Accessibility: Operationalizing a Concept with Revelance for Planners

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This is an accepted manuscript of a book chapter published by Routledge in Designing Accessibility Instruments: Lessons on Their Usability for Integrated Land Use and Transport Planning Practices on 8 May 2019, available online:

http://www.routledge.com/9781138206939

ACCESSIBILITY: OPERATIONALISING A CONCEPT WITH RELEVANCE FOR PLANNERS

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Abstract:

Earlier chapters in this book have shown that whilst accessibility is a well-studied concept in the scientific literature its use in practice is still limited. In this chapter, we examine 24 of the latest wave of Accessibility Instruments (AIs) represented in COST Action TU1002 to assess

their potential usability as planning support tools for transport and land use practitioners. We here describe their key features (background, conceptual framework and theoretical underpinnings, operational aspects, relevance for planning practice, strengths and limitations, and visualization) in some detail and we reflect in a more nuanced way, as urban planners, on the data collected thought a survey, on how these instruments can most usefully be deployed to address land use and transport planning issues. We also describe the developer's perception of usability collected through the same survey used for collecting the key features. We identify, per item, significant similarities and differences and reflect on potential implications for their usability in planning practice. Besides the Accessibility Instruments Survey, this chapter also uses data also from the AIs summary reports, which provide much richer information and explanation than the developer's survey of how they anticipate their instruments could have a role in urban planning.

The chapter is structured into six sections. The first section provides an overview of the background of the 24 AIs involved in this research, followed by a description of the role in urban and transport planning of the AIs. The third section concludes the debate around the key features of the 24 AIs going into detail on conceptual and operational issues, such as, the conceptual framework and theoretical underpinnings, the operational characteristics, and the visualization of outputs. Section 4 provides a specific analysis of the developer's perception of usability of their AIs. This is followed by a more general debate on the relevance of AIs for planning practice. Finally some general conclusions are drawn.

Keywords: accessibility instruments; accessibility planning

1. BACKGROUND

The chapter provides insights on a set of accessibility instruments (AIs) developed in Europe, exploring their general characteristics and the developers' perceptions of their usability (for a complete list of the AIs under analysis, their acronyms and full names see Table 1) (see also Hull et al., 2012 and Papa et al., 2014). Previous studies have in fact identified a gap between the clear definitions and measurements of accessibility and the limited number of researches focusing of the planning tools that make use of these measures and in particular that focus on the use and the usability of these decision support tools in spatial and transport planning practice.

Acronym	**Name**	**References**
ABICA	Activity Based Indicators of Connections and Access Needs	Nielsen & Næss, 2012
ACCALC	Database Suite for Calculation of UK Accessibility Statistics	Halden, 2012
ATRaPT	Accessibility Tool for Road and Public Transport Travel Time Analysis	Larsson & Elldér, 2013
ASAMeD	Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance	Charalambous & Mavridou, 2012
ATI	From Accessibility to the Land Development Potential	Kovač et al. 2012
Contactability	Contactability	L'Hostis, 2012
EMM	Erreichbarkeitsatlas der Europäischen Metropolregion Muenchen	Keller & Wulfhorst, 2012
GDATI	Geographic / Demographic Accessibility of Transport Infrastructure	Zakowska et al. 2012
GraBAM	Gravity Based Accessibility Measures for Integrated Transport-Land Use Planning	Papa & Coppola, 2012; Coppola & Papa, 2013
HIMMELI	Heuristic three-level Instrument combining urban Morphology, Mobility, Service Environments...	Iltanen, 2012
IMaFa	Isochrone Maps to Facilities	Arce-Ruiz et al. 2012
INViTo	Interactive Visualization Tool	Pensa, 2012
JAD	Joint-Accessibility Design	Straatemeier, 2012
MaReSi SC	Method for Arriving at Maximus Recommendable Size of Shopping Centres	Tennøy, 2012
MARS	Metropolitan Activity Relocation Simulator	Emberger and Pfaffenbichler, 2013
MoSC	Measures of Street Connectivity: Spatialist Lines	Trova, 2012
PST	Place Syntax Tool	Ståhle, 2012
RIN	German Guidelines for Integrated Network Design-Binding Accessibility Standards	Gerlach, 2012
SAL	Structural Accessibility Layer	Silva 2012
SNAMUTS	Spatial Network Analysis for Multimodal Urban Transport Systems	Curtis, 2011
SNAPTA	Spatial Network Analysis of Public Transport Accessibility	Hull & Karou, 2012
SoSINeTi	Social Spatial Changes because of New Transport Infrastructure	Höemke, 2012

TRACE	Retail Cluster Accessibility	Verhetsel et al. 2012
UrbCA	Cellular Automata Modeling for Accessibility Appraisal in Spatial Plans	Pinto & Santos, 2012

Table 1 - List of AIs reviewed

Most of the AIs in this Action were developed as a means of aiding scientific enquiry into the dynamics of urban change. This, particularly, is a characteristic of instruments developed by PhD students. In many cases, these instruments have moved with the researchers into planning practice and now serve to provide policy and planning support. In three of the countries in this Action (Germany, Norway and the UK) accessibility analysis is a requirement of planning or transport policy implementation. However, in only half of the countries represented in this Action accessibility is accepted by practitioners as an appropriate measure of built environment performance.

All the instruments, of those fully developed by the time of the survey (some were under development), can support at least one of a number of planning policy tasks. Twelve[1] of the instruments have been used to inform the urban and transport planning process. For example, ACCALC is used by the UK Department of Transport to calculate car and non-car user accessibility opportunities to various land uses in terms of travel time and accessibility opportunities, as part of the neighborhood statistics published by the government. MaReSi SC has been applied by planning authorities in Oslo for some years to estimate the square meters of shopping space required for a given population size. RIN is used by the German government to set standards for public transport and slow modes. This shows that for specific planning tasks, AIs have a role in supporting planning policy.

Instrument developers were asked to categorise their instrument according to a pre-defined

1 ACCALC, ASAMed, ATRaPT, GraBAM, IMaFa, JAD, MaReSi SC, MARS, Mo SC, PST, RIN, SNAMUTS.

set of planning goals (see Table 2). Overwhelmingly, the instruments focus on the main planning task of deciding where to locate residences, activities and services. The other main planning goal that is well represented by these instruments is how to manage and encourage particular transport modes.

Acronym	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 redictions of emission / energy use?	Other
SNAMUTS	■	■	■	■			■
RIN	■	■		■	■		
ATI	■		■	■			
JAD	■		■				■
ABICA	■	■					
MARS	■			**– Multi objective**		■	
EMM	■				■		
PST		■					■
ACCALC				■			■
IMaFa							■
SoSINeTi							■
ASAMeD	■ **– Urban planni**						
SNAPTA	■						
HIMMELI	■						
INViTo	■						
Contactability	■						
MoSC	■						
TRACE	■						
UrbCA	■						
ATRaPT		■ **– Transpo**					
GDATI		■					
GraBAM		■					
MaReSi SC		■					
SAL		■					

Table 2 - Coverage of land use and transport planning questions by the AIs

Within the instruments primarily motivated by a policy support aim, three 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 ACCALC, EMM, InViTo, JAD, MARS, RIN and SNAMUTS. A second group rather aims to develop tools for the assessment of *land use* and proposals for land use change. Examples are TRACE, RIN, MaReSi SC, IMaFa, SNAPTA. The third group focuses on *transport* development proposals and/or service provision and how we can improve the accessibility to amenities/ services. These include ATRaPT, GDATI, GRaBAM, MaReSi SC, and SAL. This variety of motivations is both a challenge and an asset for the COST Action, and for the general field of Accessibility planning. 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 and the field 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.

