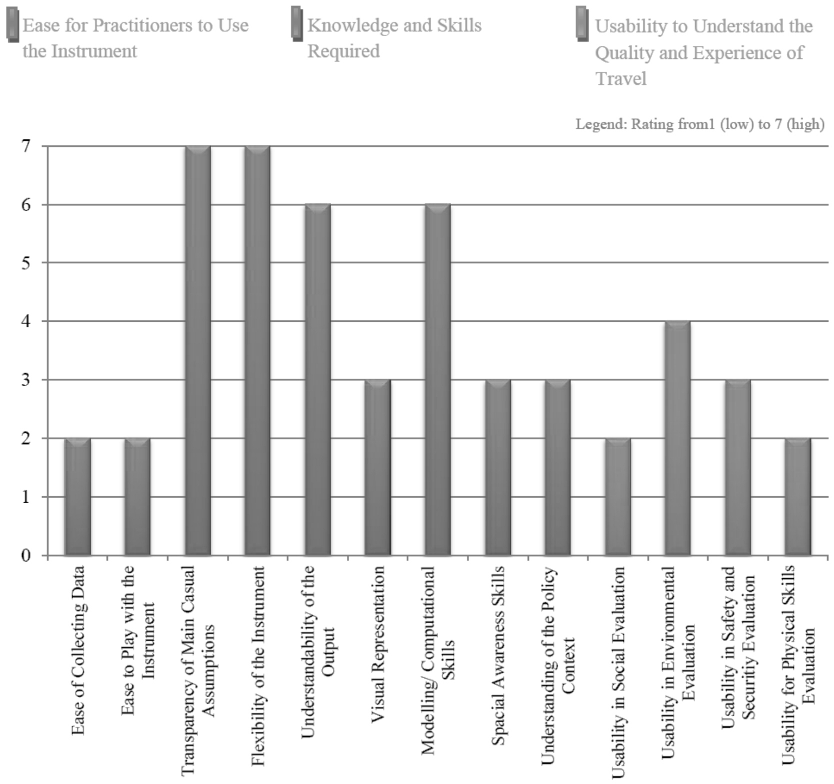
Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Time-space measures
Components:	Some accessibility components (Don't know yet which)
Level of Spatial Aggregation:	Urban parcels Plots; Buildings; Transportation terminal/ hubs Road centre lines Blocks
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None / aggregate measure
Transport Modes:	Waling; Car
Purposes/ Opportunities:	No purpose/ Not applicable

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Politicians Retailers Citizens Developers/ Researcher
Interpretable Units Used:	Distances in time (minutes) and space (meters)
Intended Use to Connect Service Users and Providers:	Tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Data availability Political commitment

GraBAM – Gravity Based Accessibility Measures for Integrated Transport-Land Use Planning

Enrica Papa, Università Frederico II di Napoli, Italy (enpapa@unina.it)

1. Planning Context

Geographical Scale	Supra-Municipal
Status:	Implemented as part of the planning process
Planning Process:	Formal planning process

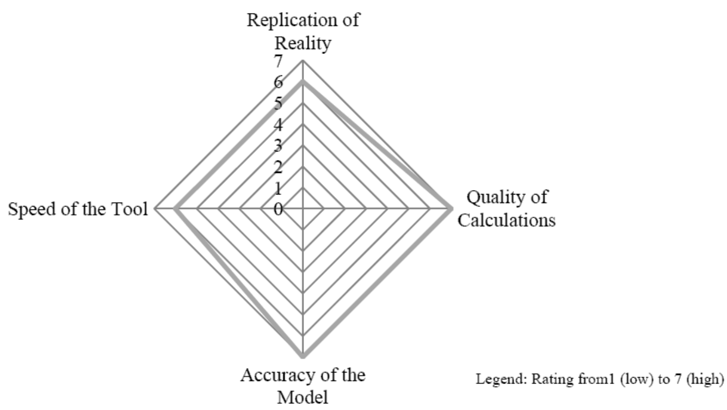
2. Planning Goals

Public Stakeholder Goals:	How to manage, encourage or reduce the use of transport modes
Private Investors Concerns:	Where to locate business Where to invest in real estate
Main Individual Goals:	Choosing household location

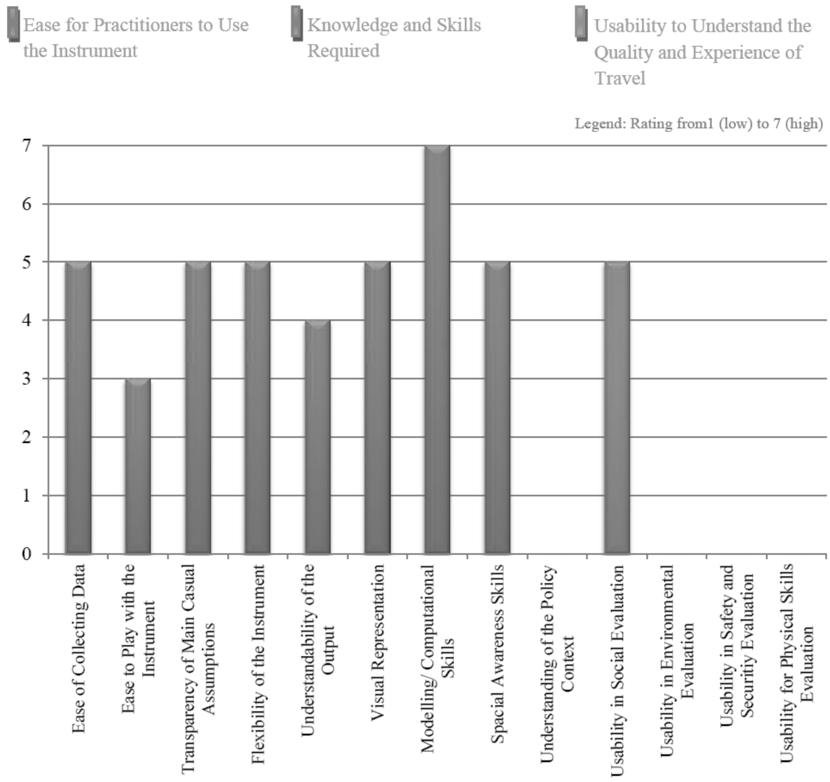
3. Characteristics of the Instrument

Decision Support Task:	Active decision support tool
Accessibility Measure Tradition:	Gravity measures
Components:	Some accessibility components (Land-use; transportation; temporal)
Level of Spatial Aggregation:	Census tract (aggregated)
Level of Socio-economic Disaggregation:	Work/ Non-work
Level of Temporal Disaggregation:	Peak/ Off-peak
Transport Modes:	Public transport (regional metro); Car
Purposes/ Opportunities:	Work; Education

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planner
Interpretable Units Used:	Sum of the generalized travel costs, weighted by an attraction term representing either the opportunities to be reached in other zones or the potential *consumers* of an opportunity located in zone *i*
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To support strategy/ option generation To support strategy/ option selection
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Data availability Staff technical skills

JAD - Joint-Accessibility Design

Thomas Straatemeier, Universiteit van Amsterdam, Netherlands (tstraatemeier@goudappel.nl)

1. Planning Context

Geographical Scale	Supra-Municipal
Status:	Implemented as part of the planning process
Planning Process:	Formal and informal planning processes

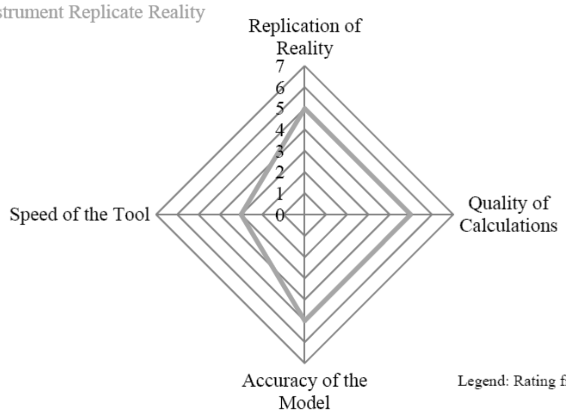
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location of residences How to activate a satellite/remote region How to ensure access to basic services and social and economic equity Creating a low energy built environment
Private Investors Concerns:	Where to locate business Where to invest in real estate How to create places with high land values through transport investment
Main Individual Goals:	Choosing neighbourhood/ housing area with good choice services available

3. Characteristics of the Instrument

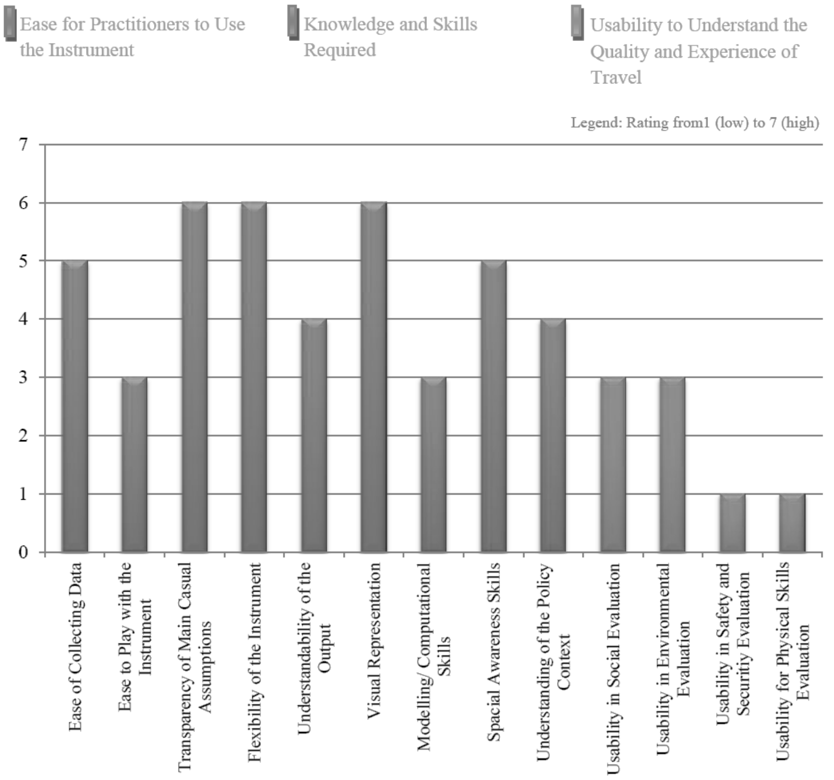
Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Contour measures Gravity measures
Components:	Some accessibility components (Land-use; transportation; temporal)
Level of Spatial Aggregation:	NUTS 3 Plots; Transportation terminal/ Hubs Intersections Individuals
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	Peak/ Off-peak
Transport Modes:	Bicycle; Public Transport (all); Car
Purposes/ Opportunities:	Depends on the user

