Mobilistics Proposal to a Scientific Discipline
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Abstract
1) Transportation refers to a complex system based on numerous decisions to bring access to activities in a geo-space. The transportation system is highly adaptive in time and space but it is also very sensitive to disturbances which can result in system collapses.

2) Tendencies are now being seen toward a paradigm shift in transportation solutions as the epoch of “building away the problems” through large investments in road infrastructure is more and more being considered to come to an end. Instead, the transport demand must be handled and managed to bringing accessibility with reference to environmental goals. The existing infrastructure must also be more efficiently used.

3) A theory on mobility is presented based on that transport being an integrated part of the activity pattern of an individual. The demand for transport is “generated by dissatisfaction with one’s own space in a special moment, event or situation”. The individual tries to optimize the net benefit of the movement from one place to another in comparison with the expected utility at the destination and the sacrifices in time, money, discomfort, risks etc. caused by the transport.

4) A specific theme - here called Mobilistics - is proposed in order as a special scientific discipline for research and development in mobility. The target will be to formulate and verify theories and models for four specific areas:
   - Traffic Genetics, how transport demand is generated and satisfied under various conditions and constraints with reference to individual choice behavior, socio-economic conditions, policy instruments etc.;
   - Transport Informatics, how to bring information to different decision makers all over the transportation field for transport consumers and traffic operators, also avoiding transport by using telecommunication;
   - Traffic Flow Dynamics, how to apply IT and other techniques to manage and control given traffic flows in networks with reference to efficiency, safety and environmental consequences;
   - Mobility Management Methodology, how to manage transport demand and organize traffic service with reference to existing infrastructure and land use.

All these areas are highly integrated. Earlier experience in traffic studies, transport demand management, para-transit and mobility management is here of great interest for reducing dependency of private cars.

5) Mobilistics can be considered a scientific discipline as it covers a defined mode, because the ones and methods are available, and education, organizations and networks are established. However, there is need for special professorships and university institutions.

To be presented at URBAN TRANSPORT SYSTEMS (conference in Lund, Sweden, June 7-9, 1999)
TRANSPORTATION AS A SOCIA L PHENOMENON
Transportation “the act of transporting” refers to a complex, non-linear system of activities based on individual decisions to bring access to numerous activities in a geo-space. The system is highly adaptive in time and space but also very sensitive to disturbances which can result in system collapses.

Transport is defined as the movement of a person or goods from one point to another. A transport problem is an individual and private issue that deals with gaining access to a desired location according to given rules and conditions. These playing rules are set by political and administrative decisions on taxes and fees, speed limits and regulation of working hours for professional drivers, for example, and by transport operators in providing a certain degree and quality of transport service, fares etc.

Traffic includes the total quantity of movement activities in a geo-space and can be described by and related to the type of transport during a specific time period. Traffic problems represent collective and societal mailers and are observed as the consequences of transport, mostly negative ones, such as congestion, time delays, accidents, noise and exhaust.

Transport and traffic problems can be related to the degree to which desired goals are fulfilled in four areas:
- socio-human factors, e.g. degree of accessibility for different types of transport consumers, quality of transport service such as reliability, comfort, time consumption, information;
- public health factors, including degree of risks, safety and security, stress, impact of noise, exhausts and influence of traffic on health and well-being factors;
- environmental factors, e.g. consumption of energy, land and other natural resources, global and local impact of emissions, impact on surroundings and aesthetic factors;
- economic factors, e.g. degree of capability, efficiency of capital investments, operation costs.

These factors are integrated, e.g. traffic injuries and environmental impacts have economic consequences, and environmental factors have an influence on public health (Figure 1).

Figure 1. Transport and traffic problems can be related to four highly integrated areas.
URBAN TRANSPORT DEMAND AND SUPPLY

Urban transport problems can not be treated without reference to traffic problems, i.e. congestion, losses in time and money, accident risks, and environmental impact. On the other hand, traffic problems can not be treated without reference to transport problems, e.g. satisfying the individual need for a reasonable degree of accessibility and mobility. Individual decisions in transport affect to a greater or lesser degree the total traffic situation, however, which then affects other transport consumers, and increasing traffic has an influence on traffic flow, time delays, accident risks etc. Transport consumers are dependent on policy decisions, on technical standards in traffic infrastructure etc. and on decisions made by operators of traffic service. Lobby groups and also individual behavior will have an impact on the need for improvements in operation and on traffic infrastructure.