2. ACESSIBILITY INSTRUMENTS: THEIR ROLE IN URBAN AND TRANSPORT PLANNING

Table 2, which is based on the questionnaire results, gives some idea about the orientation of the instruments towards the planning concerns of government agencies. Roughly half of the instruments claim to support most planning tasks; i.e. they can be applied to create new insights, justify existing decisions, to support strategy/option generation and selection, and support the integration of urban planning perspectives. The remaining instruments have a more specific application focusing on one or more of these tasks or focus on providing spatial and social analysis on the connectivity of the urban fabric. The design of the questionnaire to

AI designers did not anticipate instruments would have a direct user-focused approach. Three instruments, however, do look at accessibility from the individual's viewpoint. The planning aspiration of how to design accessible buildings and places is the subject of SoSINeTi. The instrument explores the impact of new transport facilities, i.e. better accessibility, on human behaviour and what social and behavioural changes can be observed in better accessible municipalities. MaReSi SC implements the sector plan for retail development in Oslo by calculating the maximum size for new shopping centres or extensions in specific locations to serve a population equal to the number living within walking or cycling distance from the centre. Whilst the primary aim is to ensure an effective use of shopping facilities, it focuses directly on ensuring that the daily shopping needs are easily accessible by local residents. ACCALC's aim is to facilitate user-focussed planning. The instrument is an extension of activity based transport and land use modelling optimised to provide information relevant to understanding time, cost, physical, safety, temporal and other barriers to access. Since it is used to produce neighbourhood data for the UK government it focuses on the 16 categories used in national analysis: e.g. job seekers, students, car ownership, households receiving income support, etc.

Most developers present instruments that deal with accessibility in a static fashion, i.e. they try to depict accessibility conditions for a given scenario (in the past, present or future), but 3 developers mention that their instruments focus on measuring the impacts on time of land use changes and impacts of infrastructure investments. According to this, AIs can be categorized into: passive decision support instruments (aids the process of decision making, but cannot bring out explicit decision suggestions or solutions), active decision support instruments (can bring out such decision suggestions or solutions), cooperative decision support instruments (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), ex-post evaluation instruments and strategic planning support instruments (see Table 3).

Acronym	Strategic Planning Support instrument	Ex-post evaluation instruments	Cooperative Decision Support instrument	Active Decision Support instrument	Passive Decision Support instrument
ATI	■				
EMM	■				
HIMMELI	■				
IMaFa	■				
INViTo	■				
JAD	■				
SNAMUTS	■				
ASAMeD		■			
SNAPTA		■			
SoSINeTi		■			
MARS		■	■		
UrbCA			■		
ATRaPT			■		
Gdati			■		
MoSC			■		
TRACE			■		
GraBAM				■	
MaReSi SC				■	
RIN				■	
PST					■
SAL					■

In this table two instruments (Contractibility and ABICA) are not analyzed because of the lack of data

Table 3 - Characteristics of AIs: relationship with the users

Table 4 relates AI to scale. One grouping of instruments focus on the municipal administrative area and/ or the wider city-region or travel-to-work area. These instruments are categorised in Table 4 as city-regional since they are more focused on the detailed spatial interactions and try to represent these interactions between land use and transport and to suggest something about the connections or access needs. The spatial scale has clear linkages to the type of planning goal or question being asked. If as in the last group the focus is on the liveability of neighbourhoods or social cohesion, then access to basic services by walking, cycling and public transport are issues that local or municipal planners will need to ask. If the planning goal is the economic competitiveness of the city or region, then the focus will be the ease of reaching employment locations from residences and transport hubs, particularly by public transport. This scale is also appropriate for comparing across cities. If the planning goal is sustainable growth patterns and a reduction in greenhouse gas emissions, then the appropriate spatial level for analysis is the supra-municipal to national to supra-national.

Some instrument developers focus on urban-level accessibility (e.g. car or public transport distance), while others focus on neighborhood-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 more scales, by using more than one instrument can be a potential goal for accessibility research in the future. In fact many of the instruments cover multiple geographic scales. The group of instruments that can be applied at the national- supranational levels provide broad-brush comparisons between countries and cities to highlight their differences in terms of connectedness or accessibility. For example, Contactability can compare cities based on the travel times using public transport. Accessibility is used as a competitiveness indicator for cities. GDATI interrogates the public transport network characteristics and compares this with urban density indicators. IMaFa uses time thresholds to measure the accumulated opportunities (facilities) the population has access to. ACCALC has a similar focus, whilst TRACE focuses on retail opportunities. Whilst these instruments can also be used to test out transport/ land use policy proposals, MARS specifically has this focus. It can be applied to suggest how policies can be optimised as well as testing out how policy instruments will perform in future scenarios. ABICA measures the connectedness of municipalities compared with other areas. Many instruments capture the current desire lines between origins and destinations/opportunities, focusing on the morning commute or peak hour traffic, and then go on to interrogate this data by mapping, for example, the catchment area of a particular facility/location. Travel time is used by SNAMUTS to identify the best public transport route between the activity centres (across the whole metropolitan network and between each centre). ATRaPT was designed to demonstrate how accessibility to commercial services could be improved in sparsely populated areas in a region. UrbCA and GraBAM measure the effect of transport investments on accessibility and the resulting land use change. Their focus is similar to MARS in that they allow the simulation of different planning solutions taking into account different conditions or scenarios. HIMMELI attempts to understand the behaviour of retailers and shoppers through simulating the dynamics of a competitive retail market. The interactions between land use and transport and shoppers' perceptions of accessibility are key to understanding the selection of shopping destinations. JAD uses a simplified set of accessibility measures to analyse the effects of different transport scenarios on settlement design. EMM uses accessibility indicators to answer several planning questions including the potential for transit-oriented development, how vulnerable a municipality would be in a peak oil situation, or if stricter CO_2 emission regulations were enforced.

There is a third group of instruments more focussed on the accessibility needs at the neighbourhood spatial scale. They cover access to basic services such as education, health care, daily shopping, social services and leisure facilities. Two of these instruments, MaReSi SC and SoSINeTi have already been described above because of their innovative approach to built environment users and user needs. SoSINeTi and SNAPTA focus on evaluating the impact of public transport investment on access to basic services. ATI focuses on the accessibility to public utility infrastructure (roads, water supply, energy services). All the other instruments in this group give prominence to walking and/ or cycling modes of transport. Four instruments take a broad canvas evaluating the accessibility of neighbourhoods to facilities/ services in the wider region (INViTo, SAL, MoSC, PST).