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planner Health Service Planners Education Service Planners Politicians Citizens
Interpretable Units Used:	Scaling to average Sometimes quantiles
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Formal processes Data availability Different planning objectives/ assumptions

MaReSi SC - Method for Arriving at Maximus Recommendable Size of Shopping Centres

Aud Tennoy, Norwegian Institute of Transport Economics, Norway (ate@toi.no)

1. Planning Context

Geographical Scale	Municipal Neighbourhood
Status:	Implemented as part of the planning process
Planning Process:	Formal and informal planning processes

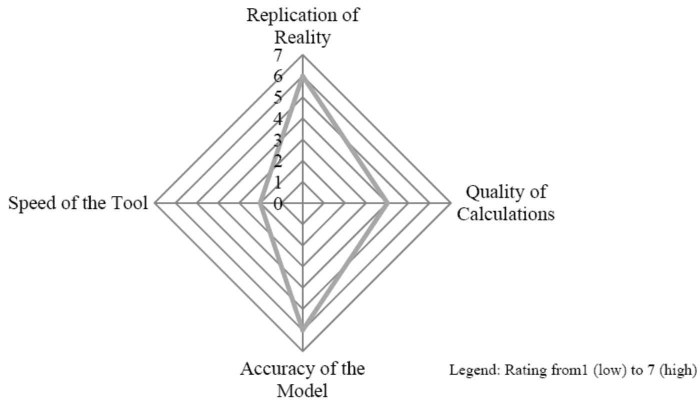
2. Planning Goals

Public Stakeholder Goals:	To manage the use of a transport mode (car)
Private Investors Concerns:	How shopping center can be allowed to be built
Main Individual Goals:	Reduction of car dependency Better accessibility to shopping and services

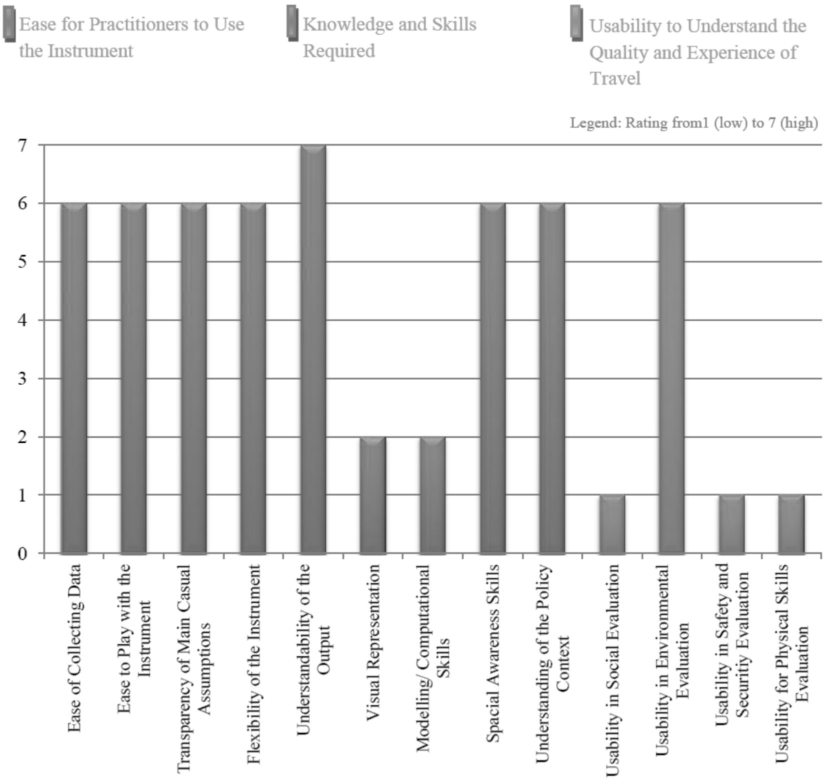
3. Characteristics of the Instrument

Decision Support Task:	Active planning support
Accessibility Measure Tradition:	Gravity measures Competitions measures Time-space measures How spatial development affects travel behavior
Components:	Some accessibility components (land use, transport systems)
Level of Spatial Aggregation:	Plots; Buildings; Transportation terminal/ hubs; People living within 1 and 2 km real distance; Center structure in municipality; Market shares for the center and others of the same type
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	Year; day
Transport Modes:	Any modes
Purposes/ Opportunities:	Shopping

How the Instrument Replicate Reality



4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Politicians
Interpretable Units Used:	Direct, not normalized, not weighted and nor transformed in ways
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To support integration of urban planning perspectives To help defining what kind of spatial developments/projects should be allowed on particular areas and on particular sites
Institutional Issues Blocking Effectiveness :	Black boxing and competing analyses from the intitiators' consultants

GDATI - Geographic/ Demographic Accessibility of Transport Infrastructure

Lidia Zakowska, Cracow University of Technology, Poland (lzakowsk@pk.edu.pl)

1. Planning Context

Geographical Scale	National Supra-Municipal Municipal
Status:	Research tool In development
Planning Process:	Formal and informal planning processes

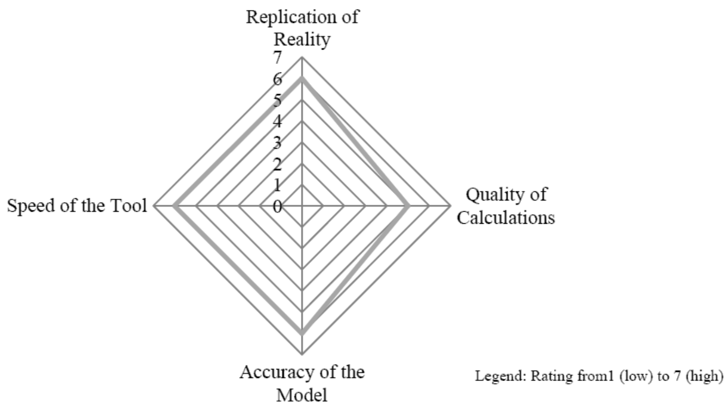
2. Planning Goals

Public Stakeholder Goals:	To manage the use of transport modes
Private Investors Concerns:	Where and how to develop public transport services
Main Individual Goals:	Choosing household location

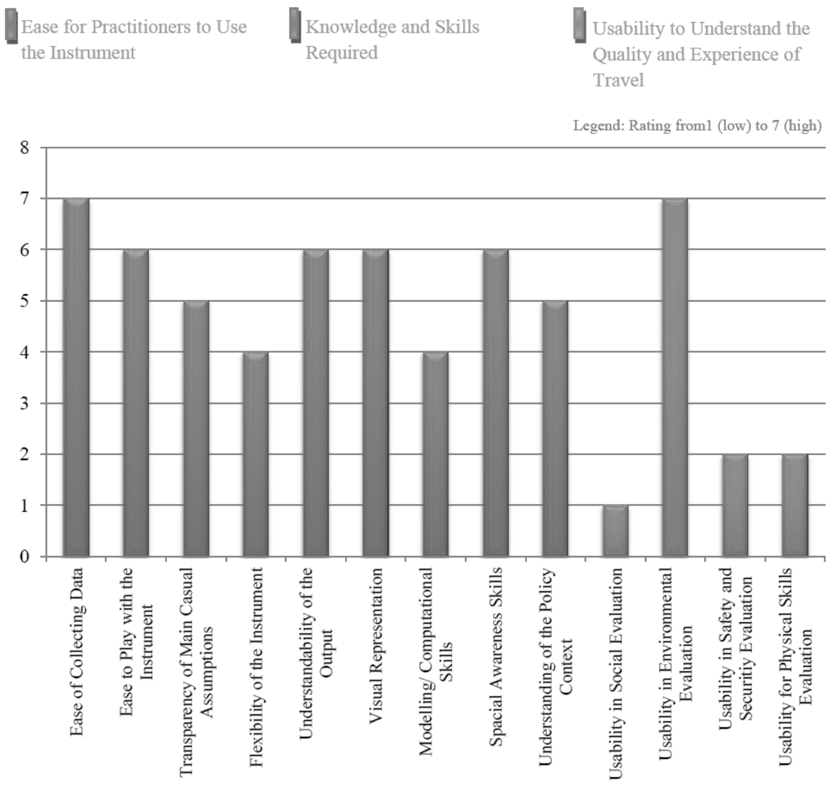
3. Characteristics of the Instrument

Decision Support Task:	Cooperative decision support tool
Accessibility Measure Tradition:	Spatial separation measures Network measures
Components:	Some accessibility components: land-use; transportation
Level of Spatial Aggregation:	NUTS 2; NUTS 3; NUTS 4/ LAU 1 Transportation terminal/ hubs Axial lines; Road center lines
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None/ aggregate measure
Transport Modes:	Public transport (bus, tram, train)
Purposes/ Opportunities:	No purpose/ not applicable

How the Instrument Replicate Reality



4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Developers/ Researchers
Interpretable Units Used:	Not used
Intended Use to Connect Service Users and Providers:	Networking tool for users to inform providers Tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To justify decision/ positions already taken
Institutional Issues Blocking Effectiveness :	Separate urban and transport institutions Formal processes Financial arrangements Data availability Political commitment

SAL – Structural Accessibility Layer

Cecília Silva, Oporto University, Portugal (ccsilva@fe.up.pt)

1. Planning Context

Geographical Scale	Supra-Municipal Municipal Neighbourhood
Status:	Research tool
Planning Process:	Formal planning process

