URBAN MOBILITY AND PUBLIC POLICIES AT A CROSSROAD: 50 YEARS AFTER W. HANSEN, THE PARADOXICAL COME-BACK OF ACCESSIBILITY

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ABSTRACT

How accessibility shapes land use? Giving this title to his founding paper, in 1959, W. Hansen offered us a promising concept to analyse urban dynamics and urban shape. Fifty years later, introducing accessibility measurement within GIS-tools helps us to understand why transportation policies are, in urban areas, at a crossroad. In a large number of European cities, transport policies are about to face major shifts. In places where, some years back, road and highway projects were favoured, other priorities are materialising. Many elected representatives of large cities have opted for the development of public transit and also public bikes. Everything goes as if car mobility had no priority any more, while it still represents the bulk of transportation. In this paper, we use the concept of accessibility defined by Hansen. Directly inherited from cost benefit analysis, i.e. giving an important role to individual time gains, gravity accessibility should now lead paradoxically to a new approach of collective interest and assessment of strategies and measures, based on space usage. Sustainability issues are pushing forward the need of accessibility obtained by improving the urban functions within the catchment areas of pedestrian trips, cycling and transit rather than by increasing the catchment area by higher car speed.

Keywords: Accessibility, Urban mobility, Public policies, Sustainability, GIS

0. INTRODUCTION

In a large number of European cities, transport policies are about to face major shifts. In places where, some years back, road and highway projects were favoured, other priorities are materialising. Many elected representatives of large cities have opted for the development of public transit and also public bikes. Everything goes as if car mobility had no priority any more, while it still represents the bulk of transportation. In this context, French policies seemed to copy on trends from Germany ("modèle rhénan" – the Rhine model) while Germany is still learning from the French enthusiasm (urban quality of French tramway projects, public bike systems…). To which extent is this new orientation meeting the general interest of sustainability? And what can we learn from each other?

To answer this question, the paper proposes to come back to the concept of accessibility, defined by W. Hansen 50 years ago. *How accessibility shapes land use*? Giving this title to his founding paper, in 1959, W. Hansen offered us a promising concept to analyse urban dynamics and urban shape. Directly inherited from cost benefit analysis, i.e. giving an important role to individual time gains, gravity accessibility should now lead paradoxically to a new approach of collective interest and assessment of strategies and measures, based on space usage. Introducing accessibility measurement within GIS-tools helps us to understand why transportation policies are today, in urban areas, at a crossroad. Sustainability issues are pushing forward the need of accessibility obtained by improving the urban functions within the catchment areas of pedestrian trips, cycling and transit rather than by increasing the catchment area by higher car speed.

To illustrate the relevancy of this new approach of accessibility, we will start by a presentation of some salient facts to enlighten some past tilts in urban transport policies (1). Then we will detail how accessibility, and especially gravity accessibility (2) helps us to understand the new challenges of sustainable urban mobility, illustrated by some German and French examples (3). We will conclude about some potential future changes in urban transport policies explaining why we have now to turn Hansen's title in "how collective land-use priorities shape accessibility" (4)!

1. URBAN MOBILITY AND PUBLIC POLICY: SOME SALIENT FACTS IN EUROPE

The usual focus on speed and travel time gains

Usually, travel time budget (TTB) is considered as a cost by the economists. To reduce this cost, during all the 20th century, new transport modes have been developed in order to increase the average speed of trips and namely urban trips. From that point of view, walking and cycling were not very relevant in comparison with motorised mobility, especially car mobility, a strong means to boost the average speed. However, the generalisation of car mobility led to a lot of unexpected results: road congestion, urban sprawl and finally a constant and even an increasing TTB. According to Y. Zahavi, the TTB should be constant within motorised cities. Whatever the time and the space, that is to stay whatever the development stage and the size of the city, the average TTB should be about one hour per inhabitant and per day. This stability can be explained by the reinvestment, in a longer travel distance, of the gains obtained by a higher speed.

When we consider on the one hand European cities and on the other hand North-American cities, we see a substantial difference. In North America, the average speed of private cars on roads is higher, giving rise to a tendency to urban sprawl. This can be seen in Chart 1, which demonstrates the paradoxical effect of car speed (Crozet & Joly 2006). When average speeds are high, urban users tend to cover greater distances. As assumed over thirty years ago by Y. Zahavi, when the travel time budget (TTB) is constant those who are mobile reinvest in travel the time that they save through speed. Hence the increase in distance covered, which is something of a paradox for the low-density cities of North America. It is as if the fact that North American car-drivers travel faster encourages them to cover longer distances, but also to spend more time travelling, as we shall see below.