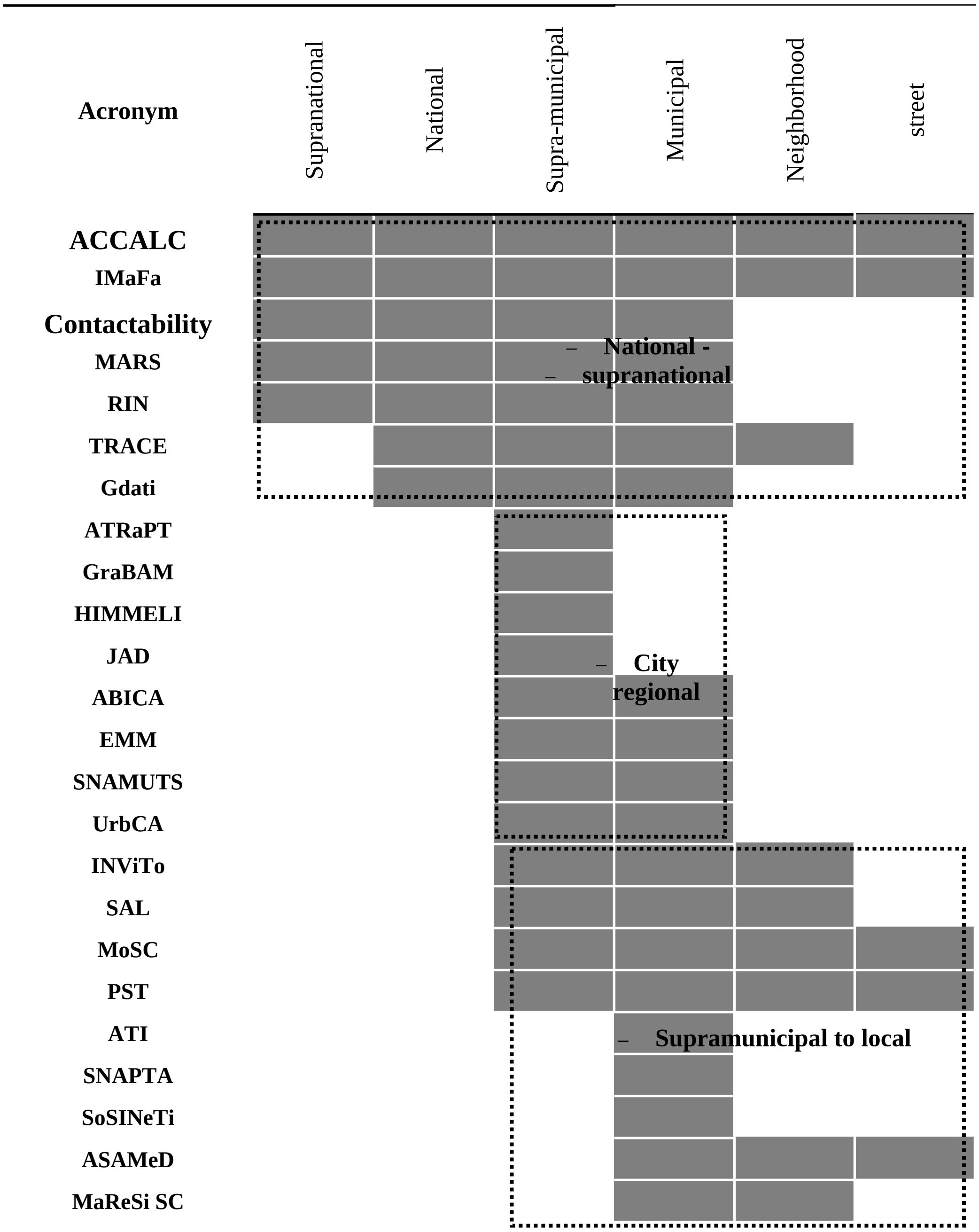


Table 4 - Geographical scale covered by the AIs

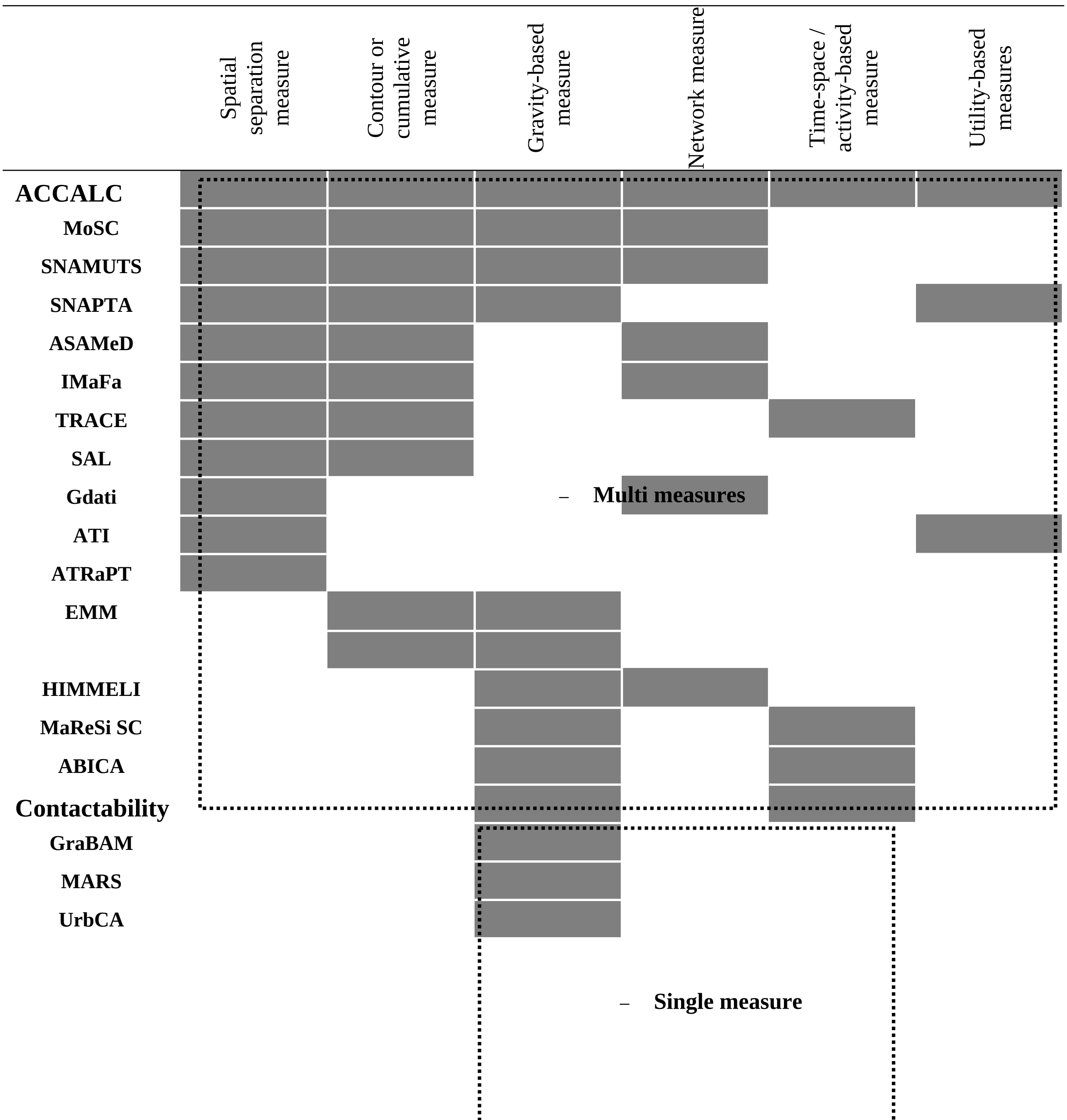
3. CONCEPTUAL AND OPERATIONAL ASPECTS OF ACCESSIBILITY INSTRUMENTS

3.1. Conceptual framework and theoretical underpinnings

One key element that distinguishes the AIs is the type of accessibility indicators that they use. A review of the literature reveals numerous studies that have attempted to classify such measures (Geurs and van Eck, 2001; Geurs and van Wee, 2004; Curl et al., 2015). The various approaches differ in their level of complexity and practical applicability. We refer to the following categories of accessibility indicator:

- Spatial separation measures or infrastructural-based measures: these relate to the performance of the transport supply network and include measures of travel impediment, such as physical distance (by mode), travel time (by mode), travel time (by network status—congestion, free-flow), travel cost;
- Contour or cumulative measures: these represent the accessibility at a location to another or to a set of destinations, counting the number of opportunities reachable in a given travel time, distance or cost, or measuring the time or cost required to access a fixed number of opportunities;
- Gravity-based measures: based on the concept of attraction and impedance, these can be considered as an extension of cumulative measures, with the use of weight opportunities by an impedance factor (i.e. travel time, distance, generalized cost etc.) and the attractiveness of the destination (i.e. the distribution of population, employment, income, etc.);
- Network measures: this group of measures, based on graph theory and network analysis, correlates accessibility with topological measures of the transportation network;
- Time-space / activity-based measures: these relate to individuals' level of access to spatially distributed activities, consider location of activities, travel through the network and incorporate a behavioural element, usually captured via travel diary data; and
- Utility-based measures: these include individual behaviour characteristics in accessibility and are supported by travel behaviour theories. They consider the likelihood of an individual making a certain travel choice based on the maximization on his/her utility. The measure of accessibility defined in this way is in monetary units.

Table 5 presents a classification of the instruments according to the type of accessibility measure used. Eight AIs are attached to only one of the accessibility indicator categories referred above while other AIs use combinations of these. Utility measures are less frequently used for accessibility measuring in this sample of AIs. Furthermore one group of AIs concentrate only on the physical 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. 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. Examples are ASAMeD and MoSC. Most of the activity related instruments utilise gravity based accessibility measures and are thus related to the modelling tradition of urban geography. Instruments that are part of larger model structures, like HIMMELI and UrbCA are related to different traditions of modeling 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.



PST					
RIN					
INViTo					
SoSINeTi					

Table 5 - Measures of Accessibility used in the AIs