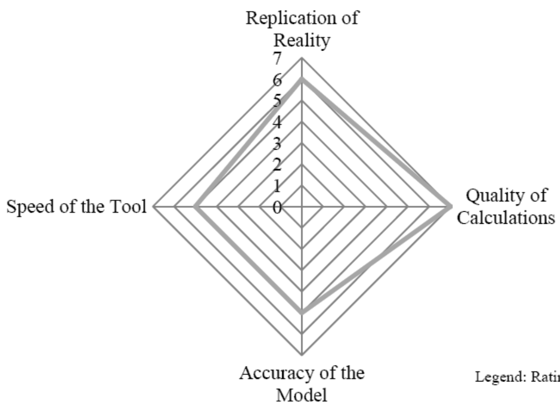
2. Planning Goals

Public Stakeholder Goals:	How to manage, encourage or reduce the use of transport modes (all)
Private Investors Concerns:	Not applicable
Main Individual Goals:	Choosing household location

3. Characteristics of the Instrument

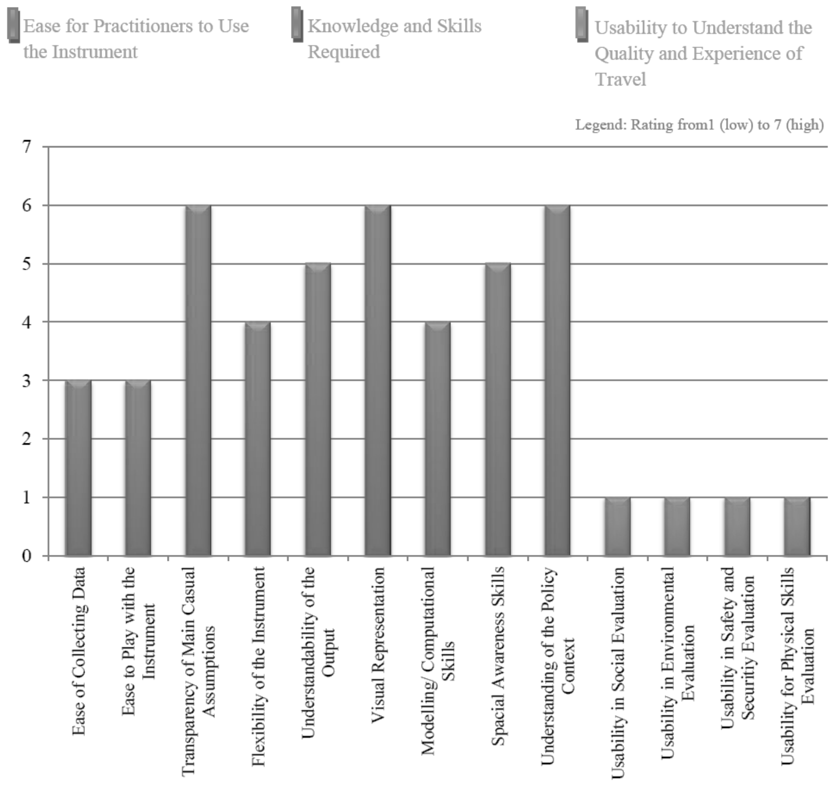
Decision Support Task:	Passive decision support tool
Accessibility Measure Tradition:	Contour measures
Components:	Some accessibility components (Land-use; transportation)
Level of Spatial Aggregation:	Census tract Plots
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	Peak/ Off-peak
Transport Modes:	Waling; Bicycle; Public Transport (all); Car
Purposes/ Opportunities:	Any purpose

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planner Developers/ Researcher
Interpretable Units Used:	Scale of classes is defined and a grouping of clusters with clear meaning
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Political commitment Accessibility is not seen as priority (rather mobility)

UrbCA - Celular Automata Modeling for Accessibility Appraisal in Spatial Plans

Nuno Pinto, Coimbra University, Portugal (npinto@dec.uc.pt)

1. Planning Context

Geographical Scale	Supra-Municipal Municipal
Status:	Research tool
Planning Process:	Formal and informal planning processes

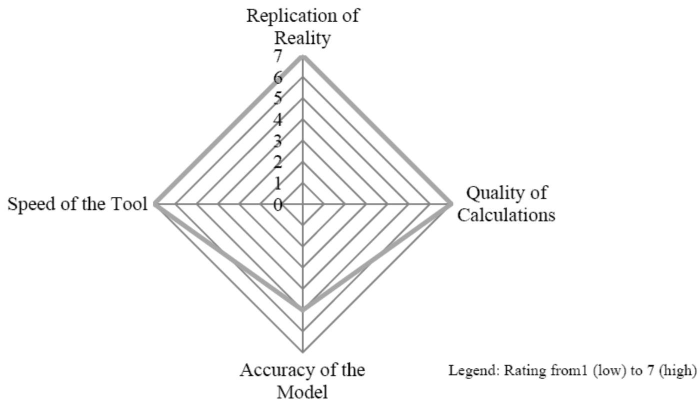
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location of residences/ activities/ services
Private Investors Concerns:	Where to invest in real estate
Main Individual Goals:	Choosing household location

3. Characteristics of the Instrument

Decision Support Task:	Cooperative decision support tool
Accessibility Measure Tradition:	Gravity measures
Components:	Some accessibility components (Land-use)
Level of Spatial Aggregation:	Census block Road centre lines Individuals
Level of Socio-economic Disaggregation:	Not applicable
Level of Temporal Disaggregation:	Year to decade
Transport Modes:	Car
Purposes/ Opportunities:	All purposes (aggregate measure)

How the Instrument Replicate Reality



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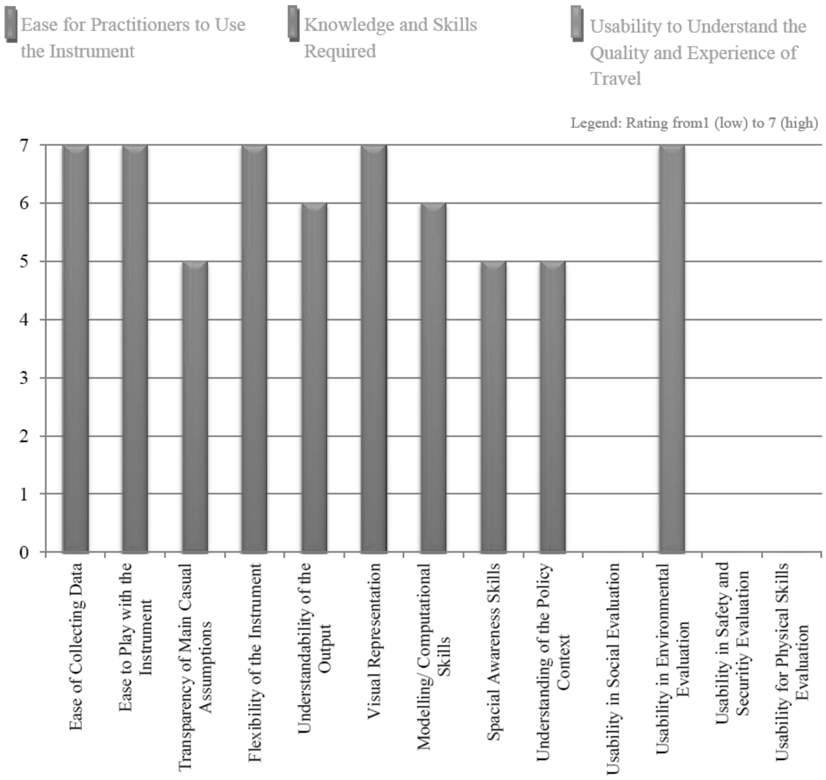


Potential Users:	Spatial/ Urban Planners
Interpretable Units Used:	
Intended Use to Connect Service Users and Providers:	A tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To create new insights To justify decisions/ positions already taken To support strategy/ option generation To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Data availability

ATI - From Accessibility to the Land Development Potential

Maruska Subic Kovac, University of Ljubljnq , Slovenia (maruska.subic-kovac@fgg.uni-lj.si)

1. Planning Context

Geographical Scale	Municipal
Status:	In development
Planning Process:	Formal planning process

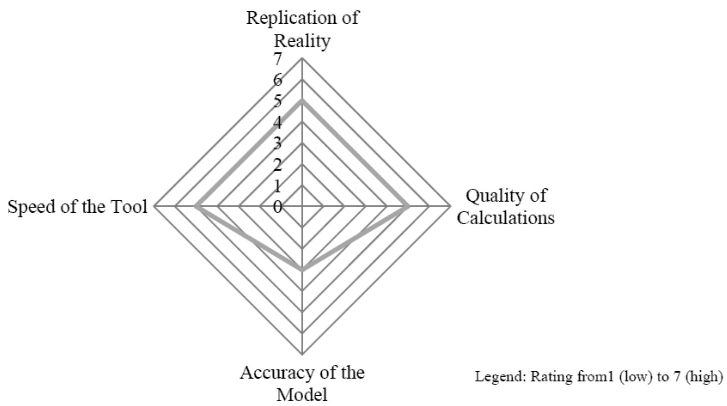
2. Planning Goals

Public Stakeholder Goals:	How to decide on the location of residences/activities How to ensure social equity and/or cohesion How to ensure economic equity
Private Investors Concerns:	Where to invest in real estate
Main Individual Goals:	Choosing household location