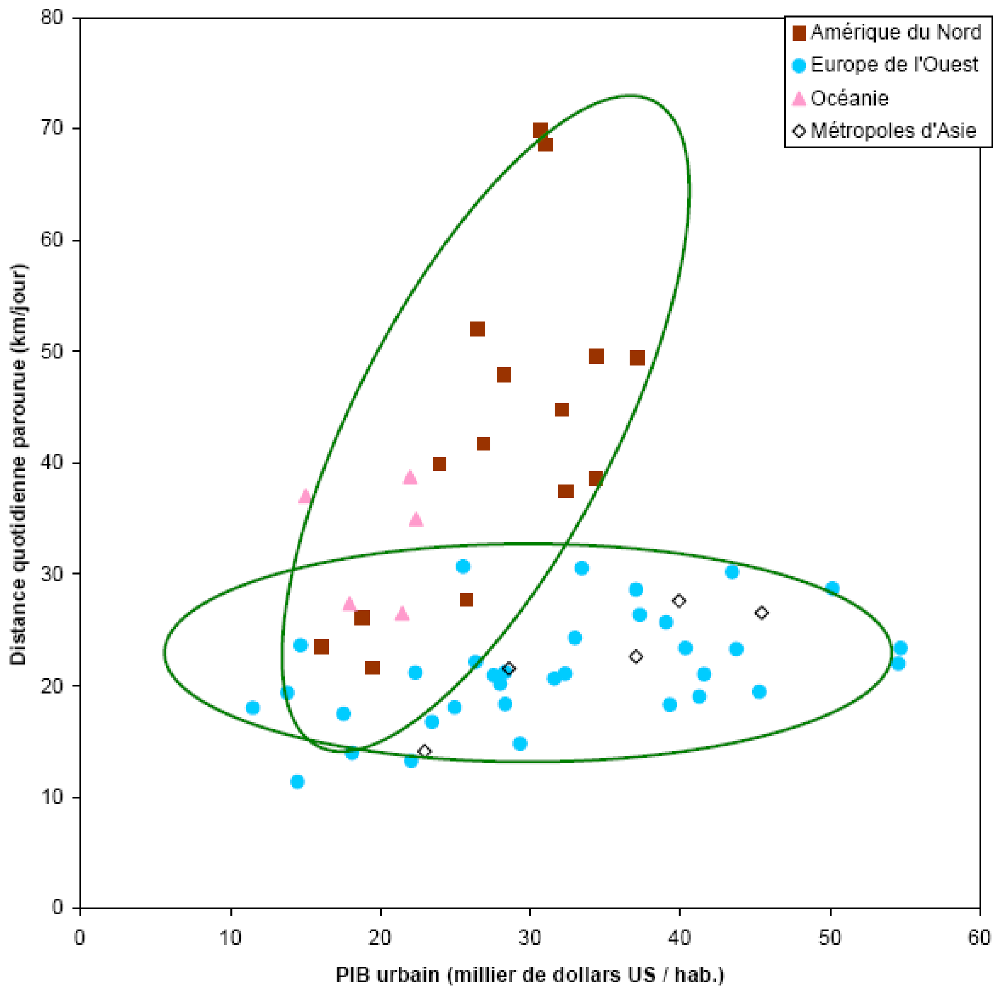

Figure 1: Average daily distance covered per person (in km) and urban GDP per person (in thousands of US dollars) in Western Europe, North-American and major Asian cities (Source: UITP millennium database)

The trend in US cities towards growth in distances and GDP is turning them into extensive entities, unlike Europe where the pattern is more intensive. Apparently, the distances covered bear no relation to urban affluence. Instead, it is linked to urban density, and more specifically job density in a specific area, but also housing density. The outcome of these highly contrasted organisational patterns can be seen in Chart 2. While job density varies quite widely across European cities, it almost always exceeds a threshold (15 jobs per hectare) that makes these jobs accessible without increasing the TTB. This is not true of the cities in North America or Oceania, where the lower the density, the greater the TTB.

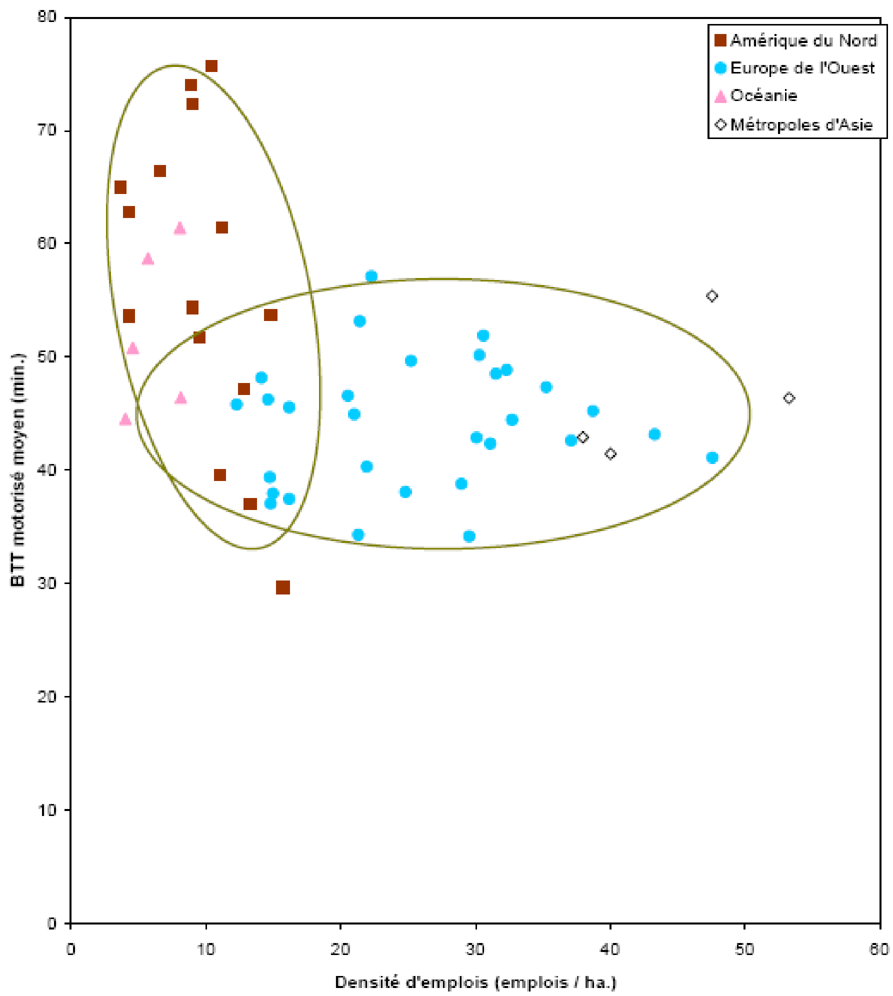

Figure 2: Motorised TTB per person (in minutes) and job density (in jobs per ha) in Western Europe, North America, Oceania and major Asian cities
(Source: UITP millennium database)

Urban mobility: towards the end of speed searching?