Some experiences can be mentioned:

1) How travel distances have increased during the past century:
2) How time consumption seems to be constant, independent of the standard of transport facilifies and income level;
3) How more road infrastructure “building away” the problems leads to urban sprawl, more congestion and even requires more road investment;

1) In earlier times most activities were available within the neighborhood because transportation costs over longer distances were high. In industrialized society, the transportation technology has facilitated faster and cheaper motorized transport such as high-speed trams, jet aircraft, automobiles on motorways. In Sweden, the amount of vehicle kilometers is estimated in the year 1910 to 0.9 km per persons and day, in 1960 to 20 km, and today it will be 45 km (Wilhelmsen 1988).

2) Data from countries all over world shows that personal income and traffic volume grow by the same proportion. If the income increases twice, the number of passenger kilometers will be doubled. Studies also confirm the hypotheses that a person have same the travel-time budget independent of the economic, social and geographical situation (Schafer & Victor, 1997). Even if there are variations in individual behaviour, an average of 1.1 hours a day in traveling has been found (Figure 2). If the income raise, people select more faster modes of transport within the same travel-time budget. That means that slower transport by public transport will be replaced by automobiles, and at higher incomes, high-speed trams and airplanes will be used.
3) The era of the automobile has lead to urban sprawl with low-density housing areas, and a concentration of workplaces and service centers, resulting in longer travel distances, more energy consumption, and more pollution (Newman & Kenworthy 1989). As car ownership and automobile traffic increase, the service level of the public transport system decreases with less ridership, less opportunities for walking and cycling and so on. The phenomenon has been described as the evil circle of public transport decline. An analogous feedback mechanism has been called the black-hole theory of highway investment, describing how adding more capacity makes it easier to travel and encourages urban sprawl which then increases trip length, more traffic and further congestion and request for more highway investments (Figure 4). The phenomenon is also known as the Braess’s paradox: adding new routes often makes congestion worse, not better.

Figure 3. The black-hole theory of highway investments. Source: Plane (1995).

NEED FOR A PARADIGM SHIFT
For decades, congestion and safety problems have been the basic reason for the implementation of new facilities. Congestion is evident in larger cities and on main roads and causes considerable daily losses in time. Accident risks have been reduced but the number of killed and injured in road traffic is still high (the number of fatalities in the ECU countries is about 45000 per year). Also the environmental problems as noise, exhausts and visual intrusion on the local level have been recognized. Some local environmental problems have been solved by traffic management schemes and by noise protection measures such as construction of noise barriers, insulation of windows. Vehicles with lower fuel consumption and emissions have contributed to reduction of air pollution but the rapid growth in the number of cars and trucks has negatively balanced the net effect. The effect of all these efforts to solve problems has not been very remarkable as the volume of cars and trucks in traffic has steadily increased.

Today the regional and global impact of increasing fossil consumption and its consequences for human health and the earth are issues of great concern and are becoming better and better understood. Environmental impacts can be registered as diffusion of toxic substances, acidification of lakes, destruction of forests, depletion of the ozone layer, the greenhouse effect and global warming.

Many declarations have been made concerning the environment, e.g. the Brundtland Report (1987) on Our Common Future, the Green Papers from the European Commission on the Impact of Transport on the Environment, Agenda 21 from the UN Conference in Rio de Janeiro in 1992 and the Kyoto meeting in 1996.
Transportation researchers and professionals must take signals from the ecologists seriously and learn about environmental problems. There is now a tendency toward a paradigm shift in transportation solutions as the epoch of “building away the problems” through large investments in road infrastructure is being more and more regarded as a passed stage. Instead, transport demand must be handled through a directed reorganization of the societal structure and lifestyle. Among other measures, the existing infrastructure must be more efficiently used.

The main questions will be:
- How can a new transport policy contribute to sustainable development?
- How can transport demand and traffic pattern be changed in the near future?
- How can we reduce car dependency, e.g. by city renewal, by alternative modes of transport, such as carpooling, walking and biking, or the use of pro-environmental vehicles, e.g. electric cars?
- How will consumers react to various push-and pull policy instruments, e.g. pricing?
- How will road pricing affect land use and business?
- How can transport need be substituted by tele and information systems, e.g. more work at home, tele-shopping, home deliveries?
- How will consumers use and rely on specific pre-trip, on-board and destination information?
- How can we achieve better use of existing infrastructure and investments in roads and vehicles?