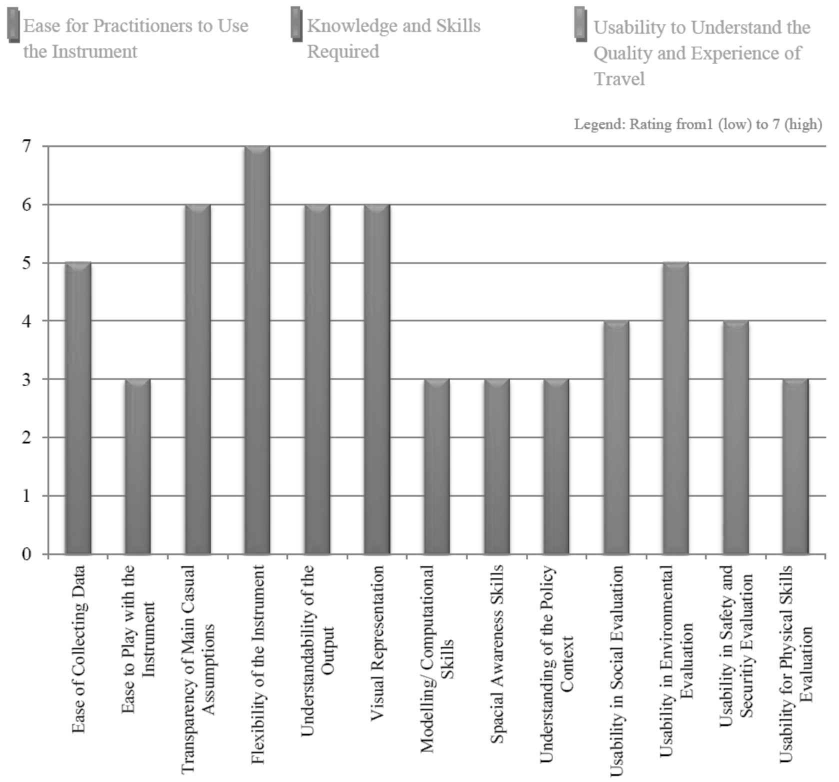
3. Characteristics of the Instrument

Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Spatial separation measures Utility measures
Components:	All accessibility components (Land-use; transportation; temporal; individual)
Level of Spatial Aggregation:	NUTS 4/ LAU 1 Plots
Level of Socio-economic Disaggregation:	Physical ability
Level of Temporal Disaggregation:	Dynamic (real-time)
Transport Modes:	Don't know yet
Purposes/ Opportunities:	Don't know yet

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planner Politicians Citizens Developers/ Researcher
Interpretable Units Used:	Don't know yet
Intended Use to Connect Service Users and Providers:	A tool to monitor consistency of perceptions/ expectations between providers, users and suppliers
Intended Role in Urban Planning:	To support strategy/ option selection To support integration of urban planning perspectives
Institutional Issues Blocking Effectiveness :	Don't know yet

IMaFa – Isochrone Maps to Facilities

Rosa M. Arce Cruz, Politécnica de Madrid, Spain (rarceruiz@caminos.upm.es)

1. Planning Context

Geographical Scale	Supra-National National Supra-Municipal Municipal Neighbourhood Street
Status:	Research tool As part of health planning
Planning Process:	Transportation Management

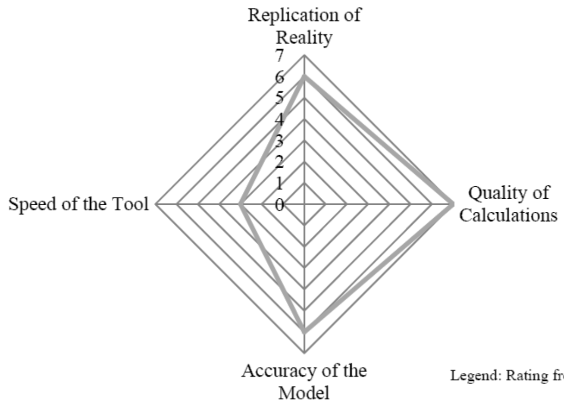
2. Planning Goals

Public Stakeholder Goals:	How to facilitate access to basic services
Private Investors Concerns:	Where to locate business
Main Individual Goals:	Choosing the best mode (s) for a particular route (s)

3. Characteristics of the Instrument

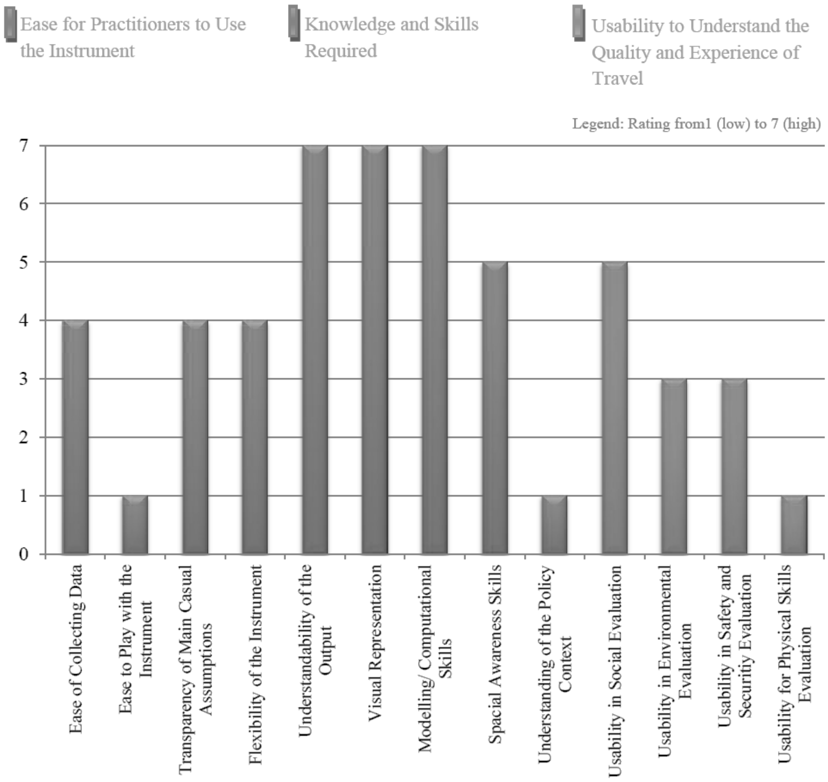
Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Spatial separation measures Time-space measures Network measures
Components:	Some accessibility components (transportation; temporal)
Level of Spatial Aggregation:	NUTS 2; NUTS 3; NUTS 4/ LAU 1 Plots
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None/ aggregate measure
Transport Modes:	Walking; Public transport (bus, metro)
Purposes/ Opportunities:	Work; Leisure; healthcare; Shopping

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Developers/ Researchers
Interpretable Units Used:	Time map
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To support decisions/ positions already taken To support strategy/ option generation To support strategy/ option selection
Institutional Issues Blocking Effectiveness :	Separate urban and transport planning institutions Formal processes Data availability Different planning objectives and assumptions Political commitment

PST - Place Syntax Tool

Alexander Stahle, KTH, Sweden (alexander.stahle@spacescape.se)

1. Planning Context

Geographical Scale:	Municipal Neighbourhood
Status:	As part of the planning process Research tool
Planning Process:	Formal Planning Process

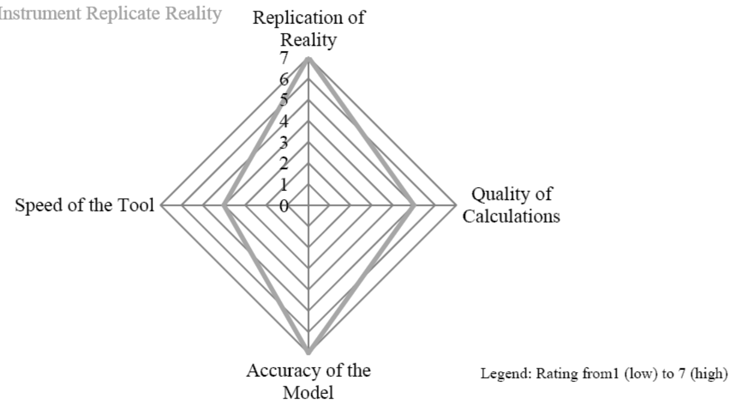
2. Planning Goals

Public Stakeholder Goals:	Traffic and urban planners in municipalities
Private Investors Concerns:	Where to invest in real estate
Main Individual Goals:	Selecting housing area with a good choice of services

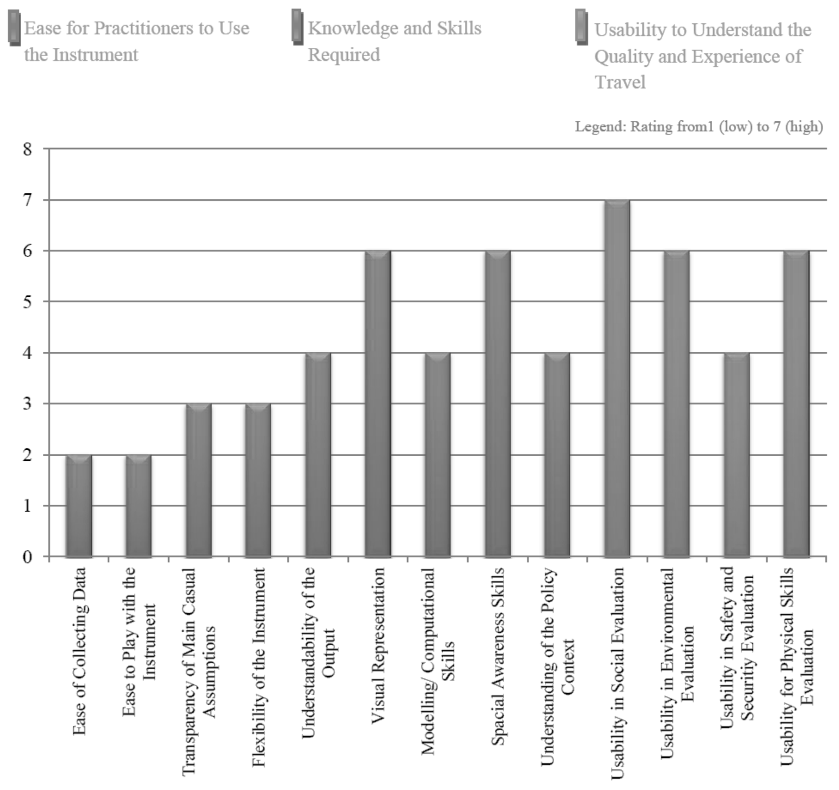
3. Characteristics of the Instrument

Decision Support Task:	Passive decision support tool
Accessibility Measure Tradition:	Network measures
Components:	Pedestrian and bike routes (segment/axis lines) Different attractors integrated (e.g. density och plots)
Level of Spatial Disaggregation:	NUTS 4/ LAU 1; NUTS 5/ LAU 2; Census tract Plots; Buildings; Transportation terminal/ hubs Axial lines; Road center lines Households
Level of Socio-economic Disaggregation:	None/ aggregate measure
Level of Temporal Disaggregation:	None/ aggregate measure
Transport Modes:	Walking, bicycle (all modes can be included)
Purposes/ Opportunities:	Any purpose

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Tool initiators
Interpretable Units Used:	Meters Number of Attractions
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To justify decisions/positions already taken To support strategy/ option generation To support strategy/ option selection To support integration of Urban Planning Perspectives
Institutional Issues Blocking Effectiveness :	Staff Technical skills