But it would be too simplistic to oppose European and North-American cities. From TTB point of view, a lot of studies show that everywhere, the TTB is slightly increasing. It is as if the average TTB of one hour was a floor, a minimum, but not a ceiling or a maximum. TTB is very often growing with the size of the city, as well as with the living standard. So, in developed as in developing countries, we spend gradually more and more time in travel. The result is, everywhere, an important urban sprawl and finally a non-sustainable urban development,

• Neither from a collective point of view (cost of infrastructures and cost of providing utilities to people disseminated in a low density area).

• Nor from an individual point of view: more time, more distance and a higher share of household's revenues spent to develop mobility.

The paradoxical result of these tendencies is now, in a lot of European countries, a growing number of constraints on car mobility.

In a large number of European cities, transport policies have known some major tilts. In places where, some years back, road and highway projects were favoured, other priorities are materialising. Abandoning the engineer's rationale, always fascinated by speed and technical improvements of vehicles, it is as if elected city representatives in Europe but also in Asia had ceased to bank on speed, and especially on road speed, at any price, and were instead opting for density and reliability. Many elected representatives of large cities have opted for the development of public transit and also public bikes. Everything goes as if car mobility had no priority any more, while it still represents the bulk of transportation.

In Paris as well as in Lyon, Geneva, Barcelona, Munich or London, constraints imposed to cars have not reduced the city centres' dynamism. It is as if the issue of speed in urban areas had been considered differently: a new public preference has emerged, in favour of density and reliability.

- By developing relatively slow modes of transport such as tramways and buses, new mobility policies have suggested that city-dwellers reconsider how they view city attractiveness. Rather than focusing on speed, and the distance it provides, residents are invited to make choices that reflect the advantages of proximity. There is accordingly a move towards denser urbanisation in the areas served by public transport (PT).
- As if to show that reliability and speed were now the prerogative of public transport, many large cities have opted to curb or reduce average car speeds in urban areas by choosing not to reduce road congestion. The initial grounds were road safety and the environment, but the main reason has been to break the spiral whereby increasing road capacity gradually induces traffic growth. Taking into account the decreasing returns of car mobility in dense areas, PT seems to be the best way to improve transportation supply in urban areas.
- With lower speed and rising travel costs in urban private car traffic – also due to energy scarcity, climate policies or congestion charging – the only way to improve or at least ensure accessibility is to increase the quality of urban functions (density, diversity, design).

2. ACCESSIBILITY: A NEW DEAL FOR AN OLD CONCEPT

The context of land-use and transport interaction

Land-use and transport are related to each other in a dynamic, non-linear system. Figure 3 is showing a basic scheme of the interactions between land-use, transport and activities on the long-term and short-term level of mobility.

As a basic element in long-term mobility decisions, location quality is mainly influenced by accessibility in terms of transport offer quality and urban structure. Urban development takes place with a certain delay in time depending on these location qualities as well as on urban potentials and on planning and realization processes (cooperation). On a short-term level in mobility decisions, the local and regional spatial structure largely is influencing every day activities and travel behaviour (activity program, destination choice, mode choice, route choice) – some of the aspects are also directly influenced by transport offer itself. In summary, realized travel demand is negatively playing on transport offer quality (congestion …) that only can be improved by external investment or management in operation.

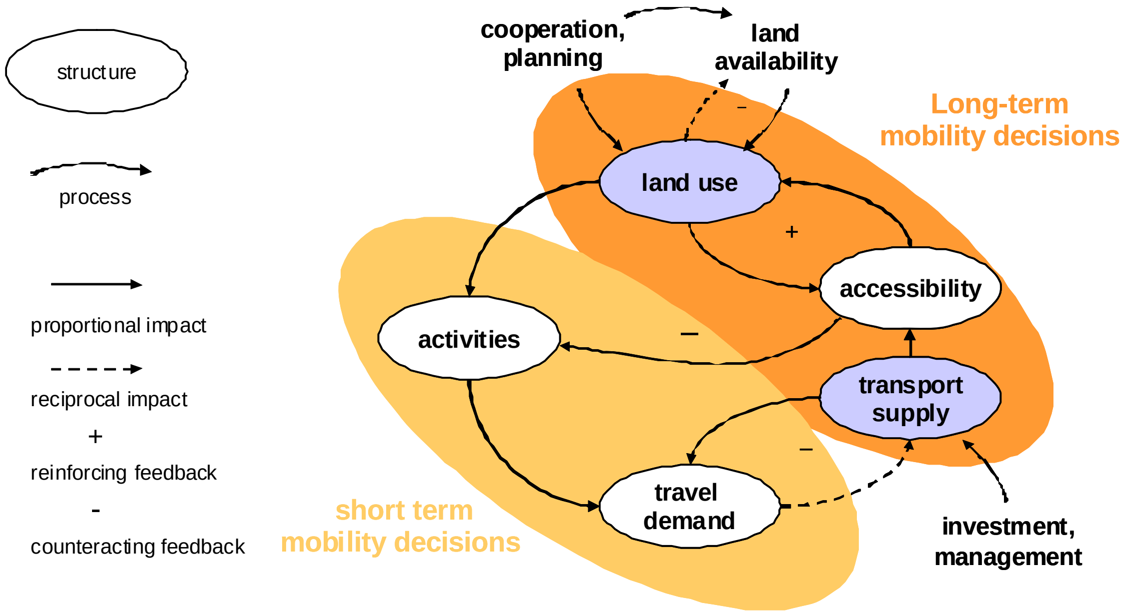

Figure 3: Land-use and transport interaction scheme (Source: Wulfhorst 2003)