A new approach is thus necessary if we will search for transport solutions contributing toward a more sustainable society.

**APPROACH TO A THEORY ON MOBILITY AS A PART OF THE INDIVIDUALS’ ACTIVITY PATTERN**

The behavior of individuals has long been studied in travel surveys (de Dios Ortuzar et al., 1998). A great deal of statistical data is available that shows trips over the day, week and season, and how trips are related to type of means, type of household, income level, age structure etc. Models for trip generation and distribution among destinations and modal split have been constructed and used for traffic forecasting (Hanson, 1998).

Literature is available on human decision making and choice behavior, e.g. Arrow (1963), Sjöberg (1983). However, it is remarkable that very few theories have been formulated for how individuals make strategical decisions in transport. The following is an approach to setting up a general theory on strategic choices in transport, related to the activity pattern of individuals.

1) The activity pattern of an individual consists of a series of things done outside the home sphere, and these activities generate a need for movement on foot or by vehicle in order to gain physical access to a specific destination (Manheim, 1979). Some of these activities are bound or forced in space and time, e.g. going to work and school or an appointed meeting, while others are more or less free and open to individual choice, e.g. shopping, going to the movies and visiting friends. The activity pattern and corresponding movements can be described in spacetime diagrams (Hägerstrand, 1970, Lentorp, 1977).

2) The demand for transport is “generated by dissatisfaction with one’s own space at a special moment, event or situation”. The need for something cannot be satisfied in the present sphere and, as a result, a transport demand is defined. The individual has therefore to make a range of decisions to gain access to a specific activity and satisfy a given need: to move or not to move (or use telephone instead), at which destination, at which time, using which mode or combinations of modes, along which route. All these decisions are linked together but can be changed during an ongoing transport, e.g. by a change of routes.

3) In decision making, the individual tries to optimize both the total and subtotal benefit in relation to positive and negative consequences of each decision (Ben-Akiva, & Lerman, 1985).
The decision maker evaluates alternatives in normal cases routinely or momentarily, identifying consequences in a short time perspective. This means that more direct, immediate factors, e.g. time savings, have a higher ranking than long-term consequences, e.g. risks for serious injury.

4) The strategy for a decision maker to move from an origin (0) is to obtain a desired or expected net benefit $b(D)$ at the destination (D) in relation to the known utility $U(O)$ at the origin point. However the estimated or expected sacrifices $c(OD)$ for the movement by a transport means in time, money, discomfort, risks etc. will be considered. The logical result of an optimal decision will therefore be that the expected net benefit $b(D)$ is greater than the sacrifices,

$$b(D) = u(D) - U(O) - c(OD)$$

or be seen as an optimization problem,

$$b(D) = \text{optimum} \{u(D) - U(O) - c(OD)\}$$

The expected utility and the sacrifices are given by uncertainty but are in most cases known to the decision maker.

Note: This statement is valid not only for person transport but also for goods transport - products are transported from e.g. a production site to other points in order to meet the market and obtain a higher value and price of the product.

5) The decisions are related to a set of constrains which will influence the choice of destination, departure time, transport mode, route etc.

- **type of need**, e.g. buying a product used daily does not require a selected evaluation of destinations while seldom purchased product means a more careful selection of one or more destinations;
- **access to transport service**, e.g. public transport service, transport service for disabled, disposition of a private car;
- **ability and opportunity to move**, e.g. free from handicaps and walking problems, valid driving license, temporary transport inadequacy (weather conditions, vehicle failure) etc.
- **specific preferences**, e.g. need for privacy in transport, unwillingness to drive a car, demand for comfort and seating, guarantee for reliability in arrival time;
- **economic resources**, e.g. how much money the individual is willing to pay for a specific transport to a specific destination;
- **available time**, e.g. how stress and a shortage of time will influence the choice of destination, mode of travel, risk taking etc.
- **available information**, e.g. on timetables, travel costs, park-and-ride facilities, available parking space and price at the destination;
- **force of habit**, e.g. unwillingness to change habits, habits by routine;
- **personal awareness**, e.g. consideration of risks, environmental problems etc.