OPERATIONAL CHARACTERISTICS

The AIs have different data and data handling requirements. Related to this, they demand more or less expertise on the side of those of making the calculations or interpreting the results. Details of operational characteristics are shown in Appendix 1 (as self-reported by the instrument developers). This is an area where a trade-off needs to be made between the rigor of the instrument (e.g. its accuracy, or comprehensiveness) and the ease with which it can be employed (e.g. with respect to readily available data and expertise).

With regards to operational characteristics, AIs differ in terms of the transport mode analysed (see Table 6): all the main transport modes are covered by the AIs analysed, with a prevalence of instruments for accessibility planning by public transport. With regard to multimodal approaches, we found instruments able to use any mode (such as MaReSi SC, MARS, EMM, RIN and SAL). 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 (ATRaPT, SNAMUTS, SNPTA, GDATI and SoSINeTi).

Acronym	Car	Public Transport	Walking	Bicycle	Other	Not applicable
MaReSi SC	X	X	X	X	X	
MARS	X	X	X	X		
EMM	X	X	X	X		
RIN	X	X	X	X		
SAL	X	X	X	X		
JAD	X	X		X		
GraBAM	X	X				
INViTo	X		X			
HIMMELI	X					
UrbCA	X					
IMaFa		X	X			
ATRaPT		X				
GDATI		X				
SNAMUTS		X				
SNAPTA		X				
SoSINeTi		X				
ASAMeD			X	X		
PST			X	X		
MoSC			X	X		
ATI			X	X		X
TRACE						X

– **Multi modal**

– **C**

– **Sustainable mobility**

In this table two instruments (Contractibility and ABICA) are not analyzed because of the lack of data

Table 6 - Transport modes considered in the AIs

As regards the trip purposes used in the instruments (see Table 7), the majority of the instruments take account of all trip purposes (work, leisure, healthcare, shopping, and education). Some of these use aggregate measures 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.

Acronym	All purposes (aggregate measure)	Work	Education	Leisure	Healthcare	Shopping	Other	not applicable
EMM	■							
JAD	■							
MoSC	■							
PST	■							
RIN	■							
SAL	■							
SNAMUTS	■							
SNAPTA	■							
UrbCA	■							
IMaFa		■		■	■	■		
GraBAM		■	■					
MARS		■					■	
HIMMELI						■		
MaReSi SC						■		
TRACE						■		
ATRaPT								■
ASAMeD								■
ATI								■
GDATI								■
INViTo								■
SoSINeTi								■

– **Multi purpose**

– **Systematic trips**

– **Un-systematic trips**

In this table two instruments (Contractibility and ABICA) are not analyzed because of the lack of data

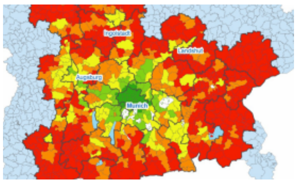
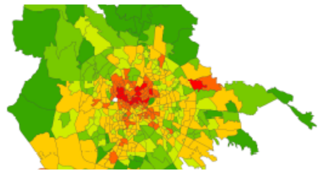
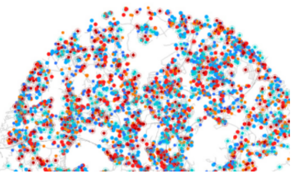
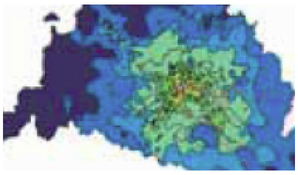
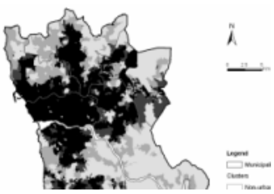
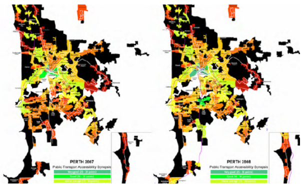
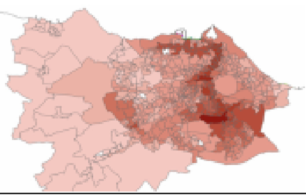
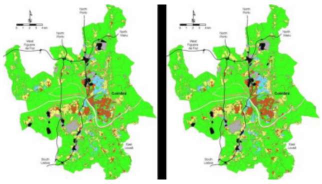
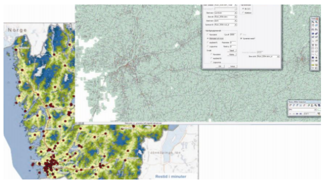
Table 7 - Trip purpose used in the AIs

3.3. Visualization of outputs

The AIs 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. This might be a concern from a user perspective, as this kind of outcome might be needed for some users to make sense of accessibility, which can otherwise be treated as a 'slippery' concept, not to be trusted by decision makers. Nevertheless, most of the accessibility tools generate a visual product, generally represented by bi-dimensional maps.