However, there is no direct, linear and automatic link between the different structure elements. Change in structure is always due to processes and decisions of actors. The adequate representation of these dynamic interactions often is missing in land-use and transport planning due to lacking empirical knowledge and lacking methodological instruments (Wulfhorst, 2007).

Accessibility issue is then at the heart of the interactions of territorial structure and transport planning. On the one hand, accessibility is playing on long-term location choices; on the other hand it largely influences short-term trip destinations and trip distances. From historical times to the present we can observe the creation of towns and the development of urban facilities at places with a specific quality of transport supply. But how to define precisely accessibility?

Accessibility: definitions

At a basic level, accessibility can be defined as the ease with which one can reach a location to perform an activity (Morris and al.1979). In this sense it already incorporates two different but complementary aspects: the opportunity or possibility of interaction between two (economic) agents and the (geographic) distance that has to be covered in order to realise this interaction. Consequently the concept of accessibility can also be seen as an interface between (urban) economy and (transport) geography.

One of the most influential works on accessibility concepts and definitions was produced by Hansen (Hansen 1959, p. 74 ff), who defined "accessibility at point 1 to a particular type of activity at point 2 as directly proportional to the size of the activity at point 2 and inversely proportional to a function of the distance separating the two points. The total accessibility at point 1 to the activity is the summation of the accessibility to each of the points around point 1."

We can thus describe accessibility as a function of territorial structure and transport supply.

$$A_i = \sum_j D_j \; f(c_{ij})$$

with

A_i = Accessibility to destinations D from point i
D_j = Activity destinations at points j
c_{ij} = Generalized costs (time, prize, comfort of the trip)

In spite of being a well-known concept, accessibility can be differently interpreted according to respective disciplines. It depends on whether it focuses on the accessibility of a place or an individual, relative accessibility (to an area) or integral accessibility (for all areas in a territory), or whether it views accessibility as a tool for assessing individual utility or a transport system. Four basic perspectives have been presented by Geurs and van Wee (2004):

- The location-based approach refers to urban planning objectives including inhabitants and activities distributions. The number of opportunities reached (within a constraint transport time) is viewed as the main access-index component
- The infrastructure-based approach takes into account transportations' systems assessing performance or service level with travel time or cost (with or without congestion charge).

- The person-based approach considers individual constraints and behaviours. Individual accessibility can be limited by duration of mandatory activities, time budget for flexible activities and travel speed allowed by the transport system.
- The utility-based measures refer to benefits the people derive from access to activities.

According to this basic definition different accessibility measurements can be distinguished, like isochronal based measures or gravity based measures:
Isochronal based measures count the number of opportunities in a constraint distance, time or any other resistance parameter (like monetary budget, CO_2 emission, TTB etc.). Therefore these measures can be easily interpreted and communicated. However, isochronal based accessibility indicators are not able to measure accessible opportunities continuously with increasing travel resistances, and are therefore always reduced to an 'inside or outside' perspective.

Gravity-based accessibility results depend on a continuous evaluation of opportunities based on a resistance function to reach the activities in question. Hence, gravity-based measures are more powerful than distance measures in giving more detailed insight concerning the transport system and land-use relationship.
Let us go back to the most specific presentation of the gravity accessibility, done by Koenig (1980). The accessibility (***A***) between an *i* zone and all the mass of opportunities (***D***) of a group of areas *j* obviously depends on these masses, but weighted by the resistance factor represented by the generalised costs of transport (***Cij***), affected by a β coefficient that accounts for the qualitative elements which increase or reduce the satisfaction towards transport cost. Paradoxically, although they have a high time value, qualified persons with a high salary have a low value β. It is as if travels were better accepted, although they represent a cost: a transport cost included in a negative exponential, which means that the more transport cost grows, the worse accessibility gets.

$$A_i = \sum_j D_j \exp\left(-\beta c_{ij}\right)$$

This formula explains why public policies were and still are attracted by potential gains of speed brought by new transport infrastructures. A motorway or road enlargement used to critically increase accessibility and still do, in certain instances. As soon as quick transport means are available, the accessible zone and hence housing and job opportunities are significantly growing. Since the transport cost impacts accessibility exponentially, it gives an important weight to any significant improvement in speed. This explains the growing success of rapid transport means like the plane or high-speed trains. This same dynamic of accessibility gains allowed by improvements in average speeds justifies the tremendous success of cars in industrialised countries. Thanks to the individual car, average distances covered each day per person have skyrocketed. But urban areas, this omnipresence of cars has tended to turn the car "solution" into a problem.

To enlighten this problem we can use accessibility and especially accessibility maps to turn a complex indicator that cannot be easily understood by politicians or citizens, into an understandable result, easy to disseminate. It is now possible to face this challenge by the way of GIS. Accessibility measurement within GIS-tools helps us to understand why transportation policies are, in urban areas, at a crossroad.