SoSINeTI - Social Spatial Changes because of New Transport Infrastructure

Maike Homke, ETH Zurich, DARCH-gta, Switzerland (mhoemke@ethz.ch)

1. Planning Context

Geographical Scale	Municipal
Status:	In development
Planning Process:	Not applicable

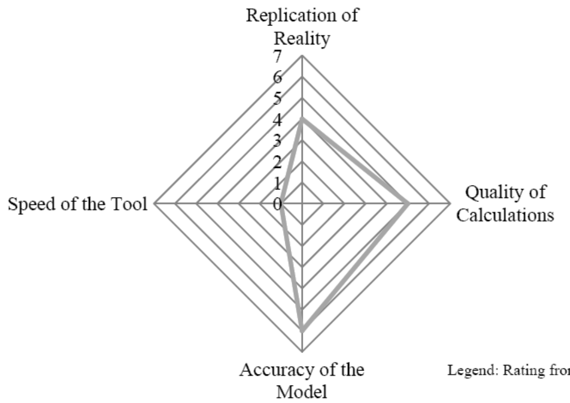
2. Planning Goals

Public Stakeholder Goals:	Other
Private Investors Concerns:	Don't know yet
Main Individual Goals:	Don't know yet

3. Characteristics of the Instrument

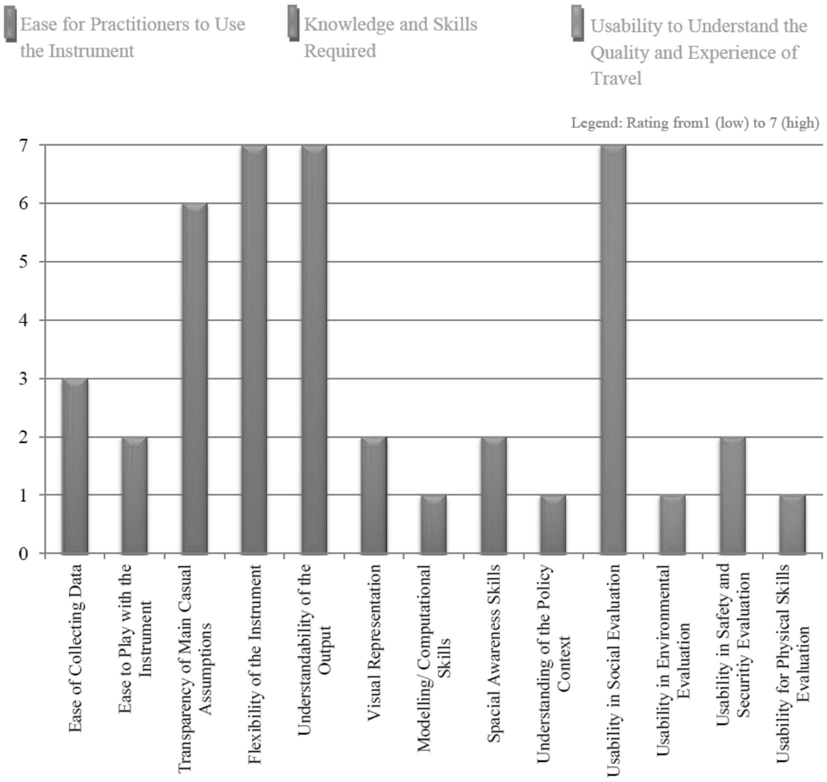
Decision Support Task:	Used in the ex-post evaluation of the decision impact
Accessibility Measure Tradition:	Time-space measures
Components:	Some accessibility components (Transportation; Individual)
Level of Spatial Aggregation:	Not applicable
Level of Socio-economic Disaggregation:	Not applicable
Level of Temporal Disaggregation:	Year
Transport Modes:	Public Transport (Train)
Purposes/ Opportunities:	No purpose/ Not applicable

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners
Interpretable Units Used:	Not applicable
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To understand social changes because of better accessibility
Institutional Issues Blocking Effectiveness :	Not applicable

SNAPTA - Spatial Network Analysis of Public Transport Accessibility

Angela Hull, Heriot-Watt, United Kingdom (a.d.hull@hw.ac.uk)

1. Planning Context

Geographical Scale:	Municipal
Status:	Functioning as a research tool
Planning Process:	Formal Planning Process

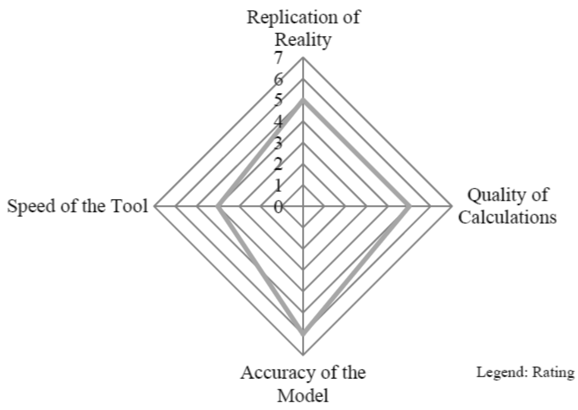
2. Planning Goals

Public Stakeholder Goals:	How to decide the location of residences /activities / services
Private Investors Concerns:	Where to locate business
Main Individual Goals:	Where to locate business

3. Characteristics of the Instrument

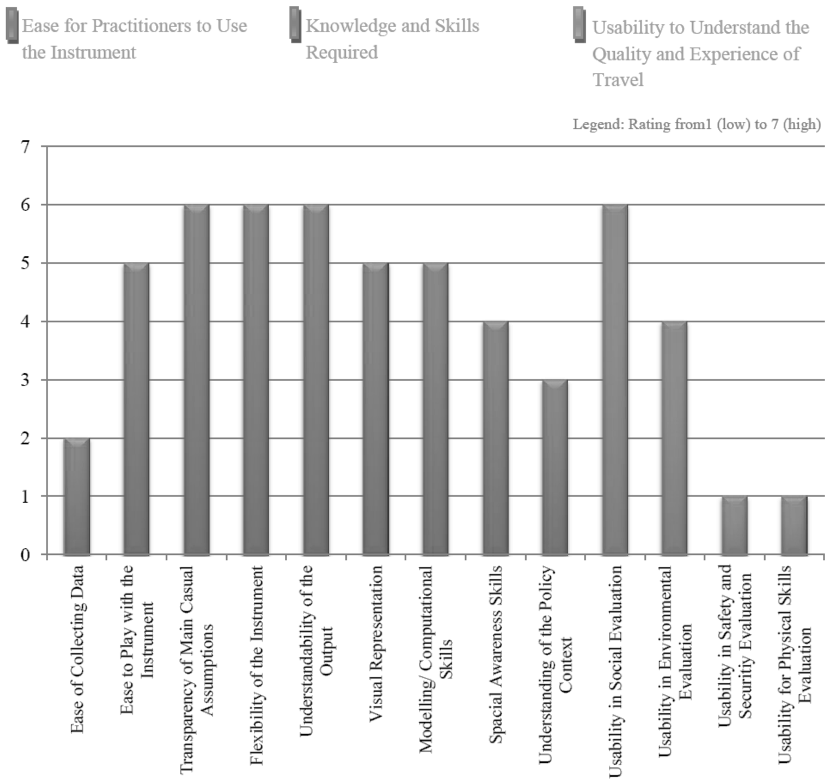
Decision Support Task:	Used in the ex-post evaluation of the decision impact
Accessibility Measure Tradition:	Spatial separation measures Contour measures Gravity measures Utility measures
Components:	Some accessibility components: land-use; transportation
Level of Spatial Disaggregation:	Census tract
Level of Socio-economic Disaggregation:	Car Ownership
Level of Temporal Disaggregation:	Peak/ Off-peak Dynamic (real-time)
Transport Modes:	Public Transport (bus; train; tram)
Purposes/ Opportunities:	All Purposes (aggregate measure)

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. END-USERS AND HOW THEY USE THE TOOL



Potential Users:	Spatial/ Urban Planners Transport Planners Health service planners Education service planners; Developers/Researchers
Interpretable Units Used:	Datazone centroids used for distance origins Datazones contain 500-1000 households
Intended Use to Connect Service Users and Providers:	A tool to monitor consistency of perceptions/ expectations between providers, users, suppliers (matching top-down to bottom-up)
Intended Role in Urban Planning:	To support strategy/ option generation To support strategy/ option selection
Institutional Issues Blocking Effectiveness :	Formal processes Different planning objectives/ assumptions Staff technical skills Political commitment

ACCALC - Database suite for calculation of UK accessibility statistics

Derek Halden, DHC, United kingdom (derek.halden@dhc1.co.uk)

1. Planning Context

Geographical Scale	Various
Status:	Used in practice for about 15 years
Planning Process:	Various

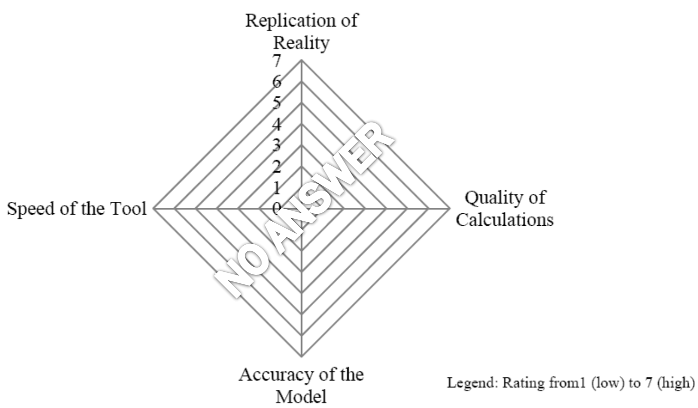
2. Planning Goals

Public Stakeholder Goals:	Various
Private Investors Concerns:	Cannot be answered
Main Individual Goals:	Cannot be answered