Many studies are going on to describe and analyze mobility, and also provide solutions to satisfy the increasing transport demand among people. However, there is a need for a special scientific discipline here called **Mobilistics**.
MOBILISTICS AS A SCIENTIFIC DISCIPLINE
Mobilistics is a highly interdisciplinary science that aims to develop theories on and organizations of mobility related to the satisfaction of transport demand for individuals. It is analogous with Logistics, which concerns the material handling and management of goods transport flows in the industrial sector. Four special areas of Mobilistics can be recognized (Figure 4):

Traffic Generetics includes studies on how transport demand is generated and satisfied under various conditions and constraints with reference to individual choice behavior, socio-economic conditions etc.

Transport Informatics includes studies on how to bring information to different decision makers all over the transportation field for transport consumers and traffic operators, also avoiding transport by using telecommunication;

Traffic Flow Dynamics includes studies on how to manage and control given traffic flows in networks with reference to efficiency, safety and environmental consequences.

Mobility Management Methodology includes studies on how to manage transport demand and organize traffic service, mostly with regard to existing traffic infrastructure and land use.

Figure 4. Four special areas in Mobilistics as a scientific discipline

These special areas in Mobilistics are highly integrated. A great challenge will be how research in Mobilistics can contribute to a more sustainable transport. However, Mobilistics should not be directly related to research and development in transportation technology or the construction of traffic facilities. The idea is to study the possibilities for managing transport demand within the existing infrastructure. In some cases, reorganization and restructuring can be necessary.

TRAFFIC GENERETICS
Many studies are being conducted to describe and analyze choice behavior (Arrow 1963) and decision making (Sjöberg 1983) and how transport demand is generated and satisfied (de Dios Ortízar 1998). Travel data is collected in ongoing disaggregated studies with reference to urban development and land use (Thomson 1977, Berechman, 1996), urban structure (Newman & Kenworthy 1989), and socio-economic factors (Hanson et al 1995). Examples of specific study areas are acceptance of road pricing and other pricing methods (Button & Verhoef 1998), and possibilities for introducing alternative modes to private cars (Tolley 1997).

Several models have been constructed for trip distribution, modal split and network assignments (Hanson et al 1995). One of the pioneers in this field is Eduard Lii (1891), an
Austnan railway statistician who in 1891 published an analysis of ticket sales statistics in the Northwestern part of Austria and defined a travel law, saying that trips $T(i)$ from a city (i) decreased with distances $x$ to other stations according to a hyperbolic curve, $1 / x$,

$$T(i) = \frac{M(i)}{x}$$

where $M(i)$ is the trip value, based on the size and other qualities of the city.

The trips from an originating city and to a specific city and its station (j) at the distance $x(j)$ is calculated as the difference between the probability $P(j-1)$ of stopping at the station (j) and to the probability $P(j+1)$ of passing the station,

$$P(j) = P(j-1) - P(j+1)$$

Trips $t(i,j)$ between (i) and (j) are derived as

$$t(i,j) = \frac{M(i)s(j)}{x(j)^2}$$

where $s(j)$ is the station distance for the city (j) in relation to surrounding stations.

Corresponding ideas for calculating trip distribution, based on comparisons of probabilities are known as Intervening Opportunity Models, first published by Stouffer in 1940, and as Gravity models (Catanese 1974, Sheppard 1995). So called Logit models, have been set up for predicting aggregate flows for modal split (Hansson et al 1995), and route choice (Thomas 1991).

**Traffic Genetics** includes research on how transport demand is generated and satisfied under various conditions and constraints. Further in-depth studies are necessary to formulate and evaluate theories on how transport demand is generated and satisfied in different situations with reference to individual choice behavior, socio-economic conditions, policy instruments etc. It is also necessary to find methods to predict changes in travel behaviour depending on societal changes and the need for more pro-environmental transport. How telematics can be used and accepted for substituting transport through teleworking, teleshopping etc. is another area of interest to be further studied and followed up in demo projects (Janelle 1995).

**TRANSPORT INFORMATICS**

The introduction of information technology (IT) is dramatically changing society and private life.

The application of IT in the transportation field will influence vehicle engineering, traffic operation, traffic control and enforcement, and information to customers (Nwagboso 1997). New and advanced technologies are widely being prototyped and tested in various forms (Figure 5). Examples of applications are:

- Traveler information, pre-trip to inform about transport alternatives (means of transport, departure and arrival times, route choice, parking fees and road tolls, and during the trip (on-board information) showing present road and traffic conditions, also avoiding transport by using telecommunication instead;
- Instruments to control driver behavior, e.g. permissions to drive (alco-keys), and automatic speed regulators in vehicles;
- Systems for safe and efficient operation of vehicles, especially public transport, commercial vehicles, and emergency management;
- Electronic payment for use of the traffic infrastructure, e.g. by smart cards.