3. PUBLIC POLICIES AT A CROSSROAD

We can give a new lease of life to accessibility concept and introduce its measurement within the new tools called GIS to help public policies to have a clearer idea of what is sustainable mobility and sustainable city. The first lesson of introducing accessibility in GIS is the understanding of the reason for why private car mobility is less and less relevant in urban areas. More precisely, private car usage is focused on the speed issue, as the car drivers, city planners were searching time gains when the redesign the cities during the 50' and the 60'. But others priorities are progressively arising on urban policies agenda. Accessibility improvements are now obtained more by increasing urban density and public transit supply than by higher speed on road network.

Hence, the concept of accessibility, directly inherited from cost benefit analysis, *i.e.* giving an important role to individual time gains, is now leading to a new approach of collective interest, based on space usage. In that context, until now, current approaches to transport infrastructure project assessment take into account travel time savings as an essential contribution to socio-economic benefits. But when it becomes more and more difficult to improve road speed and to offer time gains to car users, two main changes appear.

- Firstly a preference is given to time gains in Public Transit, when it is possible.
- Secondly, the main objective of public policies is no more speed gains but density of opportunities (jobs, shops, apartments…).

Sustainability issues are pushing forward the need of accessibility obtained by improving the urban functions within the catchment areas of pedestrian trips, cycling and transit rather than by increasing the catchment area by higher car speed. This is the paradoxical come back of accessibility considered through some collective priorities about land use!

Therefore, the concept of accessibility is still central, but in a different way, to understand local public policies. Due to environmental, financial and climatic constraints, sustainable accessibility is now directly linked to urban density and the capability of relatively slow modes (walking, cycling, tramways, buses…) to keep and even to improve attractiveness of cities, and namely to central parts of cities. Some German and French examples illustrate that new deal of accessibility.

The Greater Munich area accessibility atlas

Accessibility planning is at the heart of the research strategy of the Department for Urban Structure and Transport Planning at TUM. The strategy has been fostered by the mobil.TUM initiative and the respective, interdisciplinary project group on mobility and transport within the Institute for Transportation. The first International Conference on Mobility and Transport, mobil.TUM 2008, organised by the Department for Urban Structure and Transport Planning, as well as the following expert workshop on measurement, modelling and evaluation of accessibility were major steps into the international community and led for example to co-chairing a new cluster on accessibility within the European NECTAR network.

Current projects on accessibility analysis, linking classical transport modelling and GIS (within the French-German Bahn.Ville project, see Wulfhorst, Stoiber, 2009) as well as the elaboration of an “accessibility atlas” for the European Metropolitan Region of Munich are suitable basis for innovative research (see also Mercier, A.; Stoiber, T., 2010). Figure 4, below, shows a first example of isochronal accessibility within Munich area. It is a map of accessibility to the main train stations that represents here an attempt to characterise different locations according to their ability to offer an alternative to car mobility. The lower is your accessibility to train station, the higher is car dependency.

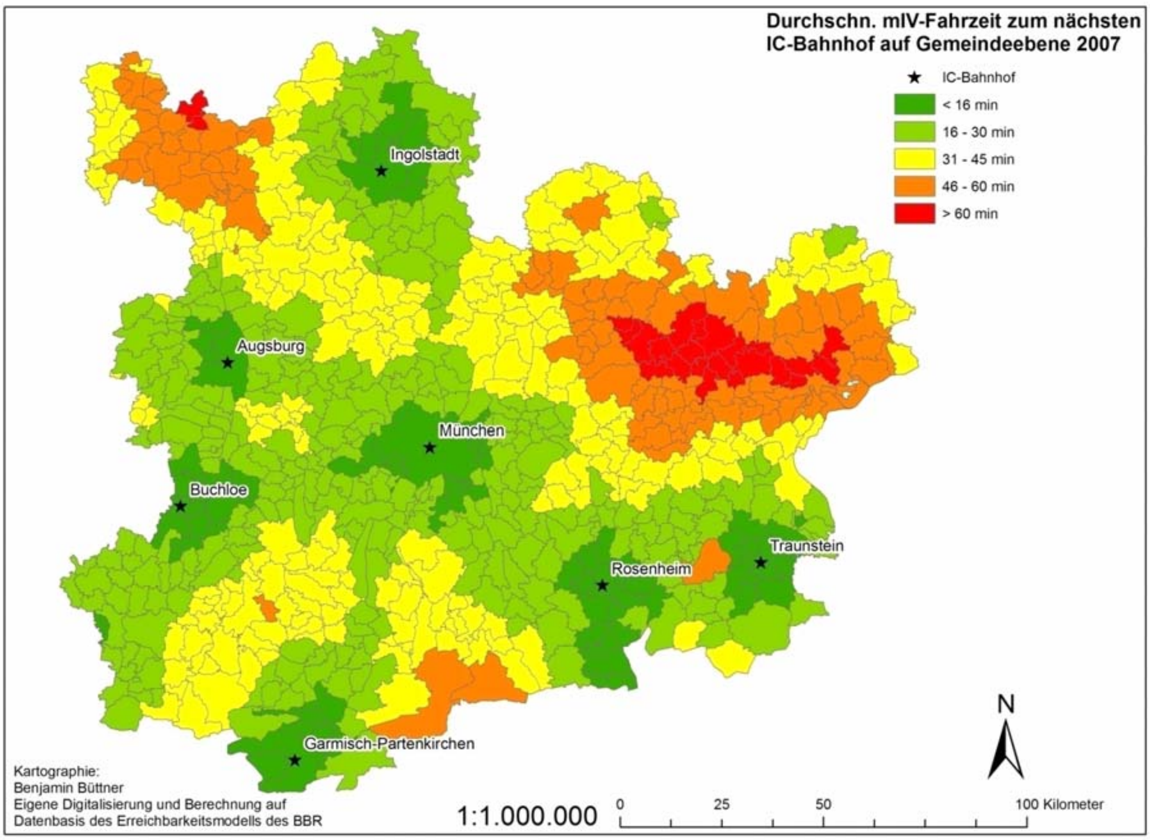

Figure 4: isochronal accessibility to main train station (in minutes) Büttner, B. (2009)