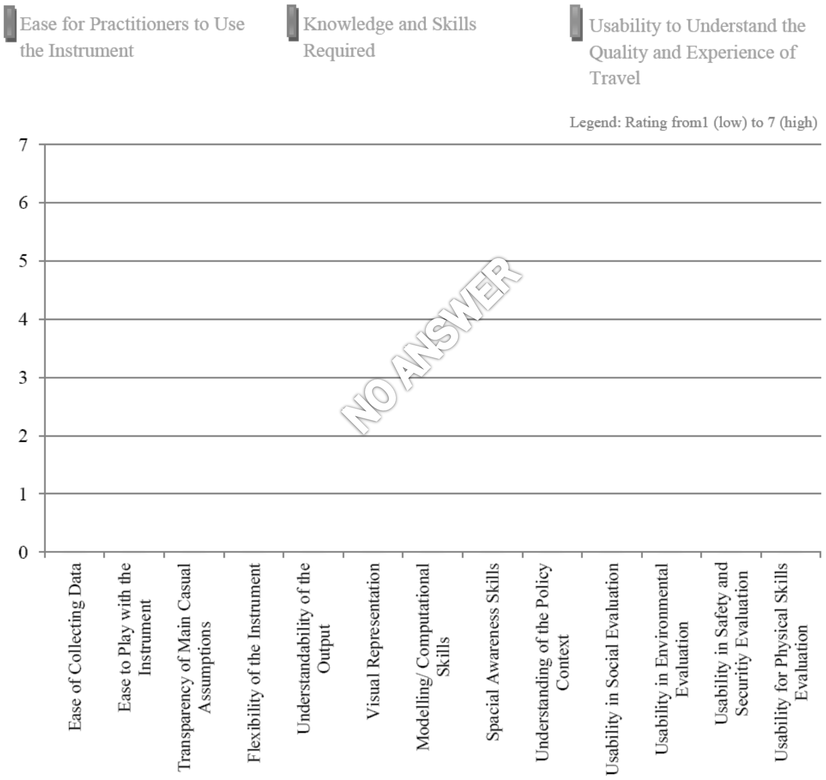
3. Characteristics of the Instrument

Decision Support Task:	Used in many different parts of the planning, appraisal and project delivery process
Accessibility Measure Tradition:	Extension of activity based transport and lad-use modeling optimized to provide information relevant to understanding time, cost, physical, safety, temporal and other barriers of access
Components:	
Level of Spatial Aggregation:	From house address point for neighbourhood analysis to regions or nations for global analysis
Level of Socio-economic Disaggregation:	Typically 16 categories in national analysis (e.g. job seekers, stdents, car ownership, tec.)
Level of Temporal Disaggregation:	Typically 30 minutes segments throughout day and night
Transport Modes:	All modes
Purposes/ Opportunities:	Any purposes

How the Instrument Replicate Reality



4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Health service planners Education service planners Developers/ researchers
Interpretable Units Used:	Yes
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To facilitate user focused planning
Institutional Issues Blocking Effectiveness :	Formal processes Different planning objectives/ assumptions Staff technical skills Political Commitment

PlaSynt – Place Syntax Instrument

Tobias Nordstrom, Spacescape, Sweden (tobias.nordstrim@spacescape.se)

1. Planning Context

Geographical Scale	Supra-municipal Municipal Neighbourhood Street
Status:	As part of the planning process Research tool
Planning Process:	Formal Planning Process

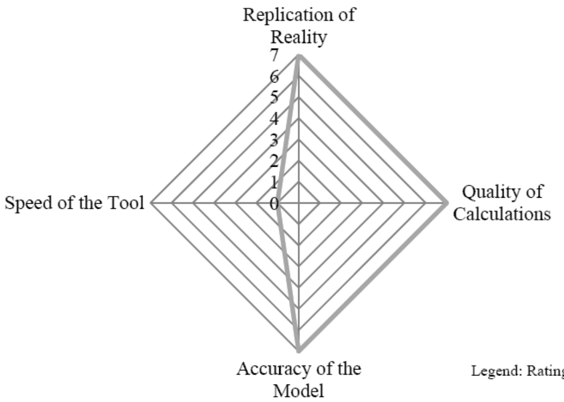
2. Planning Goals

Public Stakeholder Goals:	To understand travel habits as well as the potential of public space and its potential in social integration
Private Investors Concerns:	Local market foundation for retail
Main Individual Goals:	Where to live independent of car use

3. Characteristics of the Instrument

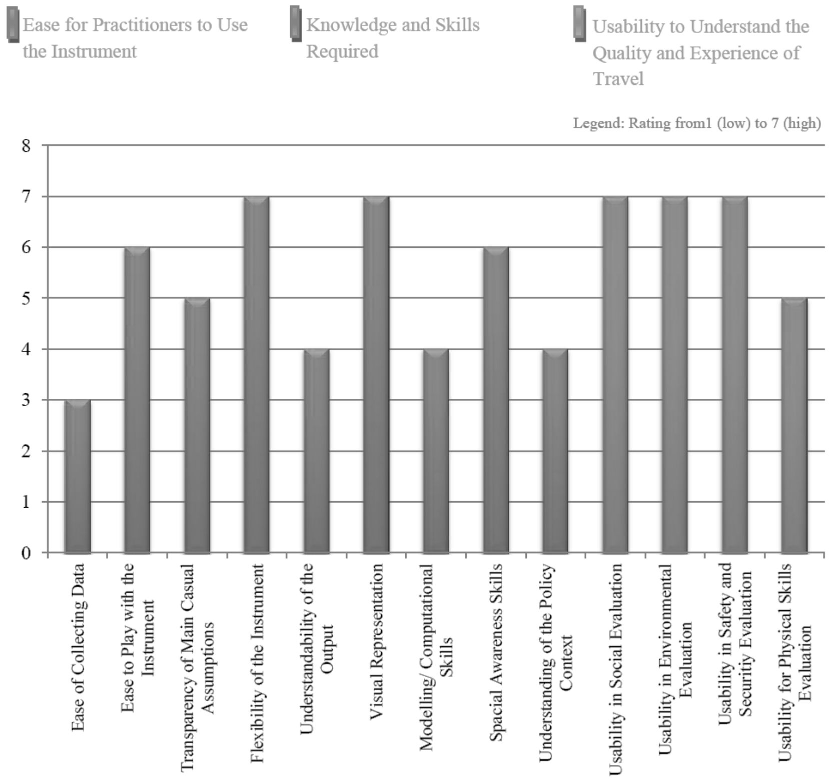
Decision Support Task:	Strategic planning support tool
Accessibility Measure Tradition:	Network measures
Components:	Some accessibility components: land-use; transportation
Level of Spatial Disaggregation:	NUTS 3; NUTS 4/ LAU 1; NUTS 5/ LAU 2 Plots Axial lines Individuals
Level of Socio-economic Disaggregation:	Income Education
Level of Temporal Disaggregation:	None/ aggregate measure
Transport Modes:	Walking, bicycle
Purposes/ Opportunities:	Any purpose

How the Instrument Replicate Reality



Legend: Rating from1 (low) to 7 (high)

4. End-Users and How They Use the Tool



Potential Users:	Spatial/ Urban Planners Transport Planners Health service planners Education service planners Retailers Citizens
Interpretable Units Used:	Distance in bith meters and axial lines Amount of attractions
Intended Use to Connect Service Users and Providers:	Not applicable
Intended Role in Urban Planning:	To create new insights To support strategy/ option generation To support strategy/ option selection To support integration of Urban Planning Perspectives
Institutional Issues Blocking Effectiveness :	Separate urban and transport institutions; Data availability; Different planning objectives/ assumptions

APPENDIX C

Overall plans and political steering documents.

The *governmental purviews for shopping centres* (Ministry of the Environment, 2008) state in §1 that it aims to contribute to a stronger regional coordination of the shopping centres policies. The objectives are to strengthen existing city and town centres, and to contribute to a more efficient land use and to more environmental travel behaviour in order to avoid a development causing urban sprawl, car dependency and worsened accessibility for those without a car. The long-term objective is to achieve a more sustainable and robust development of cities and urbanised areas and to limit GHG-emissions.

The rules for the development of shopping centres are listed in § 3. They say that shopping centres can only be established or enlarged in accordance with approved county plans or county sector plans which include directions for localisation of retail and other service functions. In areas which are not covered by such plans, shopping centres cannot be established which are larger than totally 3.000 m^2, or enlarged so that they exceed this. The County Governor can approve to disregard these purviews if, after a concrete analysis, it is found that the development is in accordance with §1 in these purviews.

One of four main objectives in the *comprehensive municipal plan for Oslo* is that "Oslo shall have a sustainable urban development" (Municipality of Oslo, 2007: 39). One of the strategies for achieving this is to continue following a coordinated land use and transport development strategy. This explicitly includes among others compact land use development in order to minimize car use. Business, retail etc. should be developed in designated public transport nodes. Økern is one of these.

The municipal sector plan for retail and services

The overall objective or goal for development of the retail- and centre structure in Oslo is in the *municipal sector plan for localisation of retail trade and other services* [18] (Municipality of Oslo, 2003) stated as to contribute to a sustainable urban development, with a compact land use and a coordinated land use and transport development. Oslo shall also have an efficient and robust centre structure with vital retail centres. For the inhabitants this means good coverage, proximity and accessibility for all to shopping and service, for the society it means localisations which contribute to improve the environment by hindering urban sprawl, and to reduce travel lengths and car use, and for the retail business it means to offer predictable and favourable conditions as terms for enable them to develop good local services in a suitable centre structure which offers stability over time. A main idea is that regional and car-based shopping centres shall not be allowed in Oslo.

These goals or objectives are well supported by the directions and the binding purviews in the plan, which make the plan a strong and powerful tool for steering retail development. According to the planning authorities (department of urban development), the plan is strong and well-functioning. The City Council has mainly been loyal to the

[18] This is also regarded as a county sector plan, for instance in relation to the governmental purviews, since Oslo is both a municipality and a county.

plan, and the developers have hence in general accepted it as a strong signal regarding what will be allowed. The planners at the planning authorities know that this is something which is taken very seriously, and they ask the experts in this field for help when necessary. The planning authorities find that the clarity and understandability of the plan is a strength. Still, it is dynamic since it is designed so that it follows the urban development. It is not detailed, and distinguishes only between two types of goods.

Theoretical and empirical knowledge in the sector plan

The municipal sector plan for location of retail and service in Oslo accounts for the understandings of how localisation of retail and services affect the retail structure, the accessibility to retail and traffic generation caused by retail shopping, as well as the empirical knowledge in an Oslo-context. It does, however, not refer to theoretical knowledge, or to empirical knowledge from other cities or to more general empirical knowledge.