Table 8 gives a graphic impression of the different of approaches to the visualization of outputs. 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.

2D areal aggregation		
ACCALC 	EMM 	GraBAM 
HIMMELI 	IMaFa 	JAD 
PST 	SAL 	SNAMUTS 
SNAPTA 	UrbCA 	ATRaPT 
2D axis-based maps		
ASAMeD	MoSC	RIN

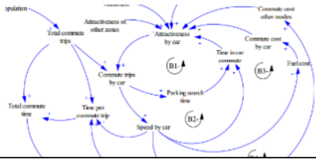
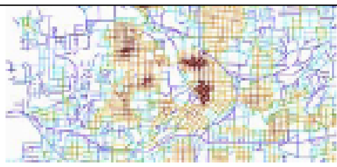
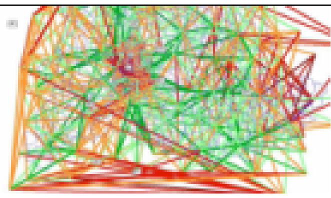
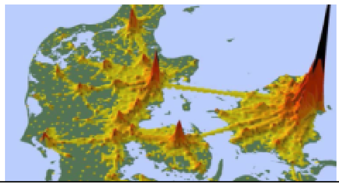
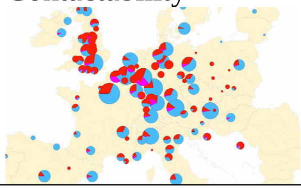
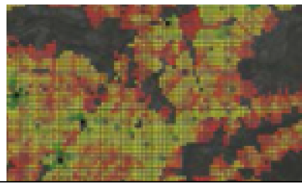
 MARS 		
2D point-based maps		3D images
ABICA 	Contactability 	InViTo 
No visual output		
ATI, GDATI, MaReSi SC, SoSINeTi, TRACE		

Table 8 - Output visualization used in the AIs

Only 5 of 24 tools do not report a visual output, highlighting the importance of visual communication for most of the accessibility studies. Except in one case (InViTo), all the AIs that have a visual output make use of bi-dimensional maps, preferring traditional methods of communication that are commonly used in spatial studies. This can be due to several factors. Firstly, 2D maps are generally perceived as easier 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 the result of a balance between the dimension of the area and the amount of data to consider.

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 behavior 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 RIN shows its output by the use of coloured axes, however the overlapping reduces the clarity of the information provided. Point-based maps are used by just two tools and in a similar way but at different scales. Contactibility uses elements of info-graphic to implement the readability of a very large-scale map, generating a picture that 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 color and size according to indicator values.

The overview on tools show 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 instrument developer hopes the audience will understand 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 spatial planners to understand spatial dimensions of key accessibility statistics. Some visualization use more artful techniques, which can be helpful in facilitating engagement, but still remain knowledge-focused.

The majority of tools show their outcomes with colors 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 color while the third uses the opposition between red and blue to highlight the contrasts. These traditional approaches to the use of color shows once again the purpose of these tools to provide results that can be understood by most people and, in particular, to inform spatial planners on the capabilities of an area to access another one or to be accessed.

4. THE USABILITY PERCEPTION OF AI DEVELOPERS

The Accessibility Instrument survey allowed us to explore the perception of instrument developers' on the usability of their instruments in planning practice. Usability was, among other things, evaluated based on developers' perception of performance and requirements of their instruments on specific issues believed to have influence on usability. These issues were:

- Quality of data used
- Quality of calculations
- Accuracy of the instrument
- Speed of the instrument
- Ease of collecting data
- Ease to play with
- Transparency
- Flexibility
- Understandable output
- Visual representation
- Modelling and computational skills required
- Spatial awareness skills required
- Understanding of the policy context

Developers' perception on the performance and requirements of their AIs on these specific issues was evaluated on a scale from 1 (worse performance or being most demanding to implement) to 7 (best performance or being less demanding to implement). Results are summarized in Table 9.

In general developers' seem to be less confident of the performance of their instruments with regard to the ease 'to play with' (average score of 3.6), speed (average score of 3.9) and the ease of collecting data (average score of 4.3). They are also less confident of the level of demand imposed on spatial awareness skills (average score of 3.5), modelling and computational skills (average score of 3.5) and understanding of the policy context (average score of 4.4). Although it is possible to find developers recognising their instruments perform poorly regarding the referred issues, the average value still reveals reasonable levels of confidence by AI developers'. All remaining issues present an average score ranging between 5 and 6, with quality of data and quality of calculation scoring highest in average. It is thus fair to say, that even among the issues recognised by developers' as 'least performing' or 'most requiring', average results suggest they still believe their instruments perform quite well.

Theme	Question	Min.	Max	Mean	Median
Quality, accuracy and speed of AIs	Quality of data	3	7	5.5	6
	Quality of calculations	3	7	5.5	5
	Accuracy of the model	3	7	5.1	5
	Speed of the AI	1	7	3.9	4
Ease of using AIs	Ease of collecting data	2	7	4.3	4
	Ease to play	1	7	3.6	3
	Transparency	3	7	5.4	6
	Flexibility	3	7	5.4	6
	Understandable output	4	7	5.4	6
	Visual representation	2	7	5.4	6
Knowledge and skill levels required by practitioners	Modelling and computational skills	1	7	3.5	4
	Spatial awareness skills	1	6	3.5	3
	Understanding policy context	2	7	4.4	4.5

Number of valid responses: 19 in all except for "understanding policy context" having only 18 valid responses.

Table 9 - Perceived usability of AIs: issues influencing usability

Table 6.9 also shows that, regardless of the issue under evaluation, there is always at least one developer having top confidence in the performance or requirements of his/her instrument. This is more than reasonable and expectable. One single exception is found regarding spatial awareness skills required from practitioners for implementation of the instrument. This result is easily understood, considering the conceptual basis of accessibility measuring and the strong mutual relationship with the spatial environment. It is not reasonable to expect that AI would require no spatial awareness skills for implementation by practitioners. If we now take a look at the minimum scores of the performance/requirements scale, results are not as homogeneous as with the maximum scores. Although there are instruments that, according to their authors, offer the lowest performance or are the most demanding, in issues such as speed or spatial awareness, for other issues, even the weakest instrument (according to the perception of their developers) actually presents fair or even median performances or requirements. For instance, understandability of outputs presents scores ranging from 4 to 7, showing high overall confidence from developers on the quality of numerical or spatial outputs generated by their AI.