Another way to put the focus on the crucial role of train to limit car dependency is presented on figure 5 showing accessibility not only by car, but also a walking and biking accessibility. If you want to reduce car dependency, it is better to have accessibility to train station without using your car! This approach of accessibility illustrates a preference for density and proximity to train station in a world where mobility is becoming a key issue for a sustainable future of urban agglomerations.

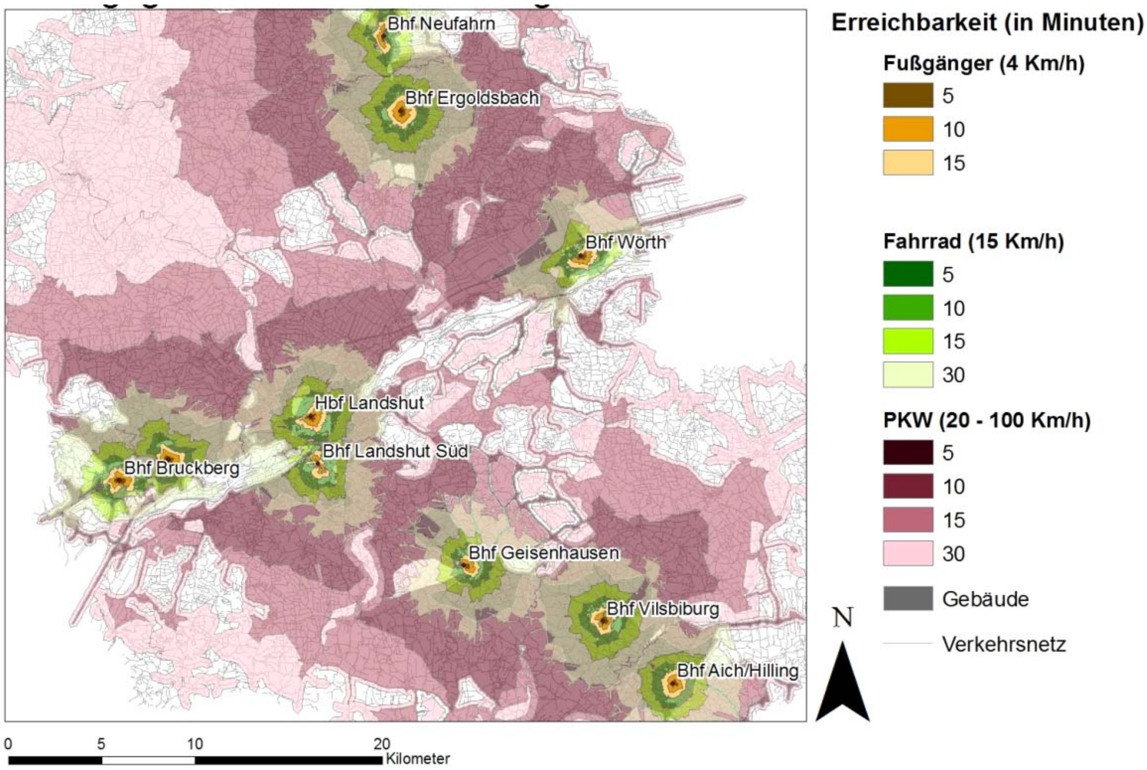

Figure 5: isochronal accessibility to main train station (in minutes)
with different modes: walking, biking, car

Accessibility is at the heart of these feedbacks. High performance of the transportation systems has enabled to reach manifold destinations in a dispersed, low density settlement structure on the level of the urban regions. But user benefit might turn out as a heavy load for the society.

Today these challenges are concerning especially the crucial questions of energy scarcity and climate change. The transport sector – by constantly growing travel distances in motorized traffic – generates increasing energy consumption despite major improvements in energy efficiency on the level of vehicles. While motorized traffic keeps on relying heavily on fossil energy resources, the current development is inducing absolutely growing greenhouse-gas emissions (+30% in the EU 25 member states during the last 15 years). In order to meet the objectives set by the IPCC and the political arena (reduction of GHG-emissions by 80% until 2050), technological improvements will not be sufficient. Behavioural changes and especially an integrated approach in developing land-use and transport supply will have to contribute at least at the same level.

Further research activities therefore will focus on:

- Setting up fully integrated database including transport supply for all travel modes (walking, cycling, private car, public transport), spatial structure (distribution of residents, workplaces, points of interest: leisure, shopping, service facilities) for the metropolitan area in a GIS environment,

- Analysing accessibility as a potential for sustainable mobility and assessing strategies and measures against their spatial impacts (identifying winners and losers, not only a single benefit-cost ratio),
- Linking the potential on the system level to individual behaviour, for example by comparing theoretical options given by the land-use and transport supply structure with the observation of realised individual mobility choices.

Accessibility in Lyon's urban area: The MOSART program

The Lyon Institute of Transport Economics has developed the MOSART project (Modelling and simulating accessibility) to set up a tool to help in decision and town planning, allowing to study the accessibility of populations to services and jobs along the various networks (private car, public transport). The objectives of the MOSART project were to develop this tool to:

- model and simulate the levels of services offered by the different transport networks (private car, public transport);
- study and analyse people's mobility,
- compare scenarios of transport policies and town planning in a sustainable development framework,
- set up an observatory of spatial accessibilities (through a web mapping).