The empirical knowledge, and the understandings based on it, is accounted for in five chapters [19]. In chapter three, data showing status and development for retail in the area, development over time, distribution in the region and in the city and changes of location of existing and future retail centres are presented.

The main understandings of the sector plan

Readings of the sector plan, and an interview with a representative from the department responsible for the municipal sector plan, have disclosed the understandings and knowledge embedded in the plan. This includes among others that the chances are higher that people walk or bicycle on a journey if the journey is short than if it is long, and that more people will use public transport on a journey if the services are good than if they are bad. Hence, if a shopping centre is located in walking and bicycling distance from as many customers as it needs to provide for the necessary turnover, and if it is located in an area well served by public transport, fewer will use a car on their travel to this shopping centre than if the location had the opposite characteristics (in the Norwegian debate one often discusses 'external shopping centres').

Following from this, it contributes to less car use if the retail centre structure consists of many smaller retail centres than of few big ones, and if these are located in the public transport nodes and in densely populated areas. Fewer and bigger centres would increase the average travel distances from the homes in the city to the nearest shopping opportunity, and hence increase car use on shopping journeys.

In order to be profitable, a shopping centre needs a certain turnover per square metre, and data exist regarding how much this approximately is in various contexts. Given that one knows approximately how much the average person spends on shopping (and there are good data for this as well) at different kinds of centres (regional city centre, local shopping area, nearest grocery store etc.), one can make rough calculations regarding

[19] Descriptions of methods, together with more results, maps etc, are presented in a more detailed 'Part II Background material' to the plan.

the number of customers needed for the profitability of the centre. This background information is described and analysed in the municipal sector plan, and is regularly updated. This updating is normally based on information from Statistics Norway and about planning initiatives reported to the planning authorities.

The sector plan states that the customers should live in walking or bicycling distance to the centre. The dimensions of a retail centre are hence defined (according to the municipal sector plan) by the number of people living in walking and bicycling distance from the centre.

An important condition for this to work is that only the main city centre of Oslo is allowed to grow big enough to be a regional shopping centre which to a large extent attracts customers from outside its own 'neighbourhood'. It is of course acknowledged that there is competition between centres, but also that most people do much of their shopping at the nearest facility. It is also acknowledged that people do shop other places than at their nearest centre. Still, as the overall planner at the planning authorities explained, since this is happening in more or less similar ways all over the city one still can define the size of the centres based on the number of people living in walking and bicycling distances from the each

This strategy has created the present retail structure

This way of thinking and acting regarding the retail development in Oslo is what has created the structure one finds today, and which in the analysis is found to be a good and in general satisfactory structure which serves the objectives of the sector plan well.

A dynamic and adaptive – but clear and strong - steering tool

This also makes the sector plan dynamic, since the maximum size of the shopping centres changes as the population size and retail structure change. However, if major changes are implemented in this system, for instance that a new regional shopping centre which draws large parts of its customers from other centres' a market area is established, this will affect the whole retail structure. The smallest centres may be forced to close down, and others may offer less than today. Both of these effects would cause people to travel longer distances in order to do their shopping, which also would cause more road traffic. Hence, it is an important part of the Oslo plan that *only the city centre is allowed to grow big and regional.* This is in accordance with the understanding of the city as a complex and dynamic system.

By deciding the location of the shopping centres (marked on map), as well as the criteria for their dimensioning, Oslo has created a steering instrument which allows the city to develop a centre structure with many and smaller shopping centres rather than few and large ones. According to their own analyses, this will contribute to a centre structure which ensures good accessibility to necessary services for the inhabitants, and which requires rather low car use on travels related to shopping.

This is also recognised several times in the developers' analyses and descriptions, where it for instance is expressed that the longer journeys the higher car shares, the higher share of the customers living close to the centre the less car use, the bigger centre the higher car use and so forth.

The developers/initiators expressed in interview that they find the sector plan to be undemocratic. It is too rigid due to political directives regarding how the retail structure is supposed to develop. The initiator doubts that there can be any real planning and steering of retail development, but agrees that some kind and degree of steering is both necessary and desirable.

APPENDIX D

SECTION 3: ACCESSIBILITY INSTRUMENTS

Accessibility is considered in many ways within planning practice and this guidance on writing short reports about each instrument is intended to provide a flexible framework to communicate the different practices in place. The report guideline below has some main headlines and you should complete one report for each instrument you highlight.

Accessibility Instruments can be:

Measuring attributes of places or people – e.g. planning tools to identify how to make places more liveable or ways of identifying the opportunities available to people when planning new facilities or destinations.

Analytical methods to apply accessibility principles within planning – e.g., parking policy standards based on accessibility criteria or public transport service delivery requirements based on people's accessibility needs.

Models to understand dynamic effects and connectedness in transport networks, in particular the dynamics between spatial plans and transport investments.

Indicator calculation methods where indicators are used to audit, monitor or set standards for planning policies (e.g. travel time indicators)

Others?

An overarching consideration is that we are focussing on information/knowledge to support the planning/policymaking process not on planning/policy measures as such. For example, a policy to locate large traffic generators close to railway stations is not an 'Accessibility Instrument'. On the other hand, information/knowledge that helps identify what in this context a 'large traffic generator' is, or what the level of service of the railway station should be, could be considered an 'Accessibility Instrument'.

The report should not exceed 2000 words and be at least 1000 words. To better illustrate the application and/or methodology of the Accessibility Instrument, the report should ideally include a minimum of 1 and a maximum of 3 figures.

The report should be posted on the website AND sent by e-mail to l.bertolini@uva.nl by 19th December 2011. Instructions on how to post the report on the website will follow in due time.

Each report will be reviewed by two people: a member of the section 3 working group (Luca Bertolini, Sanna Iltanen, Bruno Santos, or Derek Halden) and a member of another working unit (you will be each asked to review a report).

Reviewers will send guidance on corrections to be made by January 13th 2012.

The final version must be posted on the website AND sent by e-mail to l.bertolini@uva.nl by January 27th 2012.

Please write your report according to the following structure and taking into account the following questions:

Sub-section title	Questions to answer	Word length
1.Background	What was the motivation for developing your accessibility instrument? What were the scientific questions it wanted to answer, if any? What were the planning problems it wanted to address, if any?	Min 150 words; Max 300 words
2.Conceptual framework and theoretical underpinnings	How does your instrument define accessibility? How does your instrument measure accessibility? Which are the theoretical underpinnings of this definition and measures? Why did you choose this definition and measures?	Min 150 words; Max 300 words
3.Operational aspects	Which types of accessibility does the instrument measure (see examples below)? Examples of accessibility types are: walk times to public transport services or to local facilities, travel times using public transport systems, travel times by private car, potential customers within a defined catchment area, degree of spatial separation/integration etc. How does your instrument calculate accessibility? Which data is required? Is the data publicly and freely available? If not at which conditions can it be obtained? How is the data processed? What are the hardware and software requirements? Is the software publicly and freely available? If not, at which conditions can it be used? How much time does the calculation require?	Min 250 words; Max 500 words

Sub-section title	Questions to answer	Word length
	Which degree of technical expertise is required to perform the calculation? Which degree of technical expertise is required to interpret the results?	
4.Relevance for planning practice	What information does your instrument produce that can be useful for planning practitioners? Has the instrument been used before in a real planning context? If yes: Where and when? Which planning problem, or problems, did the instrument address? How did the instrument help in decision-making? What difference did it make in the planning outcome and/or in the decision-making process? If no: Why not? Has the possibility of using the instrument to address a planning problem and support a decision-making process been otherwise explored? If yes, provide a brief description of the planning problem and how the instrument can provide support to decision makers.	Min 200 words; Max 400 words
5.Strengths and limitations	What are the most important strengths and weaknesses of your instrument from a scientific point of view? What are the most important strengths and limitations of your instrument from a practice point of view? If the instrument has been used before in a real planning context: What where the most important positive and negative reactions of planning practitioners? If the instrument has not yet been used in a real	Min 250 words; Max 500 words

Sub-section title	Questions to answer	Word length
	planning context: What do you expect to be important advantages and disadvantages of using your instrument to support planning practice? Are you planning any future improvements to the instrument, either from a scientific or practice point of view? If yes: Which improvements are you planning to address scientific limitations? Which improvements are you planning to address practice limitations?	
Figures	Figures are meant to illustrate the report (e.g. in sub-section 3 or 4). Provide each figure with a number and a short description/caption. Refer to figures in the text wherever appropriate.	Min 1 figure Max 3 figures

Note: If the Accessibility Instrument presented by the WU is part of a broader instrument, please focus the paper on the Accessibility Instrument with very brief reference (in the 'Background' section) to the broader planning instrument of which it is part (answer all remaining questions with regard to the Accessibility Instrument only).