If we look at the distribution of scores for each issue under evaluation (Figure 1) we can see that transparency, quality of data, quality of calculations and visual representation are among the issues which most developers' (around 80%) rate as well performing, with a score of 5 or higher. Of these, quality of calculations shows the highest number of very high confident developers' (rating their instrument with score 7). Accuracy of the model, flexibility and the production of understandable outputs is also generally positively perceived by developers, with around 70% considering their tool as performing well, with a score of 5 or higher. In accordance to what has been seen in table 8, this figure also shows speed, ease of collecting data, easy 'to play with' as the worst performing issues with many developers having low perception of their instruments. With regard to requirements, the figure shows many developers find their instruments most demanding of modelling and computational skills, spatial awareness skills and understanding of the policy context. Of these, modelling and computational skills stand out as the requirement found to be very demanding by almost 20% of the instruments (in the opinion of its developer).

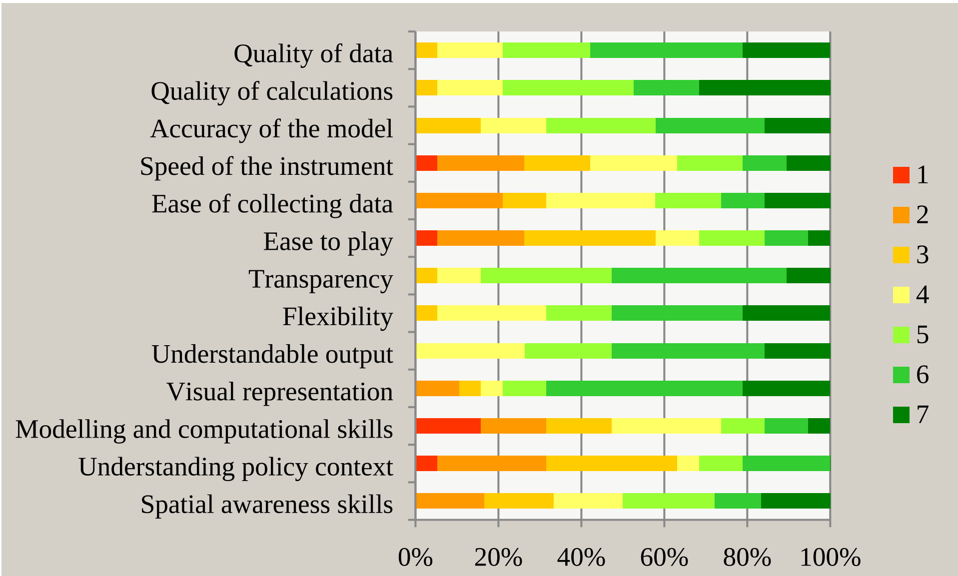


Figure 1 - Perceived usability of AIs: Comparison of Full Responses

5. DISCUSSION AND CONCLUSIONS: STATE OF PRACTICE ON THE DESIGN OF ACCESSIBILITY INSTRUMENTS

The instrument developers provided information on how relevant their instruments are for planning practice both in their responses to the Questionnaire survey and their summary reports. Table 6.2 has summarised the planning questions or problems the instruments address and sections 6.1 and 6.2 have discussed their role in the planning process. The discussion in these sections has highlighted the significant similarities and differences among the 24 instruments. Appendix 2 provides further data on the useable outputs from each instrument and whether they have been used to inform actual planning decisions. As stated earlier, these instruments offer a variety of different approaches to measuring spatial relationships. Some tools have been developed to measure accessibility; some are expert systems to help define and answer planning problems; and some are repeatable analytical methods using existing and widely available tools such as GIS systems.

There is sufficient diversity of instruments in the COST Action, which can provide support to planning practice across each of these planning issues. For instance, some instruments, by analysing interactions in the urban fabric as urban areas change provide information and analysis to support the learning process about spatial interventions. These tools help practitioners make strategic long term planning decisions. Examples of these instruments are ABICA, MARS, and SNAMUTS. Other instruments are more active and provide practitioners with solutions to planning problems. Examples of these instruments are GraBAM ,MaReSi SC, and RIN. A further set of instruments focus on ex post evaluations of transport and land use proposals to identify the impact of these interventions. Amongst these instruments are ASAMED, SNAPTA, SoSINeTi.

Within the research purpose of the COST Action, the AI framework reported upon in this chapter provided the grounds for a discussion around the state of art of developed AIs, the usability and the use of the accessibility concept and measures in planning practice. Highlights from this debate, which is more extensively documented in Bertolini et al. (2012), are reported below.

The wide variety in the AIs tasks, in the goals and tasks of planning and the even greater variety in their content focus makes the elaboration of a concise summary of all analysed instruments difficult. Indeed, a first conclusion of the work carried out in the COST action is the existence of enormous diversity and differences of approaches in all instruments, both in practice and in research. This also provides an encouraging outlook towards the future and the possibilities that arise to define new instruments and improve the existing ones. Starting from this variety, it is possible to enlighten some of the strengths and weaknesses of the COST Action instruments and then go on to explore why they are not used more frequently by planning practitioners.

A key strength of these instruments is that they 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) provide analysis on the ease or difficulty of reaching different activities to (4) inform the development and monitoring of policy goals ranging from economic development, to social equity and environmental preservation. They all have one common feature; a database of spatial relationships between origins and destinations. Whilst the kind of activities or services included in the measurements varies, accessibility analysis increases awareness about the development potential of locations and how well different activity patterns can be served in a particular location.

There is broad diversity in the theoretical underpinnings of the instruments. Most of the activity related instruments utilize gravity based accessibility measures and are thus related to the modelling tradition of urban geography. Instruments that emphasize 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 to refer to space-time geography or information visualization.

With respect to operational aspects, one key consideration is that, in line with the assumption that accessibility is a complex, multi-dimensional concept AIs incorporate a variety of indicators, each of which is specifically designed to explain one specific aspect of accessibility. Most instruments deal with aggregated measures of accessibility, by either considering network distance (despite the mode) or the different modes together. The techniques for measuring accessibility can include different types of measure (spatial separation measure, contour measures, gravity-based measures, utility based measures, network measures, activity-based measure) in the same instrument, as some opportunities lend themselves to thresholds (e.g. a post office as similar services regardless of size) whilst others (like food shops) use continuous functions based on floor space and choice. These measures can be used in different questions, for example a time contour destination measure is a catchment, where a time contour origin measure is a choice of opportunities.

It is interesting to highlight, that all the AIs analyzed, despite especially involving public transportation, also cover all the main transportation modes. Additionally, roughly half of the analyzed AIs have a multirole in urban planning, focusing on most of the different activities for which planning support systems are generally developed. Most of the instruments are used in land use planning or are multipurpose oriented rather than transport planning oriented. In terms of scale, the instruments cover all geographical scales, from supra-national scale to the street level. The most frequent scale used is the municipal and the supra-municipal. However, most of them can be used at two or more geographic scales.