This tool aims at providing accessibility indicators which can be the basis of mobility policies and town planning by introducing the accessibility concept at the heart of the reasoning. The main idea is to propose to inhabitants and urban users another view of urban mobility.

For instance, at the level of Lyon's urban area (296 local administrations – 3,316 square kilometres) we are setting up a web mapping tool which helps to define policies of public mobility and town planning, but also supports private choices in terms of location, transport means and itinerary. By using a very sophisticated traffic model, but also precise spatial databases, an interactive GIS and a powerful digital simulation, we are constructing for the Lyon's region, the prototype of what will be in coming years, the common management tools of persons and goods mobility.

Figure 6 thus shows the gravity accessibility differential between public transport and private car at peak hours. The pink and red squares represent the areas where accessibility by public transport is better than accessibility by private car. Blue squares reflect the opposite situation.

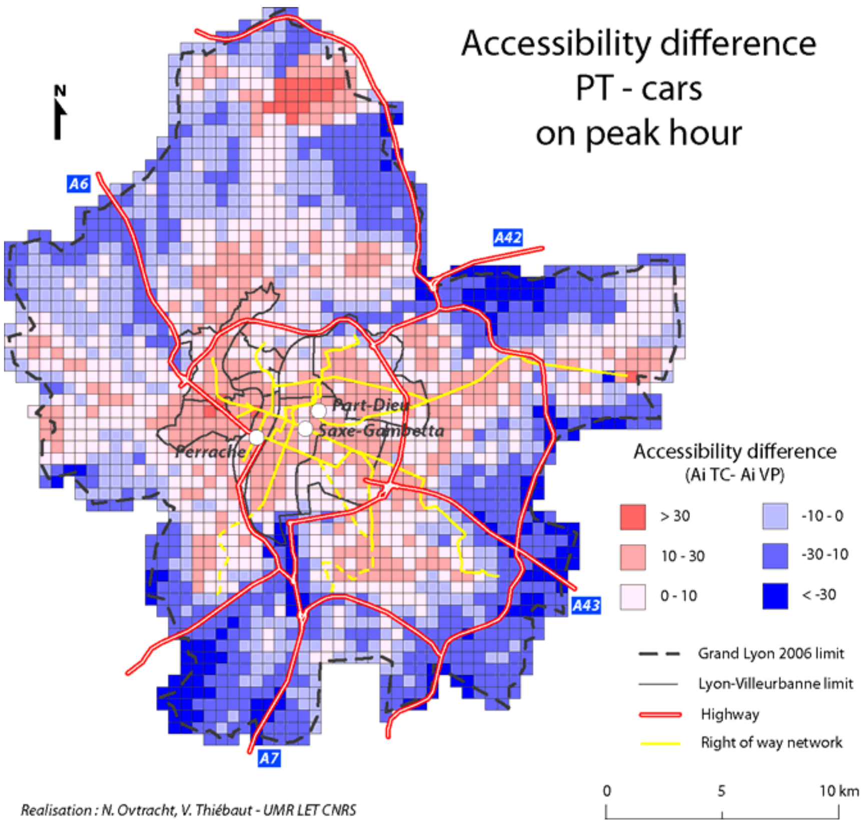

Figure 6: Accessibility difference public transport-car at peak hour

At a first glance, this figure stresses the positive impacts of urban motorways on car accessibility. Close to rapid highways (in red) the blue colour is dominant. However, alongside public transport axes (subway and tramway in yellow), pink and red are prevailing. Such a figure directly questions elected representatives and citizens. What do you wish for the middle and long-term: to spread the relative part of blue areas or that of red or pink areas? It is highly possible that depending on the situation, each person might wish either one or the other of these two possibilities. As a car driver, it is tempting to prefer blue areas, which means creating new rapid highways. However, by remembering the likely effects of the latter on the city and on road congestion, the collective interest suggests on the opposite to favour public transport, the only means to improve or at least maintain the accessibility level in dense areas.

It is hence not surprising to know that the transport authority of Lyon urban area (SYTRAL) has decided to develop 4 new tramway lines opened between the end of 2000 and April 2009. It should be stressed that these lines are all serving the eastern and southern parts of the urban area, where the working-class lives. The accessibility trade-off is not solely a patrimonial choice to enhance the city centre's attractiveness, where most of the well-off are living, due to the housing costs. Since public transports are expensive and are financed by all the administrative units of the urban area, a trade-off has been done in favour of the working-class neighbourhoods.

This example sums up the fact that the crucial point in sustainable urban mobility is how to make use of the well know feedbacks on accessibility in an opposite way. 50 years after Hansen's paper on "how accessibility shapes land use" (Hansen, 1959), it is time to ask: How public policies on land-use and transport supply can help to maintain an acceptable level of accessibility in a context of rising travel costs? How to shape urban structure and transport networks in order to reduce travel demand volumes needed to fulfil our mobility needs?

4. CONCLUDING REMARKS: HOW COLLECTIVE LAND USE PRIORITIES SHAPE ACCESSIBILITY!

Urban mobility and the related public policies are at a crossroad: we cannot go on like we have done in the oil age. Accessibility has to be addressed within a strategy of sustainable development in order to cope with the three main challenges of the future.