Transport Informatics as a special theme covers many areas related to consumer behavior and the acceptance of different technical innovations. There is need for further studies how the...
new technology can be adapted to humans and used in a reasonable and acceptable way, both from personal integrity and ethical points of view.

**TRAFFIC FLOW DYNAMICS**

Traffic flow theory and network simulation on the micro level has been used during the last 50 years and was already applied during the Second World War (Beckman, 1956) and referred to highway capacity problems (Transportation Research Board 1994). Examples of simulation issues are delays at toll booths, the appearance of congestion, and capacity of intersections. However, traffic as a non-linear system needs further research, not only based physically on mathematical models but also considering behavior of road users in different choice situations.

The main idea of Traffic Flow Dynamics is to get an optimal use of a transport system through regulation and control of the traffic flow. Research and application of IT techniques are rapidly going on all over the world (Catling 1993, Nwogoboro 1997). Systems are known as IVHS (Intelligent vehicle-highway systems), ATS (Advanced transport systems), and ITS (Intelligent transport systems). The so-called KomFram is a system for public transport (Franzén 1999). Basic instruments are the use of GIS (Geographical Information System) and GPS (Global Positioning System).

Further research and feedback of experiences are necessary to obtain an optimal real-time control of the traffic flow for both public transport systems and the automobile system. Application of artificial intelligence and expert systems will here be of interest for monitoring and control of traffic flows.

**MOBILITY MANAGEMENT METHODOLOGY**

We have an over-capacity in the existing traffic infrastructure if we look for the use of the opportunities over day and night in link and seat capacity. Mobility management will be an issue of great interest for finding ways to coordinate and satisfy transport needs and optimize the use of a given land use and traffic and infrastructure with regard to social and environmental goals. Many types of mobility management are applied, such as car and van pools, car clubs for ownership sharing and rental, home delivery service, better use of existing public transport service (also for delivery transport), walking and biking instead of shorter ear driving etc. (Tolley 1997). Mobility centers on both regional and local levels (in neighborhoods and at companies) will be an essential part of a programme for marketing and promoting sustainable transport service.

Further research is necessary to find ways to organize new transport alternatives to reduce the dependency on private cars and to achieve an effective use of existing vehicle capacities. It is also important that experience from projects is further followed up and analyzed.

**CRITERIA FOR FORMING A SCIENTIFIC DISCIPLINE**

Mobilistics is here proposed as a specific scientific discipline. The question is in which degree Mobilistics fulfills criteria for a specific discipline. Some general factors constituting a scientific discipline have been defined (Molander 1990). There should be:

1) **Specified education** which supplies and defines a minimum of competence for researchers;
2) A **defined theme** (or niche) in which all the aspects of reality and problems are noted and in which researchers try to increase and improve knowledge;
3) **Basic knowledge and information** to study the area, which can be found in textbooks and classical publications (in the meaning of fundamental or pioneering work);

4) **Established rules and methods** to gain and increase knowledge in the area;

5) **Ideals and forebids** for reference (also bad example as well);

6) **Organizations and institutions** that socially and economically guarantee survival, further research and preferably also expansion;

7) **Networks for communication** between researchers for the exchange of concepts and knowledge, for critiques and peer reviews through seminars, conferences, magazines etc.

If we apply these criteria to Mobilistics, we find that this specific area can be considered a scientific discipline and that there are ongoing efforts to extend the area. Networks for communication exist thanks to the 4th framework in Transportation in EU. However, there is need for special professorships and university institutions.

**CONCLUSIONS**

Transport and traffic problems have long been solved by technical measures. However, there are now tendencies toward a paradigm shift in transportation solutions as the epoch of “building away the problems” through exclusive and large investments in road infrastructure more and more coming to an end. Transport demand must instead be handled and managed to bring accessibility while considering social and environmental goals. Furthermore, the existing infrastructure must be more efficiently used.

A specific scientific discipline, here denoted *Mobilistics*, is proposed in order to produce theories and methods for how to manage transport demand and contribute to sustainable development.

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