Together the instruments in this COST Action can answer several planning questions:

- What are the main drivers for change and the main trends that have influenced the existing levels of accessibility and which will, to all extents and purposes, influence future accessibility levels? Once understanding of the relationship between land use, urban form, and transportation systems are enhanced, this can be used to support policies that seek to reduce the transportation effort to reach the range of opportunities available. For instance, how can the location and dimensioning of new shopping centres be achieved so that they don't cause growth in traffic volumes and/or close-down other, more accessible centres.

- What are the impacts of new transport and land use interventions on accessibility to jobs, services and facilities? This analysis can be carried out at the different geographical scales and can be used 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. This type of analysis can also be used to understand how the accessibility of different population groups is and might change – and thus contribute to discussions on equity issues.

- In what ways can the efficiency of use of the current transport infrastructure be increased, through new interventions to reduce the CO_2 and energy impacts of transport choices? What can be the role of transport interventions? What can be the role of land use interventions? This analysis can help to deliver CO_2 and energy reduction targets set by higher tiers of government.

Despite trying to limit the complexity of the instruments through dealing with accessibility in a static fashion or limiting the land uses or transport modes covered, some of the instruments take several days to set up (preparing and inputting data) which require a high level of expertise. Several instruments are based on GIS software, some use data management software, and only a few use (or develop) open source tools. As documented in detail in Bertolini et al. (2012).

Only few instruments have no visualization tool. The rest have visual outputs that provide representations translating key accessibility data into relatively simple maps and graphs. Eighteen of the accessibility tools generate a visual product, generally represented by bi-dimensional maps (See Table 9). These provide representations, which distil complex concepts into relatively simple maps and graphs helping planners to understand spatial dimensions of key accessibility statistics. The other tools provide numerical outputs or lists in tables, matrices or datasheets, which may require a high level of expertise on the part of practitioners to interpret. Prior to the COST Action, few of the instruments had developed user interfaces that allowed potential users to 'take control' of the analysis. The theoretical basis of the instruments, their customized data needs and outputs did, therefore, create barriers to use. This raises the question of the availability of the appropriate skill sets, time and financial resources in public agencies.

The COST instrument developers have found that the concept of accessibility is not understood well by planning and transport practitioners. Attention, and money in transport planning, is focused on the delivery of specific projects and as spatial planning teams are downsizing, they too are focusing on project specification and delivery. There will always be relatively more analysis required to monitor accessibility and the opportunities to citizens for health, education, work, leisure, etc. It should be noted that some of the instruments in this Action are beginning to focus on the individual and the choices they can make, and to understand the accessibility needs of diverse groups of people.

With regards to AI developers' usability perception, transparency, quality of data, quality of calculation and visual representation are the issues developers are most confident of. Among these, quality of calculations is the one with the highest confidence among developers. Accuracy of the model, flexibility and the production of understandable outputs is also generally positively perceived by developers, with around 70% considering their tool as performing above average. On the other hand, developers are aware of the limitation regarding calculation speed and playability of their tools.

To mesh well with the needs of practitioners, instrument developers need to understand the different stages of the policy cycle and the planning questions at these different stages that their instrument can support/throw light on. Whilst the instruments may not be able to provide much understanding on the causality of the spatial accessibility patterns, beyond crude ideas of attractiveness, they can be used to inform discussions between the public sector, developers and local residents particularly in situations where tensions may exist between the groups. Why do practitioners feel unable to use these instruments to support their policies? Is it because this multi-dimensional concept cuts across the responsibilities of transport and land use planners? To understand the interactions between land use and transportation policies, the instruments draws on the characteristics of the transport system (e.g. speed, and travel costs) as well as the land use system (e.g. densities and mixes of opportunities). Is this integrated approach seen as the preserve of long term policy planners testing out different scenarios with land-use and transport models? Are AIs seen as in the same specialist domain? Whereas Google maps is perceived to be ‘accessible’, practical and usable. This may well be the benchmark against which the instruments in this Action will be assessed.

Other areas of improvement mentioned by the instrument developers in their self-assessments reported in Bertolini et al. (2012) 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 factors could be improved for enhancing the usability of these instruments. One key element is that AIs should relate directly to policy issues and goals, ranging from economic development, to social equity and environmental preservation. Furthermore, starting from the assumption that accessibility is a complex, multi-dimensional concept, AIs cannot use just one or few indicators, but they need to use a variety of indicators, each of which is specifically designed to explain one specific aspect of accessibility (Keller and Wulfhorst, 2012).

Some of the instrument developers, 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 AI 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 discussed in Bertolini et al. (2005) sums up this conundrum and seems to point to a key area of discussion and exploration when assessing and improving the usability of AIs for planning practice. In its essence, this dilemma posits that there is an inescapable trade-off between the scientific rigor of an instrument (e.g. in terms of its accuracy or comprehensiveness) and its practical relevance (e.g. with respect to the availability of material and human resources, or to the interpretability of the outcome by its intended users). For both aspects there is something to be said. The answer, however, cannot but vary depending on the context of application, of which the workshops documented in further chapters of the book provide a broad range.

APPENDIX 1: COMPARISON OF THE OPERATIONAL ASPECTS OF THE AIS (AS SELF-REPORTED BY INSTRUMENT DEVELOPERS)

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
ABICA **Activity Based Indicators of Connections and Access Needs**	-Activity based indicator -Visualization of interaction patterns/desire lines that indicate loads, demand for capacity, and spatial patterns of dependency and centrality	-OD datasets (generally not free) -In the 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 skills)
ACCALC **Databased suite for calculation of UK accessibility statistics**	-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 datasets, travel times, etc. -In the UK data has become much more freely available over the last years 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 analyse policy questions in real time **Software** -Microsoft Access or MS SQL +Excel -ACCALC is hoped to provide a web-based user front so that anyone can use the tool free of charge	-A high level of technical expertise is needed to run the analysis

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
ATRaPT Accessibility Tool for Road and Public Transport Travel Time Analysis	-Compares accessibility to amenities by both road and public transport using (i) a location based accessibility measure and (ii) an isochronic or cumulative opportunity measure	-Topographic and land use data -Road network database, regional transport authority public transport database -Spatial registry data of individuals and workplaces. All are purchased except the public transport data	**Time** -3 weeks to input the data and set up. Database queries only take 1 minute on a standard computer **Software** -GIS	-Complex and non-intuitive system that requires expert knowledge and resources to set up and maintain
ASAMED Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance	-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 **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

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
ATI **From Accessibility to the Land Development Potential**	-Physical distance and capacity of the existing and proposed transport infrastructure -Accessibility is determined by (i) the distance; (ii) the capacity of elements; (iii) costs	-Land use data, 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 based on input from surveys and workshops	**Time** -Not described **Software** -ArcGIS with spatial analyst	-The interpretation of results does not require specific 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 www.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