- A social challenge: how can we ensure that the residents of a metropolitan area, irrespective of social rank, continue to have access to all urban amenities?
- An environmental challenge because of the external cost of mobility, especially car mobility (space consumption, emissions of pollutants, noise…);
- An economic challenge due to the increasing cost of passengers mobility for public finance and for commuters because of congestion. What becomes accessibility when you have more and more congested roads and when employment areas are more and more difficult to access during peak periods?

At this point of the reasoning a temptation rises. If higher speed is responsible for urban sprawl and non-sustainable cities, is it possible to reverse the process? Should we impose to the urban citizen a lower speed in order to come back to denser cities, to cities where walking and cycling would be the best way to go from one point to another point of the city? Obviously, we have to be careful, even if a higher speed has a lot of side effects, is it really a relevant objective to return to pedestrian cities, or more generally speaking, to “low speed” cities? Once more, we have to avoid putting the focus on speed and more generally only on transportation issues.

It is better to take into account the complex system of mobility and interactions of land-use and transport according to economic needs, social conditions and the environmental challenges of sustainable development. If we admit that we cannot simply go on satisfying a given travel demand by additional transport supply (without caring about the related feedback mechanisms), but rather recognise that we have to manage transportation demand by land-use and transport measure, accessibility planning may be a promising strategy.

Accessibility planning as a concept of strategic planning should therefore aim towards ensuring and improving mobility options that, from a collective point of view, enable economic development and social exchange, while at the same time reducing the negative effects of transport.

Major aspects of this concept include (compare figure 7):

- the efficient improvement of transport supply by increasing the interconnection of existing transport networks and active investment (infrastructure and services) in sustainable modes of transport;
- the orientation of urban development to this transport system, especially by dense, mixed-used and polycentric settlement structures as well as high-quality public spaces and urban design; and

- specific measures in mobility and transportation demand management, based on information, consulting and restrictions, taking into account the internalisation of external costs.

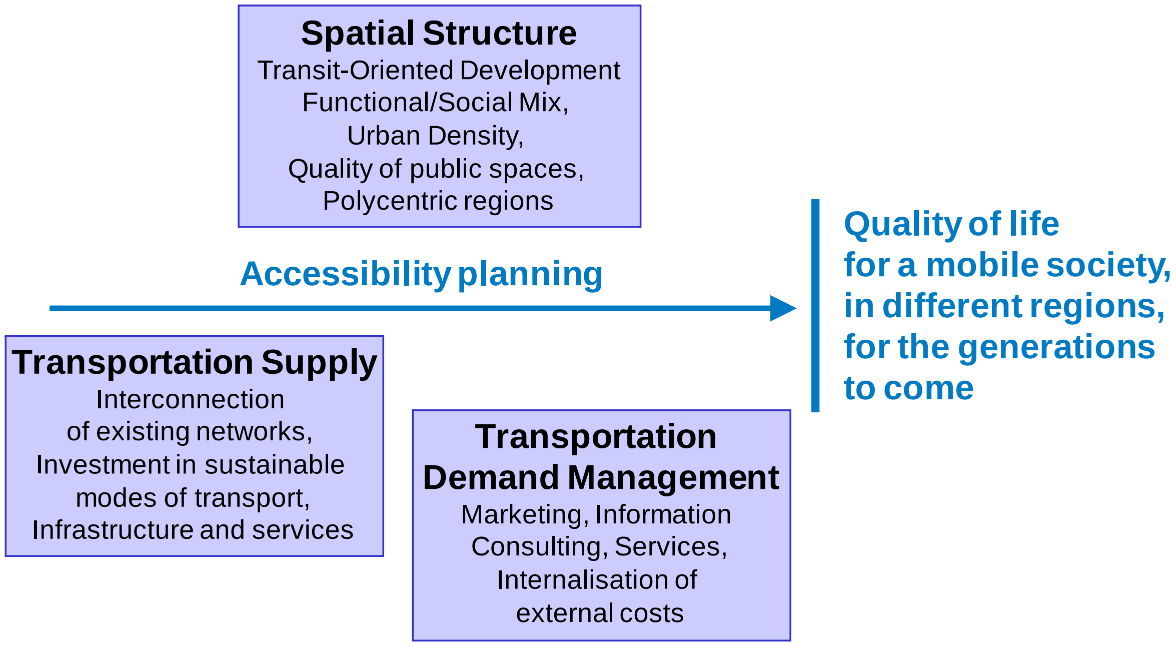

Figure 7: Accessibility Planning as a strategy for sustainable mobility (Wulfhorst, 2008)

The importance of accessibility is likely to increase in the near future for both public concerns (e.g. attribution of urban rights, transport project appraisal) as well as for individual decision-making (e.g. location choice, car dependency), especially due to demographic changes, energy costs and climate change mitigation policy.

Accessibility planning could contribute in providing methodological and professional support to deal with these challenges – and this on various scales, from the gap between the subway vehicle and the station platform, to the quality and quantity of pedestrian trips within an urban neighbourhood to the linking of metropolitan regions by high-speed transportation.

Today, there is no integrated tool to measure and evaluate accessibility regarding mobility needs, urban attractiveness and traffic impacts.
The key challenge in this context is to enhance methodological instruments in order

- to develop new methods in evaluating benefits as well as internal and external cost of the transportation system,
- to integrate the dynamics in space and time of the different transport modes and spatial options as well as long-term strategic mobility decisions and short-term activity behaviour and finally
- to integrate the user needs, specific perceptions of different groups or individuals (actors/agents).

Many links between individual benefit (utility maximisation) and a system optimum (given limits of sustainability) as well as the behavioural processes (decisions) against an existing potential / structure have to be developed in modelling the system interactions.

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