APPENDIX E

Table Comparison of the operational aspects of the Accessibility instruments

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
SNAMUTS	Relation between public transport (PT) service and land use (LU) activities Utilizes six indicators: 1) ease of movement along PT network; 2) directness of journeys on PT; 3) combine effect of PT on LU intensity; 4) competitiveness of PT vs car; 5) geographical distribution of attractive travel paths; 6) nodal connectivity.	Not described	Time Not described Software ArcGIS	Not described
TRACE	Distance of retail clusters to relevant infrastructure (e.g., train stations, major roads) Other accessibility measures could be calculated (such as gravity-based)	Geo-referenced data of shops Type o retails, net floor surface, and type of shopping area Data available from Locatus database (payable)	Time 1 to 1.5h for a set of 34000 records in a mid-range laptop Software ArcGIS with Spatial Analysis extension	Both performing calculations and understanding the results is relatively easy The tool is intuitive and can be used by anyone familiar with ArcGIS

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
ASAMeD	Degree of spatial separation/integration Travel from one line to another across the graph in topological terms (referred to as *depth*)	Axial (vector) maps, with the set of lines of sight passing through every public space Automatically generated from vector maps or manually from image files of maps	Time Few minutes for small urban areas Few hours for a city Software Depthmaps (Windows) is publicly and freely available Open-source	The analysis is calculated automatically without any special knowledge or technical expertise Broad knowledge on theory of space syntax is needed to interpret the results
ABICA	Activity based indicator Visualization of interaction patters – desire-line traces that indicate loads, demand for capacity, and spatial patterns of dependency and centrality.	OD datasets (generally not free) Danish case: obtained from either Danish commuter survey or the Danish National Travel Survey	Time Not described Software Software to handle with large datasets, geo-statistics and maps (e.g., ArcGIS or open-source R)	Handling of data and analysis does require some technical expertise (more than general GIS courses)
HIMMELI	Proximity of households to retail units in travel cost Clustering of each retail units (with respect to other retail units)	Data concerning households + retail services (typology and location) and transportation systems (travel cost matrix)	Time 20000 discrete spaces = 50 minutes Software MapInfo (script coded in Basic and C#)	Not described

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
Contactability	Travel time using public transport (rail and air)	Data available from OAG (www.oag.com) for flights and by automatic queries of the public website DieBahn.de for the train timetables	Time 1,5 months to do a case study (from data collection to cartography) Software MySQL+Musliw (not publicly available)	The degree of technical expertise is high for calculation and processing information The degree of technical expertise for interpretation is low
EMM	Regional Level: gravity index that estimates accessibility to population and job potentials (travel time in car and transit) Local Level: large variety of indicators combining travel times in car, transit, cycling & walking, analyzing accessibility to facilities, transport hubs, and other POI	Structural data: population and employment (public in Germany at the municipality level) Transport data from OpenStreetMap (free-online), transit web-sites	Time Varies but is generally high (several hours to several days) Software Online (GIS-based) tool has been developed that, currently, is still not publicly available	Only usable by experienced modellers (GIS & databases) No technical skill will be needed to access the online tool
RIN	Journey times between central locations and residential areas Transport network sections are classified according to the level of central locations connected and their function	Not described	Time Not described Software Not described	Not described

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
MoSC	Street connectivity (space syntax)	Street centre line information from standard GIS street network or CAD files	Time Ranges from seconds to few hours Software Spatialist_lines (upon request) – plug-in of ArcView	Basic knowledge of GIS software to perform calculations Visual maps are easy to understand
InViTo	Walking time from the nearest public transport access point	Network information (usually free from OpenStreetMaps)	Time Not described Software Rhinoceros (commercial) combined with its free plug-in Grasshopper	Not described
GraBAM	Gravity indicator for: • residents towards workplaces • economic activities towards residents Distance measured in generalized travel cost	Socioeconomic (National Statistics) Land use characteristics and transport network	Time Not described Software TransCAD GIS software	The use of the software requires a medium level of expertise, for calculation and interpretation

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
JAD	The accessibility measure varies with the applications Are related to societal goals (cohesion, competitiveness, sustainability) The accessibility is measured with a distance decay function	Spatial and travel time data (usually owned by municipalities)	Time One day for travel times calculation + 15 min for maps production Software ArcGIS	GIS skills are sufficient
MaReSi SC	Real walking distance from dwelling to shopping centre	Residences location Retail structure (time spent on shopping, turnover, etc) Plans and probable developments Population extrapolation Spatial GIS data Data available in a plan-making process	Time Not very work-consuming Software ArcGIS	No advanced skills are needed Planning knowledge is the main competence necessary
GDATI	Geographic and demographic accessibility of transit linear and punctual infrastructure	Geographic and demographic data (obtained from GIS maps) Transport data can be obtained online or via transit operators	Time Calculations are not time-consuming, data collection is! Software Not described	Basic level of technical knowledge is needed to perform calculations Advanced level of technical knowledge is needed to interpret results

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
SAL	Compares the variety of travel generating activity types reachable by different transport modes within a given travel time/cost limit	Geo-referenced data (population, employment, activities location - by CENSUS; transport infrastructure, service level, demand) The data is generally purchased and owned by local authorities	Time May reach out to weeks Software GIS with network analysis	Advanced technical skills are needed if no processing scripts are available Results are easy to understand, considering both perceptions of accessibility and map reading
UrbCA	Travel time by private car Land use changes are used to represent accessibility variations throughout time (forecast)	Land use information (obtained from National Statistics and local planning authorities) Transportation network, including future investment/change planned (obtained from local authorities)	Time Vary from hours to 1.5 days Software Standalone Visual Basic tool	Some GIS expertise is needed to preprocessin g data No specific expertise is needed to interpret results

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
ATI	Physical distance and capacity of the existing and proposed technical infrastructure Accessibility is determined by 1) the distance; 2) the capacity of elements; 3) costs.	Land use info, density, housing construction typology, land subdivision, private/public land ownership Technical infrastructure data (distance, capacity, etc) Most data is available for free in public records; others can be measured; others will be based on surveys and workshops	Time Not described Software ArcGIS with spatial analyst	The interpretation of the results will be easy
IMaFa	Travel time by transit to shopping centres	Digital transit network (with travel times, scheduling, transfer times, stations/stops etc) Street network (for walking times) Location of shops Population data	Time Not described Software ArcGIS & EMME3 for traffic assignment (commercial) or other traffic assignment software	Some technical knowledge of network analysis using GIS is required Results can be understood by everyone

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
PST	Space syntax	Not described	Time Not described Software Place Syntax Tool for MapInfo A DLL library coded in C/C++	Not described
SoSINETi	It measures different types of accessibility and compared over the years: Travel times between municipalities Connectivity Rent market changes (social)	- All the data is available but needs own investigation and research All observations are long-term observations within 5 up to 10 years	Time Depends, but no longer than one or two weeks. However, it has to be repeated every year, maybe more often. Software No soft- or hardware is needed but a statistical program, such as SPSS, can be used	No special requirements in technical expertise are needed Some interest in social sciences and empirical methods will help

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
SNAPTA	Time access to city centre by transit Total number of economic activities or destinations within a defined catchment area using transit Gravity-based measure using morning PH travel times and quantity of activity opportunities per zone	Population: uses UK Census Data Zones Jobs, gross floor area of retail shops and facilities, number of patients: obtained under license from government organization Number of students per school and university, number of recreation facilities: obtained from websites Transportation network info	Time Data collection is very time consuming Running SNAPTA in GIS does not take a long time Software GIS (ARC/INFO)	Data input and performing the calculation requires a good knowledge of GIS The ease of interpretation of results depends on the accessibility measure used

Instrument	Type of Accessibility	Data required & availability	Calculation requirements	Expertise
ACCALC	Travel time or costs for different purposes and for different periods of the day, by different modes (transit, walking, etc),	Land-uses, data on locations, OD demand data, travel times, etc Data has become much more freely available over the last 2years with the open data government initiative. Data on commercial facilities, like shops and theatres, can still be quite expensive to purchase	Time Building the matrices takes many hours; Once built, ACCALC uses these matrices and can analyze policy questions in real time Software Microsoft Access or MS SQL (recently) + Excel ACCALC is hoped to provide web-based user front end so that anyone can use the tool free of charge	A high level of technical expertise is needed to run the analysis

APPENDIX F

Table Comparison of the planning relevance of the accessibility instruments

Instrument	Information Produced	Use in real planning
SNAMUTS	Visualises a public transport network's strengths and weaknesses Interactive design tool for scenario planning	2007 - Perth radial suburban railway and land use plans for intensification of activities 2009 – Benchmarking accessibility between cities 2009 - Impacts of orbital bus service in Melbourne
TRACE	Developed and tested to analyse retail landscape in Flanders. Analysing balance between sector efficiency and spatial goals	Not identified
ASAMeD	Space Syntax spatial configuration of social issues	Not identified
Space Syntax and SAL	Describes links between space quality, environmental characteristics and pedestrian activity	Not identified
ABICA	Analysing the connectedness of a municipality towards other areas	Research project referenced in practice
HIMMELI	Observation of factors behind different development paths allowing planners to influence development more effectively	Not as yet
Contactability	Travel times using public transport to compare cities	Used in a competitiveness indicator for cities
EMM	Potential for transit orientated development Neighbourhood accessibility Indicators for land use planning	Mainly in development stage but has been used in stress tests for sustainable mobility showing resilience of places to energy price fluctuations.
RIN	System of central locations for defining spatial components of standards Set standards for slow modes and public transport for improvement and for car to maintain current standards	Standards set and guidance issued to authorities.
MoSC	Measures of connectivity including spatial and cognitive influences on behaviour	2010 - master-plan for the King Abdullah University of Science and Technology Science Town

Instrument	Information Produced	Use in real planning
InViTo	Relationship between facilities and settlements as an influence on localism	Pilot in northern Turin to investigate the transformations resulting from the new subway Identifying new functions in the city of Asti
GraBAM	Spatial distribution of accessibility levels	Many applications most recently the Regional Metro System Plan of the Campania Region (South-Italy)
JAD	Develop measures jointly with practitioners in each local setting	Collaborative approach largely research so far but undertaken in the context of current real planning problems in the Netherlands
MaReSi SC	Number of square metres of shopping space recommended to serve a population	Applied by planning authorities in Oslo for some years.
GDATI	Various indicators relating public transport network characteristics to urban density	Only used in research so far
SAL	Diversity of accessibility indicator Accessibility cluster indicator	Information on spatial inequalities used in research in Oporto
UrbCA	Simulate different planning scenarios of land use evolution taking the influence of the transport system explicitly into account.	Not yet fully used in real-world planning processes but to be tested shortly
ATI	Indicators of different degrees of accessibility presented separately for example different services or combined	Under development and not yet applied
IMaFa	Total population within time thresholds to measure accumulated opportunities	Applied in 2005 in the Autonomous Region of Madrid, in a collaboration between the regional Public Transport Authority and the Regional Health Department
PST	Axial distance to facilities	Application in research on access to green spaces.
SoSINeTi	Accessibility to infrastructure defined in terms of economic, ecological and social evidence	Development not completed

Instrument	Information Produced	Use in real planning
SNAPTA	Zonal accessibility by public transport to show impacts from transport infrastructure changes	Development recently completed and not yet applied
ACCALC	Car and non-car user accessibility opportunities to various land uses in terms of travel time and accessibility opportunities	Used by Scottish Government and local authorities since 1999 and recommended as a suitable tool in Scottish land use planning guidance and Scottish transport appraisal guidance. Used by UK department of transport for calculating neighbourhood statistics across UK.

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