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
EMM **Erreichbarkeitsatlas der Europäischen Metropolregion Muenchen**	-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, analysing accessibility to facilities, transport hubs, and other POI	-Structural data: population and employment (publicly available in Germany at the municipality level) -Transport data from OpenStreetMAp (free-online), transit from websites	**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
GDATI **Geographic / Demographic Accessibility of Transport Infrastructure**	-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 from 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
GraBAM **Gravity Based Accessibility Measures for Integrated Transport-Land Use Planning**	-Gravity indicator for: (i) residents towards workplaces; (ii) economic activities towards residents -Distance measured in generalized travel cost	-Socioeconomic data from national statistics -Land use characteristics and transport network	**Time** -Not described **Software** -TransCAD GIS software	-The use of software requires a medium level of expertise, for calculation and interpretation

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
HIMMELI **Heuristic three-level Instrument combining urban Morphology, Mobility, Service Environments**	-Proximity of households to retail units in travel cost -Clustering of 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
IMaFa **Isochrone Maps to Facilities**	-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
INViTo **Interactive Visualization Tool**	-Walking time from the nearest public transport access point	-Network information (usually free from OpneStreetMaps)	**Time** -Not described **Software** -Rhinoceros (commercially available) combines with its free plug-in Grasshopper	-Not described

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
JAD **Joint-Accessibility Design**	-The accessibility measure varies with the applications -Are related to societal goals (cohesions, 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 **Method for Arriving at Maximus Recommendable Size of Shopping Centres**	-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 time-consuming **Software** -ArcGIS	-No advanced skills are needed -Planning knowledge is the main competence necessary
MARS **Metropolitan Activity Relocation Simulator**	-Attractiveness of sites as travel destinations for: (i) short-term commuting trips (ii) longer term location of housing and workplaces	-A broad variety of input data such as population, land use, modal split, travel time, travel cost, and prediction of their growth rates for the next 30 years	**Time** -Not described **Software** -VENSIM programme	-Requires high level of technical expertise to interpret forecasts, their sensitivity, and to understand system dynamics

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
MoSC **Measures of Street Connectivity: Spatialist Lines**	-Spatial connectivity (space syntax)	-Street centre line information from standard GIS street network or CAD files	**Time** -Ranges from a few seconds to a few hours **Software** -Spatialist_Lines (upon request). -Plug-in of ArcView	-Basic knowledge of GIS software to perform calculations
PST **Place Syntax Tool**	-Space Syntax	-Not described	**Time** -Not described **Software** -Place Syntax Tool for MapInfo -a DLL Library coded in C/C++	-Not described
RIN **German Guidelines for Integrated Network Design-Binding Accessibility Standards**	-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

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
SAL **Structural Accessibility Layer**	-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
SNAMUTS **Spatial Network Analysis for Multimodal Urban Transport Systems**	-Relation between public transport (PT) service and land use (LU) activities -Utilizes 6 indicators: (i) ease of movement along PT network (ii) directness of journeys on PT (iii) combined effect of PT on land use intensity (iv) competitiveness of PT vs car (v) geographical distribution of attractive travel paths (vi) nodal connectivity	-Not described	**Time** -Not described **Software** -ArcGIS	-Not described

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
SNAPTA **Spatial Network Analysis of Public Transport Accessibility**	-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 from UK Census data zones -Jobs, gross floor area of retail shops and facilities, number of patients: obtained under licence from government organizations -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 ArcInfo	-Data input and performing the calculation requires a good knowledge of GIS - The ease of interpretation of results depends on the accessibility measure used
SoSINeTi **Social Spatial Changes because of New Transport Infrastructure**	-It measures different types of accessibility and compares over the years: -travel times between municipalities -connectivity -rental market changes	-All the data is available but needs own investigation and research -All observations are long-term observations (5-10 years)	**Time** -Depends, but no longer than one or two weeks. However, it has to be repeated every year, maybe more often **Software** -No specific soft- or hardware is needed but a generic 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

AI	Type of accessibility measure	Data requirements	Calculation requirements (time, software)	Expertise requirements
TRACE **Retail Cluster Accessibility**	-Distance or 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 of retail, 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 on a mid-range laptop **Software** -ArcGIS with Spatial Analysis extension	-Both performing calculations and understanding results is relatively easy -The tool is intuitive and can be used by anyone familiar with ArcGIS
UrbCA **Cellular Automata Modeling for Accessibility Appraisal in Spatial Plans**	-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 planning authorities)	**Time** -Varies from hours to 1.5 days **Software** -Standalone Visual Basic tool	-Not described

APPENDIX 2: COMPARISON OF THE USABLE OUTPUTS FROM THE AIS (AS SELF-REPORTED BY INSTRUMENT DEVELOPERS)

Instrument	Information Produced	Use in real planning
ABICA	Analysing the connectedness of a municipality towards other areas	Research project referenced in practice
ACCALC	Car and non-car user accessibility 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.
ATRaPT	Compares accessibility to amenities for both road and public transport	The technical components of the instrument were initially developed by the consultancy firm WSP for the Swedish Regional Authority Skåne. The instrument has since been converted for use by Region Västra Götaland.
ASAMED	Space Syntax spatial configuration of social issues	Not identified
ATI	Indicators of different degrees of accessibility presented separately for different services or combined	Not yet applied
Contactability	Travel times using public transport to compare cities	Used in a competitiveness indicator by cities
EMM	(i) Potential for transit oriented development. (ii) Neighbourhood accessibility. (iii) Indicators for land use planning	Has been used in a stress test for sustainable mobility showing the resilience of places to energy price fluctuations
GDATI	Various indicators relating public transport network characteristics to urban density	Only used in research so far
GraBAM	Spatial distribution of accessibility levels	Many applications: most recently the Regional Metro System Plan for the Campania Region (Southern Italy)
HIMMELI	Observation of factors behind different development paths allowing planners to influence development more effectively	Not as yet

Instrument	Information Produced	Use in real planning
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
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
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
MARS	Estimates accessibility between zones for each mode of transport for short term trips (commuting to work) and long term land uses	Used to optimise public transport services and road capacity provisions to minimise public transport operators cost, minimise travel times, and minimise CO_2 emissions simultaneously in several applications for transport authorities. See http://www.ivv.tuwien.ac.t/forschung/mars-metropolitan-activity-relocation-simulator/literature.html
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
PST	Axial distance to facilities	Application in research on access to green spaces
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 in Germany
SAL	Diversity of accessibility indicator. Accessibility cluster indicator.	Information on spatial inequalities used in research in Oporto

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
SNAPTA	Zonal accessibility by public transport to show impacts from transport infrastructure changes	Application in research on transport policies in Edinburgh
SoSINeTi	Accessibility to infrastructure defined in terms of economic, ecological and social evidence	Not yet applied
TRACE	Developed and tested to analyse retail landscape in Flanders. Analyses balance between sector efficiency and spatial goals	Not identified
UrbCA	Simulate different planning scenarios of land use evolution taking the influence of the transport system explicitly into account	Awaiting testing in a real world planning process